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PROCEEDINGS OF THE SECOND ICAO FLIGHT SAFETY AND HUMAN FACTORS GLOBAL SYMPOSIUM

Washington D.C., April 1993

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Washington D.C., 12 to 15 April 1993

ORGANIZATION OF THE SYMPOSIUM

The Second ICAO Flight Safety and Human Factors Global Symposium was organized by ICAO and was held at the Omni Shoreham Hotel, Washington D.C., from 12 to 15 April 1993, at the kind invitation of the United States Government. It was attended by 325 participants from 42 States and 6 International Organizations.

The Opening Session was hosted by Mr. Garland P. Castleberry, Associate Administrator for Aviation Standards, Federal Aviation Administration. Mr. Joseph Del Balzo, Acting Administrator of the Federal Aviation Administration; Dr. Philippe Rochat, Secretary General of ICAO; the Honourable James L. Oberstar, Chairman, House Subcommittee on Aviation, U.S. House of Representatives and Dr. William R. Fromme, Director, Air Navigation Bureau, ICAO addressed the delegates. Mr. R.D. Cook, Member of the ICAO Air Navigation Commission read a message from the President of the Air Navigation Commission.

The opening keynote address was presented by Dr. H. Clay Foushee, Managing Director, Flight Procedures Training and Standards, Northwest Airlines and the wrap-up keynote address was presented by Mr. Jean Paries, Deputy Chief of the Accident Investigation Office (Bureau Enquetes Accidents), France.

The symposium was organized as one body with panel presentation and individual papers. The theme of the symposium was **"Human Factors Training for Operational Personnel"**. Presentations were grouped into sub-themes and panels were established to cover the various presentations.

The following sub-themes, divided into morning and afternoon panel sessions were covered:

1: DEVELOPING HUMAN FACTORS KNOWLEDGE

Chairperson:

Morning Session -	Capt. Neil Johnston (Ireland)
Afternoon Session -	Prof. Graham J.F. Hunt (New Zealand)

2: DEVELOPING HUMAN FACTORS SKILLS

Chairperson:

Morning Session -	Dr. Nikolai Stolyarov (Russian Federation)
Afternoon Session -	Mr. James P. Stewart (Canada)

3: HUMAN FACTORS TRAINING FOR AUTOMATION

Chairperson:

Morning Session -	Prof. Earl L. Wiener (USA)
Afternoon Session -	Dr. William B. Shepherd (USA)

The officers of the Symposium were:

ICAO

Dr. William R.Fromme	Director, Air Navigation Bureau
Mr. Paul Lamy	Chief, Personnel Licensing and Training Section
Capt. Daniel Maurino	Technical Officer, Personnel Licensing and Training Section, Secretary of the ICAO Human Factors Study Group
Capt. Haile Belai	Technical Officer, Personnel Licensing and Training Section
Mr. Herve Touron	Associate Expert, Personnel Licensing and Training section
Mrs. Alejandra Bertorini	Chief Interpreter, Interpreter, Interpretation Section
Ms. Fil Paglia	Secretary, Personnel Licensing and Training Section

UNITED STATES

Mr. Garland P. Castleberry	Associate Administrator for Aviation Standards, Federal Aviation Administration
Dr. William B. Shepherd	Manager, Biomedical and Behavioural Sciences Branch, Office of Aviation Medicine, Federal Aviation Administration
Ms. Jean Watson	Biomedical and Behavioural Sciences Branch, Federal Aviation Administration
Dr. James F. Parker	BioTechnology Inc.
Ms. Diane Christensen	BioTechnology Inc.
Ms. Suzanne Morgan	Galaxy Scientific Corporation

The working languages of the Symposium were English, French, Russian and Spanish.

OBJECTIVES OF THE SYMPOSIUM

The Second Global Symposium was part of the ten-year ICAO Flight Safety and Human Factors plan of action approved by the ICAO Air Navigation Commission and endorsed by the ICAO Council. It follows the ICAO Flight Safety and Human Factors Seminar held in Leningrad, Union of Soviet Socialist Republics, 3 to 7 April 1990.

The theme of the Symposium was **"Human Factors Training for Operational Personnel".** The great importance that ICAO places on Human Factors training for operational personnel is reflected in Assembly Resolution A26-9: "...human factors' programmes...should be put to practical use, with the view to raising the safety level of air transport..." Given this importance, it was considered essential that as many as possible attend the Symposium in Washington, so they could benefit from the presentations and discussions presented by the world's foremost experts in Human Factors. The Symposium was not only limited to officials from States but also included representatives from airlines, manufacturers, concerned international organizations and academic institutions.

The objective of the Symposium was "to improve safety in aviation by making States more aware of and responsive to the importance of Human Factors in civil aviation through the provision of practical Human Factors materials and measures developed on the basis of experience within States".

OPENING ADDRESSES

Address by the Secretary General of the International Civil Aviation Organization (ICAO), Dr. Philippe Rochat, to the Opening Session of the

Second Flight Safety and Human Factors Global Symposium

Washington, D.C., United States, 12 - 15 April 1993

In an address to the opening session of the Human Factors seminar in what is today Saint Petersburg, on 3 April 1990, the President of the Council of ICAO suggested to an audience of more than 300 experts from all over the world that, after fifty years of working on the hardware and achieving admirable levels of reliability, it was time for the aviation industry to start focusing upon its people. Three years after his suggestion, I am pleased at the response of the international aviation community.

As aviation moves towards the 21st century, our industry is facing unprecedented challenges. The Council of ICAO took up action in this regard in early 1990, and developed a global strategy of implementation priorities for the economic, technical and legal fields for the present decade. ICAO's Strategic Action Plan, as endorsed by our 174 Contracting States -- now 177 -- at our last Assembly six months ago, classifies identified challenges for international civil aviation into three types:

- **Technological and/or technical**, including CNS/ATM systems and airport and airspace congestion;
- **Economic, legal and/or financial**, which include commercial developments and economic regulation as well as financial resources, and
- **Human and/or social**, including unlawful interference, environmental protection, human resources and the subject of this symposium, flight safety and Human Factors.

I have keenly followed recent developments in the field of aviation Human Factors. Today, technology allows us to conduct controlled scientific studies of human performance in operational contexts. As such, we are able to scientifically design relevant Human Factors training programmes, included by ICAO as part of its operational personnel licensing syllabi as well as by operators in their training programmes. ICAO has initiated a sustained campaign to increase the awareness of the pervasiveness of human error in aviation safety. We now have employment selection criteria which can predict successful on-the-job performance. Technology gives us the "potential", by way of highly automated equipment -- in the flight deck, in the air traffic control suite and in the maintenance shop, -- to "engineer" or "design" human error out of aviation.

As we all are aware, in spite of these commendable endeavours, statistics attribute about 75 per cent of accidents to lapses in human performance, under the regrettably recurring label of human error. I raise the question: is it possible by way of education, training and new technology to improve these statistics? Are we in the right track? The President of the Council of ICAO in opening of the 29th Session of the ICAO Assembly last October stated: "ICAO attaches considerable importance to Human Factors. While the safety record of civil aviation is highly commendable, the fact remains that about 75 per cent of all aviation accidents are due to human error." He further added -- and in my own view this is the crux of the matter -- *"New skills, new approaches, new commitments are needed to resolve this particular problem"*.

I believe we are headed in the right direction. However, we will make tangible progress only when we make the commitments and adopt the approaches the dynamic international civil aviation system demands.

Specifically, first we must recognize the challenge of increased technology and automation, both in the interest of improved safety and efficiency. The interactions between people and high-technology are not always predictable, with occasionally dire results. Traditional approaches to personnel training and accident prevention must be reevaluated. Second, we must improve the dialogue within the international civil aviation community. Today more than ever, designers, regulators, trainers, safety investigators, researchers and operational personnel must maintain an open and candid exchange. Each needs to know the solutions the others are exploring to improve aviation safety. The best engineering solution may perhaps be in conflict with limitations inherent to humans. The best training solution may not be applicable due to constraints inherent to design. Results of research may not be relevant to the needs of an operational environment. Prevention lessons learned through the investigation of accidents may perhaps prove difficult to translate into action unless these are advanced in a meaningful context.

Finally, as it relates to aviation safety, we must think in *collective* rather than in *individual* terms. We must think in terms of *system error* rather than *individual human error*. This is nowhere more evident than in the implementation of the ICAO CNS/ATM systems. Observing a systems approach to the design and implementation of these systems, we achieve --again potentially-- the synergistic combination of the best technology can produce and the best humans can perform. If we do not, we may squander the significant system benefits. This must not be allowed to happen.

Attitudes towards Human Factors are changing. But change is sustainable only when it starts at the top. Change, as well as resources and safety, must be managed. Those who can best effect change are those who, by virtue of their positions, can make strategic decisions to change direction and commit resources as necessary.

Of course, to implement management initiatives, those in charge of the practical, hands-on implementation must possess the necessary skills to achieve it. New challenges require new skills. New skills can be acquired through *training*, but if new training approaches are to be developed, they must be preceded by a process of *education* of the strategic decision-makers in aviation. Aviation managers must understand the concepts and challenges involved in these new approaches to safety.

One thing is clear, there is a disparate level of understanding about aviation Human Factors in different regions of the world. We are trying to overcome this imbalance and this is the thrust of the ICAO Flight Safety and Human Factors programme. This is an educational programme directed to increase the awareness of middle and senior managers within the international aviation community about the importance of Human Factors in civil aviation. This Symposium is but one avenue to foster such education as the vehicle for change. Ideally, it will provide managers with the tools to develop Human Factors training programmes, recognizing the needs and constraints of their organizations. It will contribute to a more uniform level of understanding of the new challenges in different regions of the world. It will help us place proper priority on the people who manage and operate our international civil aviation system.

ICAO is also using its technical cooperation programme to provide assistance to developing States in implementing Human Factors endeavours, mostly -- but not exclusively -- related to training. The TRAINAIR programme which is a major initiative recently established by ICAO to promote effectiveness of training within international civil aviation, is an additional asset which will be used to pursue Human Factors training and education.

I extend my congratulations to the Government of the United States of America for their insight in sponsoring the event and for their generosity in its implementation.

I wish all of you a most productive week.

Thank you very much.

Address by Mr. R.D. Cook, Member of the ICAO Air Navigation Commission (USA) on behalf of the President of the Commission, Mr. Matt Wilkes

Good afternoon distinguished Guests, Ladies and Gentlemen. I bring with me from Montreal, Canada a message from the President of the Air Navigation Commission. I would like now to deliver that message.

Mr. Chairman,

Regrettably, I am unable to attend your Flight Safety and Human Factors Symposium. On behalf of the Air Navigation Commission, I can assure you of the importance that the commission considers this subject in today's and the future aviation environment. In recognition of the importance and interest in this subject, a number of members of the commission are in attendance.

The **theme** of the Symposium **"HUMAN FACTORS TRAINING FOR OPERATIONAL PERSONNEL"** is considered most appropriate and recognizes the importance of the role of the human and interrelated factors. A greater understanding and recognition of this subject in today's environment will facilitate the progressive implementation of evolving the technology in tomorrow's global operational environment.

I wish you a most productive Symposium and I am sure your discussions will contribute to the enhancement of safety of international civil aviation operations.

I would now also like to recognize my fellow commissioners who are in attendance today. They are from the States of Switzerland, Canada and Norway. Collectively as a group representing the Air Navigation Commission, we wish this meeting in meeting its goals and objectives and look forward to receiving and reviewing the proceedings from this Symposium.

Thank You.

Address by the Director of the Air Navigation Bureau,
International Civil Aviation Organization (ICAO), Dr. William R. Fromme,

to the opening session of the

Second Flight Safety and Human Factors Global Symposium

Washington, D.C., United States, 12-15 April 1993

I wish to join the Secretary General of ICAO in extending my appreciation to the Administrator of the Federal Aviation Administration for the efforts made by his staff in preparation for this joint ICAO - United States Flight Safety and Human Factors Global Symposium. I wish also to extend my appreciation to the lecturers and chairpersons of the different panels for their very significant contributions.

It is my pleasure to moderate your symposium. In anticipation to the opening of the technical agenda, tomorrow, I will briefly summarize the ICAO Flight Safety and Human Factors accomplishments for the first three years of our programme's life, and share with you some thoughts as to our future activities.

Keep in mind that the ICAO aviation Human Factors programme was established:

to improve safety in aviation by making States more aware of and responsive to the importance of Human Factors in civil aviation through the provision of practical Human Factors materials and measures developed on the basis of experience within States.

To assist us in this effort, we established a group of experts from the international aviation community, a group with diverse but complementary credentials, professional interests and geographical representation. The ICAO Flight Safety and Human Factors Study Group has been instrumental in supporting our Human Factors work. I would like to take this opportunity to express my appreciation to those States and organizations supporting members of our Flight Safety and Human Factors Study Group.

What is ICAO doing about Human Factors?

In order to increase the awareness of the international community about the relevance of Human Factors to aviation system safety, ICAO has prepared a series of reports or digests which focus on different aspects of aviation Human Factors, e.g. *Fundamental Human Factors Concepts (Digest No. 1); Flight Crew Training: Cockpit Resource Management (CRM) and Line-oriented Flight Training (LOFT) (Digest No. 2); Training of Operational Personnel in Human Factors (Digest No. 3); Proceedings of the ICAO Human Factors Seminar (Leningrad) (Digest No. 4); Operational Implications of Automation in Advanced Technology Flight Decks (Digest No. 5); Ergonomics (Digest No. 6); Investigation of Human Factors in Accidents and Incidents (Digest No. 7); Human Factors in Air Traffic Control (Digest No. 8)*. These eight digests are available and you can browse through them at the exhibition stand by the registration desk. The two last digests in the series, *Human Factors, Management and Organization* and *Human Factors in Maintenance and Inspection* will be completed during the present year and distributed during 1994. The Human Factors digests will then be consolidated into a single, ICAO Aviation Human Factors manual.

Seminar Programme

Additionally, a series of regional seminars is underway to further the educational objectives of the programme. Two regional seminars are conducted each year in our triennial programme cycle. During the first three-year cycle, these seminars have addressed the same basic Human Factors issues covered by the series of digests. At the end of each cycle, world-wide symposiums, such as this one, are held. Recent progress in Human Factors is examined by experts from the community and the plan of action for the following triennium is defined. The first world-wide symposium was held in what is now St. Petersburg, from 3 to 7 April 1990. Two regional seminars were held during 1991 and 1992. The first seminar in 1991 was held in Douala, sponsored by Cameroon, and the second one in Bangkok. In 1992, regional seminars were held in Mexico City and Cairo, this last one under the sponsorship of the Ministry of Transport and Tourism of Egypt. The next regional seminar is planned for South America towards the end of this year, and two seminars are planned for 1994, in Europe and Eastern Africa. The programme will continue in 1995, in the Asia Pacific region.

Tenth Air Navigation Conference

The Tenth Air Navigation Conference (Montreal, 5-20 September 1991) endorsed the ICAO CNS/ATM systems as the standard for the next 25 years. One of the recommendations of the Conference addressed the need to broaden the ICAO Flight Safety and Human Factors programme to include specific CNS/ATM related Human Factors issues. We have done so. Five CNS/ATM Human Factors aspects are now under review: flight deck/ATS integration; automation and advanced technology in future ATS systems; human performance in future ATS; training, selection and licensing of controllers, and safety monitoring of ATS activities.

Towards the end of this year, ICAO will produce its first guidance material on the subject of flight deck and ATS integration. We have placed special emphasis on the unique integration aspects of ATS and flight deck. The role of automation in future systems is also a matter of priority, and guidance material on that issue will be available early next year. I have no doubts that, when we next meet, in 1996, I will report to you on our significant accomplishments related to Human Factors and CNS/ATM. I will submit to you now, in fact, for your consideration, a proposed theme for the 1996 global Human Factors symposium: *Human Factors issues in future CNS/ATM systems.* Think about it.

Controlled Flight into Terrain

Finally, and perhaps most importantly, I am pleased to announce to you another ICAO Human Factors initiative, one which will translate theory into the practical reality of aviation safety improvements and, specifically, into further reductions in the rate of aircraft accidents. I refer to our Controlled Flight Into Terrain (CFIT) programme. Statistics recently released suggest that some 50 % of all aircraft accidents and incidents over the last 10 years are CFIT related.

The investigation of CFIT accidents has uncovered problems of human failures, and deficiencies in equipment design, regulations, education and training. All of these deficiencies are human factor problems and we should be able to do something about these problems. Indeed ICAO's Air Navigation Commission has agreed that in view of the critical flight safety aspects of CFIT, urgent/high priority ICAO action was warranted. It is time to move from theory to practice with our Human Factors programme. We intend to apply what we've learned to the CFIT problem, with the goal to reduce the incidence of CFIT accident so far about human factors, world-wide. Time will tell how successful we are.

I am certain that the discussions and conclusions of this symposium will provide both to ICAO and yourselves with additional tools to pursue our Human Factors objectives. I anticipate a challenging and exciting symposium. I wish you all well in your endeavours and a most rewarding week.

Thank you very much.

THE HUMAN FACTORS REVOLUTION: MEANINGFUL CHANGE OR TEMPORARY INFATUATION?

KEYNOTE ADDRESS

Dr. H. Clayton Foushee, Jr.

ICAO Flight Safety and Human Factors Symposium
Washington D.C. 12 April 1993

Dr. H. Clayton Foushee is Managing Director of Flight Procedures, Training, and Standards at Northwest Airlines. In this capacity, he is responsible for all flight training, safety, quality assurance, and operating procedures at the airline. Before joining Northwest in June, 1992, Dr. Foushee served at the Federal Aviation Administration as Chief Scientific and Technical Advisor for Human Factors. During this time, he headed a joint effort of the FAA, the National Aeronautics and Space Administration, with Department of Defence Assistance, to develop and implement a comprehensive National Plan for Aviation Human Factors. Prior to his appointment at the FAA, Dr. Foushee was Principal Scientist of the Crew Research and Space Human Factors Branch at NASA AMES Research Centre in San Francisco. Here, he headed a Research Programme on Team and Organizational Factors in both aviation and space.

Dr. Foushee is a graduate of Duke University and received a Doctorate Degree in social psychology from the University of Texas. Following his doctoral studies, he accepted a fellowship from the National Research Council at AMES Research Centre and then a permanent NASA assignment, where he began a series of research investigations into the factors that influence crew behavior. These studies shed new light on factors underlying many aviation accidents and simulated the development of new flight crew training programmes.

It's real pleasure to be here today and I'm honored to help open this ICAO Flight Safety and Human Factors Symposium. Before I do anything else, I would like to recognize the efforts of Bill Fromme and Daniel Maurino, who have worked tirelessly within the worldwide aviation community to heighten awareness of the importance of Human Factors to aviation safety. I would also like to recognize my friends at the Federal Aviation Administration (FAA), our hosts here, and in particular, Bill Shepherd and his staff for organizing this remarkable worldwide gathering.

I was fortunate to be a part of the first symposium exactly three years ago held in a city until recently known as Leningrad and in a country then refered to as the Soviet Union. I think this observation should serve as an interesting reminder that change can often be upon us before we know it. When it does occur it is often swift, sometimes complete, and we often do not understand the implications of the changes that have occured until well after the revolution is complete. Sometimes revolutions have tendency to reverse themselves after the initial excitement has subsided. In a sense, this is the theme of my remarks this afternoon.

My subject and that of this symposium, of course, is flight safety and human factors, but what I would like to focus upon today is how quickly "human factors thinking" has infiltrated the world of aviation and high technology in some parts of the world. My good friend and colleague, Earl Wiener, has referred to this period of time as the "Golden Age of Human Factors." While I certainly agree that we have made remarkable progress, I sometimes wonder whether the revolution is complete enough, or whether we really yet understand the human performance implications of the technological changes that have either already occurred or are imminently upon us. I also wonder whether the technical community's increased interest in human factors is just a temporary infatuation or whether it will really produce meaningful change.

I have been extremely fortunate that my own career has been perfectly synchronized with the increasing acceptance of human factors thinking. I was trained as a research psychologist and was headed for university career until my colleague and dissertation advisor, who is with us here today, Bob Helmreich, mentioned to me that NASA was interested in a new area of research related to human factors and aviation safety. I was invited to a meeting in San Francisco in 1979 chaired by John Lauber of the NASA-Ames Research Center, the subject of which was a newly-coined term Cockpit Resource Management Training (now "crew" or CRM). No one at that meeting really understood the meaning of that term, but the NASA team and many of the attendees did understand that there was an apparent need that was not being met in aircraft operations and training. Of course, no one in 1979 could have foreseen the explosion of interest and acceptance of the CRM concept in a less than a decade.

Shortly, after that first industry workshop on CRM, I accepted an offer from NASA and along with Lauber and Helmreich, began a research program to explore the nature and extent team performance in aviation and space environments. I remember vividly that many in the operational community were not terribly receptive to our CRM message, but things have changed--neither John Lauber, nor Bob Helmreich, nor anyone, has to work very hard any more convincing the operational community that such things are critical to aviation safety.

I left NASA in 1989 to accept an offer from the FAA Administrator to serve as Scientific and Technical Advisor for Human Factors. My position was a new one, which was created as a result of an outpouring of public concern after a number of well-publicized and entirely preventable aircraft accidents. Ironically, some of these accidents occurred in "new technology" aircraft that were highly automated as a means of reducing operator workload and human error. These aviation accidents, as well as those in other non-aviation environments (e.g. the nuclear reactor accident at Chernobyl, USSR; the accidental destruction of an Iranian airliner by the USS Vincennes; and the "Herald of Free Enterprise" ferry capsizing at Zeebrugge, Belgium) have shocked us all and stimulated new discussions of the human performance problem.

Fortunately, this high level of concern also prompted some significant action. In 1989, the Congress of the U.S. enacted new legislation, "The Aviation Safety Research Act" which provided for the increased funding of human factors research. In addition, the Air Transport Association of America (ATA) mobilized a Human Factors Task Force made up of representatives of various airlines, avionics and aircraft manufacturers, U.S. Government agencies (e.g. FAA, NASA, NTSB), labor unions, and the scientific community to address the problem. For the first time, the technical and operational community became fully involved and drafted a list of priorities for human factors. But more importantly, the operational community made an important statement about the critical importance of human factors to aviation safety and brought a tremendous amount of political pressure on the system to recognize this importance.

Just last year, Northwest Airlines asked me if I would be interested in running their flight training, flight procedures, and flight standards organizations. I was surprised at first because such organizations have traditionally been headed by individuals who have spent their entire careers in either operations or management, certainly not by research psychologists. But, it also occurred to me that their interest was in large part indicative of how far the operational community's thinking has progressed and how quickly it has embraced the importance of human factors. Moreover, I am by no means a unique case. John Lauber, also trained as a research psychologist and human factors specialist, was appointed by the President of the United States to, and now serves as a member of, the U.S. National Transportation Safety Board (John will address our closing banquet Thursday night). David Nagel, former head of the human factors division at NASA-Ames is a Senior Vice President at

Apple Computer in charge of new technology development, and I cannot resist the observation at this point that aviation systems designers could learn a great deal from Apple's success in designing "user-friendly" systems. Another former NASA colleague, Curt Graeber, manages flight deck design research and development activities for Boeing Commercial Aircraft. Bob Helmreich, also with us here, serves on several advisory panels to senior NASA management and is frequently sought after as a consultant to senior managers in aerospace organizations worldwide. Earl Wiener, who chairs the panel on flight deck automation on Thursday is a member of the FAA's Research and Development Advisory Committee, and many of us, so-called "human factors specialists" are rapidly infiltrating all aspects of the operational and advanced technology communities.

Now, some may still think that this is a rather alarming trend (and it may yet prove to be!), but I prefer to interpret it as a level of acceptance that we could have scarcely dreamed of 10 years ago. Today, "user-friendly" is becoming the buzz-word of the 90's. Even the designers of videotape recorders are now developing and advertising products based upon their ease of programming.

While I was at FAA, I was fortunate to work for an Administrator, James Busey, who genuinely understood the importance of human factors. In his remarks, he frequently referred to the need to make human factors a core technology, equal in importance to the emphasis we currently place on technological development. Unfortunately, while we now have high levels of support, we have not become a core technology yet in the aviation environment. Many productive research programs dealing with human performance in aviation have been underway in the FAA, NASA, DOD, academia, and industry for years, these efforts have never been well organized into an overall plan that addresses the comprehensive nature of human factors issues in the operation and maintenance of all types of aircraft, in air traffic control system operation and maintenance, and in the interface between air and ground. Moreover, these efforts have not yet been provided with resources anywhere near proportional to the problem. It is still far too easy, when budget money is tight, for decision-makers to defer the human factors efforts because hardware approaches to solving human performance problems somehow seem to them more tangible. New technology is always exciting and thus easier to sell.

Despite improvements in technology, 60 to 70% of aviation incidents and accidents are attributed to human performance problems, and that number has not decreased over the years. If projections for future traffic growth are accurate, in the next couple of decades, we may experience a major aviation accident every week despite constant improvements in technology. This statistic has led many to conclude that the only way to produce dramatic improvements in safety is through increased emphasis on human factors.

The National Plan for Aviation Human Factors

In November of 1990, the FAA published a two-volume, draft National Plan for Aviation Human Factors. The plan is a major step toward a coordinated national program and is the result of a concerted effort by the FAA and NASA, with significant assistance from DOD, and industry to come to grips with human performance problems in aviation. It is designed as a comprehensive, long-range plan to address the most operationally significant human performance issues in the aviation system.

The purpose of the National Plan is four-fold. The primary purpose is to identify and plan the technical efforts necessary to address the most operationally significant human performance issues in aviation as a guide to future project planning, budget formulation and implementation. For the first time, the plan has produced a general consensus between the scientific and operational communities in the U.S. on the research priorities.

The second purpose is to allocate national resources efficiently by coordinating research programs at various Government laboratories. In the past, program planning has occurred at Government agencies without any overall coordination, which has led to gaps in some areas and redundancy in others. While this situation still exists to some extent, significant improvement priority setting has occurred, particularly in the FAA and NASA programs.

The third purpose of the National Plan is to communicate research needs to academic and industry "centers of excellence." Given the magnitude of human performance concerns in aviation and budgetary constraints, it is unrealistic to expect that Government agencies will have all of the personnel or monetary resources necessary to implement this plan, without the assistance of industry and academic institutions.

The fourth purpose of the National Plan is, in many ways, the most important. It involves the means by which human factors knowledge is transferred to Government and industry. As most of you are aware, the products of human factors research have not been applied on a widespread basis (CRM training is perhaps a notable exception. The National Plan seeks to provide a framework for this application and is heavily "product-oriented."

I'd like to turn my attention now to two prominent issues in the flight safety and human factors area, the first having to do with the issue of flight deck automation and the second the effectiveness of crew resource management training.

Flight Deck Automation--Friend or Foe?

One of the biggest temptations facing the designers and engineers struggling to reduce human error in the aviation system is to address the problem by automating many of the tasks traditionally performed by humans. Many tend to accept this as a relatively recent trend, but as Charles Billings (1991) has pointed out in his very comprehensive analysis of aircraft automation, the Wright Brothers were working on a stability augmentation device in 1907, and Orville Wright won the Collier Trophy in 1913 for demonstrating "hands-off" flight using an automatic stabilizer. Ever since, each new generation of aircraft has introduced more automation. The pace of automation quickened considerably after World War II and the introduction of turbojet transports introduced new requirements for automation.

However, as Billings suggests, it was the introduction of solid-state electronics and small, powerful digital computers armed with software that made it possible to automate virtually every function and display unprecedented amounts of information, but at a cost of greater system complexity. It is this trend toward more information, more complexity, and more automatic operation that have begun to raise concerns in both the human factors and the operational communities.

Under this design philosophy, the human operator has begun to assume the predominant role of "systems monitor," or serving as a backup to the automated systems. This approach has resulted in an impressive array of aircraft and air traffic control technology that is highly reliable and which contains vastly superior capability from a pure performance standpoint. No one questions that the technology is better. The current generation of transport aircraft are vastly superior to the generations they have replaced. And yes, lest there be any doubts, with the appropriate standard operating procedures and training programs in place, they are probably safer than previous generations of aircraft. However, there are some traps built into these designs that have provoked both technical experts and operational community representatives to openly inquire, "how much further can we automate and allow for human operators to remain fully in command?" System complexity is already such that pilots under some circumstances are having difficulties staying fully in the loop. One of the humorous stories circulating in the airline industry these days, is that the most common question on the flight deck used to be, "what should we do now?" That question has now been replaced with, "what's it doing now?"

Another interesting observation is that, originally, advanced aircraft automation was often justified on the basis lower training costs due to ease of use. However, to my knowledge these cost savings have clearly not materialized. At Northwest, we operate three types of advanced "glass cockpit" aircraft (A-320, B747-400, and B-757) and our training costs are the same and in some cases significantly higher than earlier generations of aircraft. Why? Because we feel that it is critically important for our pilots to understand both the benefits and the potential pitfalls of automation, we spend a substantial amount of time teaching our pilots, for example, how to operate an A-320 in a way similar to that of a DC-3. In addition, we are also obligated to devote a considerable amount of training time to a mastery of all aspects of the advanced systems. The net result for us is usually additional training time. However, in fairness, I must also point out that it is entirely possible that this trend may reverse itself once the industry develops more experience with these aircraft and once air traffic systems are more compatible with the new technology.

One of the things that we are beginning to learn is that it is simply not true that automation is an easy way to remove human error from the system. While automation can and does eliminate certain classes of error, we have begun to realize that it can also create whole new classes of error. It has been observed by some researchers in this area (e.g. Wiener; Billings), that in some cases new errors created through automation can be worse than the types of errors alleviated by automating. We have begun to understand that automation can fail in spectacular and completely unpredictable ways. The reasons for these failures are often exceedingly complex and not very well understood. Thus, it is becoming increasingly common to hear suggestions that we critically examine our automation philosophy and consider new approaches to automation that are more "human-centered." Given these concerns, can we afford to follow the current trend toward the automation of more functions leaving humans with less to do?

Although we know that humans are far from perfect, there are certain things that they do very well. They are capable of high levels of ingenuity in the face of uncertainty, and they are capable of abstraction to degrees impossible in any computer currently envisioned--even the most advanced proposed systems for producing artificial intelligence. Yes, they do make errors, get distracted, suffer fatigue, occasionally take unacceptable risks, and just plain forget. How do we protect against the inadequacies in humans, while at the same time keeping intelligent, motivated, skilled human involved in the system? Unfortunately, no one has been able to come up with the answer to this rather complex question, but specialists in both human factors and engineering disciplines seem to now agree that it is clearly not an easy task.

Bainbridge (1987), in a very insightful analysis of automation, "The Ironies of Automation," points out that designers usually leave those tasks to the human operator that they cannot figure out how to automate. These "left-over" tasks are often rather arbitrary and may not always represent the best use of human capabilities. One of the problems with this approach to design is the expectation that humans must monitor the system and takeover should anything go wrong. The irony of this notion is that in a reliable automated system, the operator is by definition inexperienced in the cognitive and manual skills necessary to control the system, because the computer usually takes care of things. In addition, there is usually more to take care of when the operator has to intervene because the reason the system was automated in the first place was to increase its capacity--hence more work to do. To make matters worse, he or she is expected to take over at a time when the most skill is required--after the system has malfunctioned and operator workload is at its peak. And of course, the foregoing presupposes that the human operator noticed the problem in the first place since it is well known that humans suffer significant lapses in vigilance after only a short period of time in passive monitoring situations. In short, the design of many automated systems requires that the operator stay alert in boring situations, and if anything goes wrong to perform more complicated operations with lower levels of experience and skill. This is ironic indeed.

There does appear to be general agreement on certain categories of problems that have been experienced and in current generations of "glass cockpit" aircraft--problems that might benefit from a better understanding of human-computer interface, which could be applied to future designs. These include: 1) too little workload in some phases of flight and too much workload associated with programming when flight plans or clearances are changed; 2) the potential for substantially increased head down time; 3) an inadequate "cognitive map" of what the system is doing making recovery from automation failures sometimes problematic; 4) hesitancy of humans to question or take over from an automated system even when there is compelling evidence of a problem; 5) degradation of basic skills; 6) job dissatisfaction associated with the lack of a challenge; and 7) complacency, lack of vigilance, and boredom.

Most human factors specialists strongly believe that this area of research should be the top priority for human factors research and development. One thing is clear. Within the next 20 years, the technology will be available to allow the construction of a completely "pilot-less" and "air traffic controller-less" system. The point is not whether such a system is a good idea--just that the technology will probably be available. No one seriously advocates such a system. In fact, most analysts argue forcefully that humans will need to remain centrally involved. The pressure to take advantage of this technology to gain additional system efficiency and capacity will continue, as it should. It should be troubling to all of us, however, that there are no established guidelines for the human's role in such a system. The is clearly an area where the human factors revolution cannot declare victory as of yet. One of our highest priorities should be the establishment of guidelines for "human-centered" automation. Our next highest priority should be to make sure that once established, they are carefully applied at the beginning of every new system design effort.

CRM Training--Does it Work?

One of the success stories of the human factors revolution has been the rapid acceptance of CRM training concepts in the worldwide aviation community. In a period over a little over a decade CRM is now widely perceived to be a necessary part of flight crew training. In a recent keynote address to the Australian Aviation Psychology Symposium, Bob Helmreich likened the evolution of CRM over this period to a rather rapid progression from the Stone Age (rocks and clubs) through the Bronze Age (lances and spears), to where it exists today in the midst of the Iron Age (muskets and sabers). And at the risk of belaboring this metaphor, many of us hope that the evolution of CRM will soon continue rapidly into the Renaissance.

As I'm sure you all know CRM refers to the utilization of all available resources--information, equipment, and people--to achieve safe and efficient flight operations. At NASA-Ames, after a series of simulation studies, we were able to confirm what many had suspected--that one of the principal causes of accidents in aircraft operations was a failure on the part of flight crew members to utilize effectively all of the resources available to them during flight operations. We also concluded that the major factors underlying these failures had to do with inadequate training in skills associated with crew coordination, communication, leadership, and teamwork, not with technical proficiency and aircraft handling skills. We spent a considerable amount of effort discussing our findings with pilots, airline management, and aviation safety specialists and were struck by how infrequent these factors were dealt with in industry training programs, despite the magnitude of the problems. To its credit, the industry has moved quickly to address this oversight.

At its inception in the late 1970s, the acronym CRM stood for cockpit resource management training and today no one questions that CRM has advanced the cause of aviation safety. Over the years, training specialists began to realize that the applications of CRM go far beyond the cockpit door. CRM is a form of team training and the cockpit crew is part of a far larger team, that includes flight attendants, dispatchers, gate agents, mechanics, and air traffic controllers. Several airlines have begun to explore the possibility of expanding the CRM training framework to include job specialties other than pilots. This broadened framework has now been formally recognized and the acronym has changed in most circles to **crew** resource management.

Bob and his research team supported by both the FAA and NASA have been evaluating the effectiveness of CRM programs worldwide, and while there is good news, it is also clear that the revolution or evolution is not complete. I'd like to spend a little time reviewing the report card on CRM.

First, crew members find CRM and LOFT to be highly effective training. Second, there are measurable and positive changes in attitudes and behavior following the introduction of CRM and LOFT. Third, effective CRM programs generally cannot be purchased "off the shelf," and are best designed with extensive involvement of people from the organization desiring such training. Fourth, management, check airmen, and instructors play the most critical role in determining the effectiveness of CRM training, and I'll have more to say regarding this point in few minutes. Fifth, without reinforcement, the impact of CRM training decays. CRM training is clearly not something that an organization can highlight one year and consider its work complete. As the FAA's Advisory Circular on CRM so clearly states, it must be continually reinforced. And lastly, a small percentage of participants do not change as result of exposure and tend to reject CRM training, but the positives far outnumber the negatives.

Have we accomplished most of our objectives with CRM training? I would argue that the answer is emphatically no! The very fact that we still showcase CRM as a "new" type of training indicates that we have not accomplished our objectives. To be maximally effective, CRM training needs to be integrated into everything we do in training. Think about it. When evaluating a crew executing a complex Category II or some other complex maneuver, how many airlines train their instructors or check pilots to evaluate and debrief the CRM aspects at the same time they evaluate the technical aspects of the individual crew members' performance? Now, I would argue that there is more CRM to observe in the execution of those types of procedures than in many so-called CRM exercises I have observed. In fact, in several presentations over the years I have made the assertion that I will be happy when the term CRM disappears from the list of "hot" topics at conferences like these. What I mean by that statement is that hopefully the disappearance of the term will signify complete acceptance and integration into all aspects of training, the Renaissance if you will, and not rejection because of our failure.

In a time of scarce resources, and looking backward with, of course, perfect hindsight, there are some things I would do differently with regard to CRM. I feel strongly that no organization has prepared its instructor and check airman corp. to take maximum advantage of the CRM concept. In my opinion, this is the key to successfully integrating CRM into all aspects of training. I sometimes wonder if we might not have been farther along in the industry had we used all of the resources we had spent on "awareness level" or classroom CRM courses and expended these resources on instructor training instead. Better instructor preparation would have also allowed most organizations to utilize the LOFT concept more effectively. No, the revolution is not complete, but at the same time the concept is flourishing in most training programs.

The Institutionalization of Human Factors

Is the human factors revolution complete or will the increased interest in human factors fade away over time? The answer to the first of these questions is that no, the revolution is not complete and only time will tell whether we continue to move forward. In my opinion, however, we can never make a meaningful difference in the human error statistics until human factors concepts become institutionalized into the aviation culture.

This means decision-makers must become more cognizant of human factors principles. It also means that human factors principles must be applied at the earliest stages of the design process of new aircraft, air traffic control, and maintenance technology and continue through procurement and introduction. In order for this to occur, an organizational commitment to a decision-making process must be in place that formally considers the human factors implications of every facet of the aviation system. This formal process must have the support of the highest levels of management in the aviation community. Moreover, it must become an integral part of the "culture" of the organization, and this will require a fundamental shift in most organizational thought processes. This "culture-shift" has accelerated in the U.S., Japan, and some western European nations as more and more managers and decision-makers have become more sophisticated with regard to human factors principles.

Although by no means unique today, one of the earliest and most promising models for institutionalizing human factors was developed in the U. S. Army. This program is known as the Manpower and Personnel Integration program (MANPRINT), and it has been widely acclaimed as a method for applying human factors principles through the use of a "total systems approach." MANPRINT was developed in response to the "force multiplier" notion of the early 80's, whereby a smaller, but better-equipped force could theoretically out-perform a numerically superior adversary. However, this notion created considerable pressures to achieve design excellence. After a number of experiences with technically elegant systems that failed in the field because they could not be operated or maintained effectively, the concept of design excellence began to broaden to include the human operator. As a result, the Army MANPRINT program has not only been credited with improving the quality of a number of significant pieces of hardware, but it has also resulted in considerable cost-savings in a number of major programs.

The developers of MANPRINT attribute its success directly to the aggressive and highly visible support of the senior leadership. These senior managers were unusually active in persuading other senior managers that traditional practices regarding hardware and software development and acquisition needed change. Among other things, the program required that the performance of program managers would be evaluated on how well they applied human factors principles in their design efforts.

However, the aspect that has distinguished this program and made it perhaps the most ambitious attempt in the U. S. to apply human factors principles is its recent institutionalization in the Army procurement system. Procurement policy, operating principles, and management practices are prescribed in extensive documentation and are a required part of every procurement. These requirements are part of every "Request for Proposal" and are weighted heavily enough that they routinely affect contract awards. Because companies wanting to sell expensive hardware to the military have been required to formally satisfy human performance requirements, the result has been increased human factors expertise applied to system design and integration into many "corporate cultures."

As part of the National Plan, the FAA is taking steps toward making human factors part of the aviation culture. These include: 1) increasing the number of human factors specialists in all key agency organizations; 2) the development of human factors training courses for agency managers, system designers and engineers, certification personnel, and other job specialties; 3) reviewing and modifying all agency orders to assure proper consideration of human performance dimensions; and 4) developing formal requirements for human factors specialists to be involved in all system design teams from the earliest stages of development; and 5) increasing regulatory requirements for human factors training, such as CRM; and 6) placing a stronger emphasis on human factors as part of aircraft and avionics certification requirements.

Summary

In closing, let me reiterate what many now feel, human factors improvements will be the only way to dramatically improve the safety of the aviation system. The technology has achieved a level of reliability that will be difficult to significantly improve. Increased emphasis on human factors in the U.S. and emerging interest in other countries offer tremendous potential for improvement. However, increased efforts in the U.S. will not be adequate because the aviation system is truly global in scope. Safety problems cross international boundaries very quickly.

To a large degree, it is the people in this room, who will determine whether the human factors revolution will produce meaningful change or is just a temporary infatuation. You are the ones who must take the human factors message back to your home countries and organizations. You are the ones who must argue for the integration of human factors thinking into every aspect of the aviation culture. We've made a lot of progress in the last 10 years, but it is the next 10 that will determine the success of the human factors revolution.

«LES DÉFIS DES TROIS PROCHAINES ANNÉES»

**DISCOURS DE SYNTHÈSE PRÉSENTÉ PAR J. PARIES (FRANCE)
AU
DEUXIÈME SYMPOSIUM OACI
SUR LES FACTEURS HUMAINS ET LA SÉCURITÉ AÉRIENNE
WASHINGTON DC 12-15 AVRIL 1993**

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Mesdames et Messieurs,

C'est un très grand honneur pour mon pays et pour moi-même que d'avoir été invités à présenter quelques réflexions de synthèse finale à l'issue d'un symposium aussi prestigieux et fertile que celui-ci. Mais c'est un honneur redoutable.

Je n'aurai pas l'ambition de résumer en vingt minutes ce que tant d'orateurs bien plus qualifiés que moi ont dit pendant trois jours. Je voudrais simplement, pour que tout ceci continue et s'ouvre sur l'avenir, replacer les problèmes de formation dans leur contexte général, et réfléchir avec vous sur la façon dont l'avenir se présente.

Le programme me suggère d'organiser cette réflexion autour du thème suivant : «Les défis des trois prochaines années». Pourquoi trois années? Je crois bien que c'est le rythme qu'a choisi l'OACI pour tenir des symposiums mondiaux tels que celui qui s'achève en ce moment. L'idée est dès lors toute naturelle de se tourner un instant vers le passé : en effet «on ne prévoit bien que ce qui existe déjà».

Vous le savez, ce symposium est le second. Le premier s'est tenu il y a trois ans dans une ville qui s'appelait alors Leningrad. Je crois que l'OACI n'aurait pas pu choisir un lieu plus symbolique à l'égard de ce que je voudrais vous dire. Le monde change à une vitesse et une profondeur impressionnantes. Et bien évidemment, notre petit monde de l'aviation n'est pas épargné.

En fait, le transport aérien international vit depuis quelques années une mutation profonde, que certains sociologues appellent «mutation du système sociotechnique». Cette mutation a deux faces.

La première est d'ordre économique. Vous connaissez autant que moi le vocabulaire de ce véritable tremblement de terre qui affecte aujourd'hui la plupart des compagnies aériennes dans le monde. Il contient des mots du genre «déréglementation», «concurrence sauvage», «pertes énormes», «mise en liquidation», «rachats», «fusions».

Cette situation n'est pas exempte de risques pour la sécurité, ni à court terme, ni à long terme.

À court terme, elle engendre inévitablement des tentations d'économies sur les budgets de fonctionnement de la sécurité, tels que ceux consacrés à la formation et à l'entraînement des personnels, ou à l'entretien des matériels.

Elle engendre aussi une tentation de repli sur soi, d'économie sur les déplacements et la communication. Est-ce que vous croyez par exemple que tous ceux qui auraient voulu participer à ce séminaire ont obtenu les moyens de le faire?

À long terme, les effets peuvent être encore plus profonds. Je crois en effet que la transformation des structures économiques du transport aérien à laquelle nous assistons reflète une évolution profonde de son rôle dans nos sociétés. D'une activité privilégiée, protégée par l'intérêt du pavillon national, tourné vers les élites économiques et politiques, il devient une activité massive et banalisée. Sommes-nous certains que cette réalité nouvelle restera en pleine harmonie avec l'approche exceptionnelle que le transport aérien a su développer dans le passé vis-à-vis de la sécurité? Je crois que la question mérite d'être posée...

La deuxième face de la mutation est du registre technique. Tout le monde le répète : nous vivons depuis quelques années l'apparition d'une nouvelle génération d'avions. La nouveauté est à la fois évidente — un peu comme le passage des hélices à la réaction — et malgré tout assez confuse. On a du mal à nommer cette nouveauté. Aucun des mots utilisés (et là je dois m'incliner devant la supériorité écrasante des anglophones) «glass-cockpit», «highly automated aircraft» ne rend vraiment bien compte des différences. On a aussi du mal à dater la nouveauté.

Question : Quel est le premier avion de la nouvelle génération?

Eh bien, je vais prendre devant vous un gros risque. Un double risque. Celui d'être accusé par certains d'être vendu à Airbus, et en même temps par d'autres accusé de désigner l'A320 à la vindicte populaire. En effet, je pense que c'est l'Airbus A320 qui «incarne» la mutation dont je parle. Je pense que cet avion a établi un nouveau standard, valable pour de nombreuses années.

[Je crois que dorénavant, les avions auront des commandes de vol électriques avec des interfaces adaptées, donc différentes des commandes mécaniques. Je crois qu'ils auront des protections automatiques de domaine de vol, des systèmes gérés par calculateur et des pannes également gérées par calculateur, avec des instruments qui présentent à l'équipage les informations et les check-lists pertinentes].

Je crois que dorénavant, les avions seront construits autour d'un système centralisé de traitement numérique de l'information, devenu un véritable «partenaire» de l'équipage. Je crois que c'est un fait irréversible, qu'il modifie de façon profonde les rapports entre les pilotes et l'avion, et que nous devons en tenir compte.

Mais tout ceci constitue ce que j'appellerai la partie «médiatique» de la transformation technique. Car l'avion, loin s'en faut, n'est pas le seul élément concerné. Des évolutions analogues à celles que je viens d'évoquer, bien que moins spectaculaires, se produisent dans tous les domaines, de la maintenance au contrôle de la circulation aérienne.

[Les nouveaux outils informatiques d'assistance au contrôle, les liaisons de données numériques air-sol, les systèmes d'antiabordage embarqués, les systèmes sol d'anticollision avec le relief tels que le MSAW, sont les premiers éléments d'une mutation technique globale].

Un gigantesque réseau de traitement et d'échange d'information se construit peu à peu. Il rassemblera dans un seul système l'ensemble des fonctions de navigation, de gestion du vol, de contrôle aérien, de régulation du trafic, de planification opérationnelle et commerciale.

Quels peuvent être les effets d'une telle mutation sur la sécurité?

<u>Je crois qu'il faut se méfier des réponses trop simples...</u>

Bien sûr, la sécurité des systèmes complexes repose sur l'expérience, les essais et les erreurs du passé. Et bien sûr, par déduction immédiate, la sécurité des systèmes complexes n'aime pas les <u>situations transitoires</u>.

Et je suis sûr que beaucoup d'entre vous à cet égard pensent à nouveau à L'A320. Voilà en effet que l'avion dont j'ai dit qu'il «incarnait» la nouvelle génération subit 3 catastrophes pendant ses 4 premières années d'exploitation.

Il est terriblement tentant de conclure qu'on est allé trop loin.

Je crois que ce serait une grave erreur, et ceci pour plusieurs raisons.

Tout d'abord, on ne peut pas conclure valablement sans avoir analysé les accidents en profondeur et compris en quoi la nouveauté de l'avion, ou ses automatismes ou ses particularités, sont impliqués dans le mécanisme.

Ensuite, je crois que ce serait une vision totalement naïve du fonctionnement du système. Que cela nous plaise ou non, le monde change, les techniques évoluent, et la sécurité doit s'y adapter.

Enfin ce serait une vision naïve des rapports entre technique et sécurité.

Pour illustrer cela, je voudrais prendre l'exemple d'un autre avion : le B727. Lui aussi a connu de nombreux accidents pendant ses premières années : 4 je crois dans les 3 premières années. Lui aussi r présentait une nouveauté considérable pour les pilotes et le système. Dans son cas, le lien nouveauté-accident est clair : les pilotes habitués aux avions à hélices se laissaient surprendre par ses caractéristiques aux basses vitesses et le temps de réaction des moteurs.

Aux États-Unis, la presse de l'époque n'a pas hésité à présenter des titres comme «ground the killer». Vous connaissez la suite. Le B727 est non seulement le plus grand succès commercial, il est aussi l'un des avions les plus sûrs jamais construits. Son taux d'accident sur les 10 dernières années est du même niveau que celui des avions les plus récents.

Est-ce que cette petite histoire a une morale?

Oui, je crois qu'on peut en tirer une leçon très importante : il ne faut pas confondre changement et situation transitoire.

Si le même avion peut être successivement le pire et le meilleur, c'est que la technique et ses évolutions n'ont pas vraiment, en elles-mêmes, d'effet particulier sur la sécurité.

Tout dépend de ce qu'on en fait.

Tout dépend de la façon dont le système la prend en compte.

Et c'est là qu'un symposium comme celui-ci prend toute sa signification. Car il est évident qu'un élément décisif de la prise en compte que je viens d'évoquer est la formation et l'entraînement des acteurs de première ligne. Et je ne parle pas uniquement des pilotes.

Bien que je ne sois pas un chaud partisan de la notion de «cause primaire», je vais me référer à nouveau à la statistique annuelle de Boeing : on y constate en effet que les deux seules familles de «causes primaires» qui ont augmenté dans les 10 dernières années sont celles liées à la maintenance et au contrôle aérien.

Il était donc important qu'une place soit faite à la formation des contrôleurs et des personnels de maintenance dans ce symposium, tout comme il était important que toute cette dernière journée soit consacrée à la formation des personnels par les systèmes automatisés. Il est essentiel en effet que les programmes de formation, y compris CRM, prennent désormais en compte cette dimension de la réalité.

Plus généralement, je crois que le défi majeur des deux ou trois années à venir sera de prendre toute la mesure des transformations en cours, et de cerner clairement les adaptations nécessaires, surtout pendant la période transitoire. Pour prendre une métaphore, les systèmes sociotechniques réagissent un peu comme les êtres vivants. Tout changement important d'environnement les rend inadaptés, et ceci provoque un stress. Le bon stress est capable de rétablir l'adaptation en provoquant les évolutions nécessaires. Le mauvais stress rend malade. Dans notre cas, la maladie s'appelle accident. Tout l'enjeu des années à venir sera de libérer le bon stress et de lui permettre d'agir.

Il faudra savoir faire la part de ce qui relève de la conception, des procédures, de la formation, et peut-être même de la sélection.

Faire la part, cela veut dire ne pas faire assumer par la formation ce qui relève des défauts de conception si on peut faire autrement. Mais c'est aussi prendre la réalité comme elle est et les avions comme ils sont, sans tomber dans une sorte de guerre des boucs émissaires : c'est la faute de l'automatisation. Non, c'est la faute des pilotes.

Avant de terminer, je voudrais indiquer un certain nombre de conditions de succès face à ce défi.

La toute première, par ordre d'importance, c'est de convaincre les responsables. Il est évident que rien ne peut avoir d'efficacité réelle sans la volonté globale, la conviction des dirigeants. Ce sont eux qui pensent ce que pense le système. Ils donnent le ton, établissent les vraies priorités, celles qui sont inscrites non pas sur le papier, mais au fond des têtes et des cultures.

Convaincre les managers que, précisément parce que les temps sont difficiles, il faut augmenter les investissements dans la sécurité, la conception des matériels, la formation des hommes, voilà probablement le plus difficile des défis à venir, et je n'ose pas dire des 3 ans à venir...

Deuxième condition (et maintenant je n'établirai plus d'ordre d'importance) : faire bénéficier à l'ensemble du monde ce que chacun a appris. Les avions, y compris les plus modernes, ne volent pas uniquement aux États-Unis et en Europe. Je ne voudrais pas être mal compris. Il ne s'agit pas ici que de prétendus «savants» aillent prêcher chez de prétendus «ignorants». Il s'agit véritablement de communication, d'échange nécessaire des expériences. Je voudrais souligner ici le rôle essentiel joué par les séminaires animés par l'OACI autour du monde. Il y a eu Douala, Bangkok, Mexico, Le Caire. Il faut que cela continue. [J'ai eu la chance de participer à certains d'entre eux et je dis bien qu'il s'agit d'une chance. À chaque fois, j'ai été ravi de tout ce que j'avais appris].

Une troisième condition me paraît également importante. Rassurez-vous, c'est presque la dernière.

Je crois que convaincre et enseigner ne suffisent pas toujours. Le haut niveau de sécurité de l'aviation civile internationale s'est construit en grande partie sur des règlements. Le temps est venu, me semble-t-il, d'inscrire dans des règles les quelques acquis dont nous disposons en matière de facteurs humains. J'ai relu récemment les articles des règlements de certification des avions de transport concernant la conception des postes de pilotage. Ils demandent que les pilotes soient convenablement protégés des intempéries, et c'est sûrement très bien. Le problème est qu'ils ne sont pas d'un grand secours pour certifier un FMS. Je crois que le moment est venu de réviser les règlements qui concernent la certification, l'agrément des simulateurs, l'entraînement périodique, l'appariement des équipages, la formation des acteurs de première ligne pour y inscrire plus fermement ce que nous avons d'ores et déjà appris en matière de facteurs humains.

Enfin, et j'en aurai terminé, je pense qu'une condition décisive de succès est que nous sachions adapter le système de retour d'expérience aux nécessités de l'heure. Il n'est pas acceptable que des quasi-accidents puissent se répéter plusieurs fois dans le monde sans qu'on n'en sache rien, pour finalement se produire vraiment un jour en tuant des centaines de passagers. Il faut rajeunir, réactiver, repenser le retour d'expérience. Nous disposons des outils. Plusieurs pays ont mis en place des systèmes de recueil confidentiels d'incidents. Plus de 50 compagnies dans le monde ont mis en oeuvre des programmes d'analyse des données de vol. Il y a là un outil extraordinaire, il faut avoir le courage de s'en servir. C'est un véritable défi que celui-là, et il concerne tout le monde : les organisations professionnelles, les responsables des compagnies, les constructeurs, les autorités.

Certes il y a des obstacles majeurs : la compétition commerciale, les actions judiciaires, les actions disciplinaires, tout cela paralyse le retour d'expérience. À cet égard, il nous faut vraiment changer de siècle.

Mesdames et Messieurs, j'aurais pu allonger cette liste des conditions du succès, en parlant par exemple des nécessités de recherche, et des perspectives offertes en particulier par la psychologie cognitive. Mais je sais que j'ai déjà largement dépassé vos possibilités d'attention et même d'indulgence. Il faut savoir terminer un symposium, aussi passionnant soit-il.

Je vous souhaite un excellent retour, et je vous donne rendez-vous dans trois ans, pour le troisième symposium de l'OACI.

ABSTRACTS

Abstracts of the papers presented by lecturers are arranged in order of their actual presentation. The full text of the presentation, in its original language, is to be found in Appendix A.

DEVELOPING HUMAN FACTORS KNOWLEDGE

MORNING SESSION CHAIRPERSON: CAPT. NEIL JOHNSTON (IRELAND)

HUMAN FACTORS TRAINING FOR OPERATIONAL PERSONNEL

By Capt. Neil Johnston (IRELAND)

The primary emphasis in this paper is on Human Factors knowledge training during initial pilot training. The paper starts by reviewing the background to the existing ICAO Annex 1 (Personnel Licensing) requirement for Human Factors knowledge training. International differences in training practices are then considered and the distinction between Human Factors *knowledge* and the application of Human Factors *skills* is examined. The outline Human Factors knowledge syllabus recommended by ICAO is discussed briefly and the experience of those involved in implementing such training is subsequently reviewed.

Neil Johnston joined the ab initio pilot training programme of Aer Lingus, the national airline of Ireland, directly from school. He is now a Boeing 737 Captain with Aer Lingus. He was the founding chairman of the Human Performance Committee in IFALPA (the International Federation of Airline Pilots' Associations). He is currently chairman of the Human Factors Working Group in IATA (the International Air Transport Association). He represents IATA on the Flight Safety and Human Factors Study Group at ICAO (the International Civil Aviation Organisation). He is an Associate Editor to the International Journal of Aviation Psychology. His interests include the marriage of theory to practice in aviation and pilot training. He has been intensively involved in various innovations in pilot training, working both for Aer Lingus and as an independent consultant.

HUMAN FACTORS IN LEARNING AND INSTRUCTION

By Prof. Ross Telfer (AUSTRALIA)

At the University of Newcastle, the undergraduate program for the Bachelor of Science (Aviation) Human Factors are a key area of study. Initial concentration is on the individual's capacities and limitations as a pilot, incorporating aviation medicine and ergonomics. In the second year, when the student has attained initial licensing and is beginning multi-crew training, the focus moves to group dynamics (communication, climate, cohesiveness, etc.) and social psychology relating to multi-crew activities.In the third year, students relate human factors to learning and instruction in aviation. The first half of the year examines ground school activity, and the second half of the year deals with airborne instruction (usually linked with a flight instructor rating). The optional fourth year (leading to an Honours degree) provides an opportunity for a research project in human factors.

In contrast, a human factors course for airline training captains has to be compressed into the shortest period which will provide effectiveness. For efficiency, a multiplier principle of training trainers is utilised. To capitalise on the short contact time, pre-reading and a reference manual are provided. An instructional design is drawn from andragogy (adult learning) rather than pedagogy, concentrating on process rather than content. Modular construction and a spiral curriculum enable the course to be started economically, then expand to provide flexibility in adapting content to suit the participants' expertise and experience.

Current international research (Telfer and Moore, The University of Newcastle) with airline pilots has shown three identifiable motives and strategies used by pilots undergoing training and instruction. The deep (or intrinsic) approach, the shallow (or surface) approach, and the achieving approach can be identified by the Pilot Learning Process Questionnaire, and have clear implications for the effectiveness of pilot training.

Professor Ross Telfer is Head of the Department of Aviation at the University of Newcastle. He is the author or co-author of six books (including The Process of Learning (Prentice Hall, 1981; 1987); Psychology and Flight Training (Iowa State University Press, 1988)) and editor of Aviation Instruction and Training (Ashgate, 1993). He has published monographs, articles and conference presentations and has collaborated with aviation organizations on instruction and training. His current research looks at pilots' approaches to learning.

HUMAN PERFORMANCE LIMITATIONS REQUIREMENTS — THE UNITED KINGDOM EXPERIENCE

By Dr. Rory M. Barnes (UNITED KINGDOM)

The United Kingdom Civil Aviation Authority first considered introducing a knowledge of Human Factors into the requirements for a pilot's licence in the mid-1970s. Consultation with the training schools and other aviation organisations produced muted enthusiasm on the grounds of the additional time and cost involved and also on the basis that some of the subject matter was already covered in other topics.

Following the requirement for the introduction of the subject Human Performance and Limitations into all professional flight crew examination syllabuses in the 8th edition of ICAO Annex 1 the CAA notified the aviation community that it would be complying with the requirement and that candidates would be examined in it.

A syllabus was drawn up by the CAA following internal discussions and advice from the Applied Psychology Division of the RAF Institute of Aviation Medicine. Because of the imminence of the European Joint Aviation Authorities they syllabus was also reviewed with our European partners. The final syllabus proved to be very similar to that subsequently recommended by ICAO.

Examinations were scheduled to start in 1991, the intervening period being required to brief the training schools, airlines and other interested aviation organisations on such matters as the syllabus and the reason for including specific subjects, the qualifications for instructors, the provision of training courses for instructors and sources of suitable reading material.

When first introduced for professional pilots in April 1991 it was not necessary to obtain a pass in order to gain a licence, although a re-sit of the exam was required. Since January 1992 a pass is mandatory for the issue of a professional licence and on re-issue or upgrade of a licence. Up to the end of 1991 the pass rate was 30%. Since a pass became compulsory the rate achieved has been over 70%.

Private pilots are also required to study an appropriately adapted syllabus and to date some 2000 have sat the exam successfully.

More important than the exam itself, which is a means to an end, is the interest the subject appears to have generated within the pilot population.

Dr. Barnes obtained his medical degree from London University in 1962. After the usual intern posts he spent time in Public Health Laboratories, as a pathologist and as a family physician. His aviation medicine career started in 1962 when he joined what is now British Airways. He was originally responsible for the clinical care of air crew. He was promoted to a new post of Senior Medical Officer, Flight Training and Research with responsibility for medical training within the airline.

In 1975 he undertook a programme of research on workload in CAT IIII landings sponsored by the CAA whom he joined full time in 1976. He is currently SMO Flight Safety and Research, and Deputy to the Chief Medical Officer. His principle task is to advise on Human Factor problems. He holds specialist qualifications in aviation medicine and occupational health.

He is a Fellow of the Aerospace Medical Association and Royal Aeronautical Society and an Honorary Medical Adviser to The Guild of Air Pilots and Air Navigators. He is a Member of ICAO Human Factors Study Group.

In addition he is a qualified helicopter, glider and fixed wing pilot and currently flies with a commuter airline.

He has written papers on workload and physiological factors in relation to flight and cabin crew.

HUMAN FACTORS KNOWLEDGE REQUIREMENTS FOR FLIGHT CREWS

By Dr. Barry H. Kantowitz, Ph.D. (USA)

Human factors covers a very broad area of knowledge. For example, my own human factors textbook (Kantowitz & Sorkin, 1983) contains 700 pages divided among twenty chapters and requires an entire semester of class time: three hours per week for sixteen weeks. A more recent edited text devoted solely to aviation human factors (Wiener & Nagel, 1988) contains 684 pages in nineteen chapters. It is probably unreasonable to expect the typical flight crew to master all of this information.

ICAO Circular 227 (ICAO, 1991) offers a human factors training curriculum covering eight modules in 35 hours, only slightly less than the 48 hours required in the typical university first human factors course. This article compares the topics in the ICAO curriculum to those covered in a university human factors course, noting both differences and similarities. Suggestions are made for modifications to the ICAO curriculum that will capture recent trends in human factors research and practice.

Such trends center on the increased use of cognitive models of human behaviour to predict and explain human performance and human error. Traditional views of human factors are based upon empirical "knobs and dials" studies. Modern human factors emphasizes the need to predict flight crew behaviour based upon theories of human performance. Several aviation examples are discussed that demonstrate that the best human factors tool is a good theory. This is especially true when reviewing the human factors of flight crew interaction with advanced flight deck automation.

Guidelines for the training of professional human factors personnel (Kantowitz, 1987; Howell, Colle, Kantowitz, & Wiener, 1987) also contain useful suggestions that can be applied to the knowledge requirements for flight crews. Of course, flight crews do not need to have such a high level of training as human factors professionals; nevertheless, there is much to be gained by understanding the range of requirements for human factors specialists. Thus, implications for flight crew training are discussed.

1969 - Ph.D., Experimental Psychology, Joint Minor in Computer Science and Industrial Engineering, University of Wisconsin, Madison, Wisconsin; 1967 - M.A., Psychology, Queens College of CUNY, New York, New York; 1965 - B.A., Psychology (Research Honors), The City College of CUNY, New York, New York.

Barry H. Kantowitz is the Senior Staff Research Scientist at Battelle Seattle Research Center in the Human Factors and Organizational Effectiveness Research Center. He received the Ph.D. degree in Experimental Psychology with a joint minor in Computer Science and Industrial Engineering from the University of Wisconsin in 1969. From 1969 to 1987 he held positions as Assistant, Associate, and Full Professor of Psychological Sciences, as well as Full Professor of Industrial Engineering, at Purdue University, West Lafayette, Indiana. From 1977 to 1987 he was Director of Graduate Human Factors Training at Purdue. Dr. Kantowitz was elected a Fellow of the Society of Engineering Psychologists and the American Psychological Association in 1974. He has been a National Institute of Mental Health Postdoctoral Fellow at the University of Oregon, a Senior Lecturer in Ergonomics at the Norwegian Institute of Technology, Trondheim, Norway, a Visiting Professor of Technical Psychology at the University of Lulea, Sweden, and is currently an Affiliate Professor of Psychology at the University of Washington. He was recently appointed Human Factors Scientific Advisor to the NASA Aviation Safety Reporting System.

Dr. Kantowitz has written and edited more than one dozen books, including Human Factors (John Wiley & Sons) now in its tenth printing, and Experimental Psychology (West) now in its fourth edition. His research on human attention, mental workload, reaction time, humanmachine interaction, and human factors has been supported by the Office of Education, the National Institute of Mental Health, the National Aeronautics and Space Administration, the Air Force Office of Scientific Research, Nuclear Regulatory Commission, the Nuclear Power Engineering Test Center (Tokyo), the Electric Power Research Institute, a major Japanese airline, and the National Highway Traffic Safety Administration. He served a five-year term on the editorial board of Organizational Behaviour and Human Performance. He has published over 75 scientific articles and book chapters, including two chapters in the Handbook of Human Factors.

IMPLEMENTATION OF HUMAN FACTORS KNOWLEDGE REQUIREMENTS IN THE CANADIAN FLIGHT TRAINING SYSTEM

By Insp. J.H. King (CANADA)

Given the importance of sharing Human Factors information with member States, this paper imparts the development of Human Factors knowledge requirements in the Canadian flight training system. The report centres around the following:

1. How ICAO *Human Factors Digest No. 3* is utilized in the examination computer system and in the development of flight crew study and reference guides and examinations.

2. Adaptation of ICAO Human Factors knowledge requirements to encompass previous efforts in pilot decision-making and aeromedical information and the development of basic resource materials to support this endeavour.

3. Attempts to undertake a research study to develop and validate a total human factors program including knowledge and skill requirements.

4. Endeavours to pass on requirements and reference materials to pilot candidates.

Insp. J.H. King is an Aviation Education Specialist with the Aviation Training Division of Transport Canada. He has a Bachelor of Arts degree in psychology and geography and has done post graduate studies in educational design and teaching behaviour. He has worked as an educator, pilot and flying instructor. He has owned and operated a fixed base flying operation and has been responsible for the flight instructor and instrument flying programs at the Sault College of Applied Arts and Technology.

HUMAN FACTORS IN GENERAL AVIATION

By Mr. Ronald D. Campbell (IAOPA)

This paper is aimed at the requirements to be considered when relating Human Factors education to single pilots, as distinct from multi pilot operations which are heavily controlled and monitored by the airline oriented companies. It could therefore act as a catalyst discussion on Human Factors in the General Aviation and Aerial Work sectors.

Ronald D. Campbell, Technical Co-ordinator for the Europe Region of the International Council of Aircraft Owner and Pilot Associations (IAOPA), Frederick, U.S.A.

AFTERNOON SESSION CHAIRPERSON: PROF. GRAHAM J.F. HUNT, PH.D (NEW ZEALAND)

NEW AVIATION PROFESSIONALISM: KNOWLEDGE SYSTEMS THAT INTEGRATE HUMAN FACTOR COMPETENCIES IN JOB PERFORMANCE

By Prof. Graham J.F. Hunt, Ph.D (NEW ZEALAND)

One of the much used words in aviation is that of "professionalism". Every pilot wants the privileges (especially money), respect, and responsibilities that come from being a captain employed by a major airline. To achieve this end, pilots accept that the means to such an end involve high technical standards of performance, integrity and an acceptance of the "rules of progression" from trainee pilot; second officer, first officer and finally captain. Similar aspirations may be found with air traffic controllers, maintenance engineers and other occupational groups within the industry. Acceptance of these "means to an end" are what job incumbents mean when they describe their work status as "being professional". However, is this label legitimate? This paper will examine the strategies which will need to be implemented if airline flight crews, air traffic controllers and maintenance engineers are to develop from craft and trade based operators, to members who can be accorded the status and responsibility practised by most of the recognised professions. Aviation's need for an internationally recognized, tertiary-based content of knowledge, long accepted by other professional groups, is discussed. Included in such knowledge systems will be the need for integrating human factor dimensions,with those that recognise the cultural context in which aviation personnel operate. The *new* professionalism in aviation will result in expanding the competencies of its members in technical, management and human factor applications.

SOME ASPECTS ON OUR HUMAN FACTORS CONCEPT

By Capt. Gunnar K. Fahlgren (IATA)

I will discuss "What Human Factors mean". Some have a very negative view of it in their minds, namely that it is a contributing factor to accidents in our life. Human Factors cause accidents. Accident shall be avoided and consequently Human Factors should be eliminated.

Others have a much more positive view of this expression. Human Factors are those factors which make us human. What we need is a united and a more holistic view of the meaning of Human Factors. We need a definition suitable for our business.

I will also discuss how we should handle the pilots test/examination on the subject "Human Performance and Limitations" I will propose that written tests should be avoided on this subject.

The researches, now going on especially in the U.S.A. usually focus on the negative side of Human Factors. This is good, as we can learn our limits. We also investigate a lot more incidents now than we did before. This is also good. But we must very carefully think about, how this new approach on Human Factors will influence the image of safety. I will say that the ICAO and IATA members must control this, be aware of the risks and act in a way that this positive stake not will turn out to produce a boomerang effect on our customers and our employees. We must use the Human Factors concept positively and give our customers the correct feelings and the conviction that they can trust our industry now and for ever.

We often hear and read that 75% of all accidents are caused by Human Factors.
But we can also say that **thanks to Human Factors** other reasons for accidents are as low as 25%. Which expression do you like best?

After 42 years as a pilot, Gunnar K. Fahlgren retired as captain in Scandinavian Airlines System, where he worked as Flight Instructor, Chief Pilot and CAA inspector. He has several years of studies in psychology at Stockholm University and has been a speaker at FSF annual meetings at Tokyo 1987, Sydney 1988 and Rome 1990. He is now working as a Human Factors consultant in Sweden with branches in Belgium and Malaysia and has conducted Human Factors courses for more than a thousand pilots from twenty airlines. He is a member of IATA Human Factors working group.

TRAINING HUMANS FOR AN AUTOMATED ATC ENVIRONMENT

By Mr. Bert Ruitenberg (IFATCA)

The International Federation of Air Traffic Controllers' Associations was founded in 1961 and has since grown to a worldwide organization with over 80 Member Associations that is accepted by the aviation-world as "the voice of the Air Traffic Controller".

IFATCA participates in ICAO's Human Factors Programme and feels honoured to be invited to present a paper at this Global Symposium. In the paper, differences in ATC-training compared with pilot-training are highlighted. There are a number of areas where safety-related standards that are accepted in pilot-training are conveniently "overlooked" in ATC-training.

IFATCA's views regarding automated ATC-systems are explained, with much emphasis on the role of the Human Being in an automated environment. Will automated systems inherently lead to an increase in capacity, enabling more traffic to be handled by less Controllers, or is this influenced by the role of the Human Element?

It is our firm belief that automated systems should be designed to assist Air Traffic Controllers, to enhance both job-satisfaction and the safety-element of the Controller's task.

Therefore IFATCA has always urged that Controllers be involved from the designing-phase onward in the development of new equipment. The Human Factors aspects of automation must be fully considered when developing automated systems and should include the maintenance of essential manual skills and Controller awareness. The Human Element - the Air Traffic Controller - must remain the heart of the ATC-system, a system that is there for the Controller, not the other way around.

Mr. Bert Ruitenberg was born in 1955, and his Air Traffic Control career began in 1976, when he entered training in the Royal Netherlands Air Force. In 1980 he transferred to the Dutch CAA as a TWR/APP-controller at Schiphol Airport and has worked there ever since. As of 1988 he was also giving instruction on their ATC-simulators. From 1983 to 1989 he was a member of IFATCA's Standing Committee 4, the Federation's working-group dealing with Professional matters (working-conditions, medical items, selection and training, Human Factors, etc.). At the 1992 IFATCA Annual Conference he was elected EVP Professional, which means that he is currently the Executive Board Member responsible for the Professional matters of the Federation.

TRANSAVIA'S INTEGRATED APPROACH TO HUMAN FACTORS TRAINING

By Mr. David Lawson (UNITED KINGDOM),
Capt. Han Luchsinger and Capt. Frans Trompert (NETHERLANDS)

In 1984 Transavia Airline's Flight Training Department conducted an evaluation of Flight Crew performance to determine if current training programmes were meeting crew needs. Arising from that evaluation Transavia introduced a LOFT programme into the 1985 Recurrent Training schedule. This LOFT programme identified a discrepancy between the skill levels of crews in the technical and non-technical areas. Transavia saw the need for a programme to develop enhanced non-technical skills amongst its crews.

Working in cooperation with the Personnel and Cabin Crew Training departments, the Airline agreed a set of goals and training objectives in September 1988. Several Senior Instructors met with representatives of airline's conducting CRM training and attended CRM programmes conducted by United Airlines and KLM. Arising from this research Transavia chose Interaction Trainers Limited as consultants. ITL is a UK based company working in the field of CRM and Instructor training with many airlines around the world. ITL's task was to assist Transavia with the design, development and presentation of a Crew Management Course.

Pre-design meetings began in March of 1989 and ITL conducted the first course November 1989. Since 1989, a total of 110 pilots have attended the Transavia CMC. In 1990, ITL and Transavia introduced a two-day Follow-Up course for Instructors. The Follow-Up deals with debriefing CRM in Recurrent and Command Training. A one-day refresher course also forms part of the command training syllabus. Integration of CRM into Recurrent Training took place in 1992.

Transavia has plans to introduce CRM into all Flight Crew Check and Training as part of their continuing integrated approach to crew development.

David Lawson *was the Royal Air Force Engineer 1966-1970 and Royal Air Force Navigator 1970-1988. Operated VC10, Vulcan, Hawk, HS125 and Tornado. Joined ITL in November 1988 as a Training Consultant. Appointed to the Board of ITL as a Director in April 1992.*

Capt. Han Luchsinger *worked for the Royal Netherlands Air Force 1968-1977. Flew F104 Starfighter. Joined Transavia as First Officer 1977. Instructor Pilot 1978. Captain in 1981 and Chief Training Captain 1984-1987. Appointed CRM Project Leader 1988.*

Capt. Frans Trompert *worked for the Royal Netherlands Airforce 1966-1974. Flew F104 Starfighter. Chief Instructor of local Flying School and Regional Charter Operator 1974-1978. Joined Transavia 1978. Currently Training Captain on B737 and Type Rating Examiner. Joined CRM Project Team 1990.*

TRAINING OF NATIONAL TRANSPORTATION SAFETY BOARD (NTSB) HUMAN PERFORMANCE INVESTIGATORS

by Dr. Malcolm Brenner, Ph.D. (USA)

Human performance issues are often central to the investigation of aviation accidents. The NTSB provides training in human performance to both field investigators and human performance investigators working for the agency.

Field investigators, located in field offices around the United States, are required to conduct by themselves the investigation of small aviation accidents (typically fatal accidents in general aviation or minor airline accidents or incidents). These investigators complete an initial 2 1/2 week training course developed by the agency that covers all aspects of aviation accident investigation. It includes a 2 1/2 hour class on human performance that focuses on practical behavioral evidence that needs to be collected. The class teaches that there are five areas to be covered in a basic human performance investigation: 1) information on the individual's activities before the accident, beginning with the moment of the accident and working back at least to the beginning of the last rest period; 2) information on the individual's aviation ability (as from an interview with a flight instructor or chief pilot); 3) information on the individual's personal life (as from an interview with next-of-kin); 4) information on the individual's medical history; and 5) toxicological testing. Investigators are provided with a written reference manual. The chapter on human performance provides a short checklist of human performance questions that can be helpful for conducting interviews. Investigators can also consult with human performance investigators for assistance with their cases.

Human performance investigators, located at the agency's headquarters, form part of the major team that investigates large airplane accidents (such as fatal airline accidents). They focus on the performance of pilots, air traffic controllers, or mechanics involved in the accident to ensure adequate treatment of relevant human performance issues. Human performance investigators are recruited from 3 backgrounds: 1) an academic background with graduate level training in human performance and some degree of aviation exposure; 2) an industry background such as military/airline piloting with some degree of human performance training or exposure; and 3) a police investigation background. Human performance investigators receive the same initial training as field investigators, and, in addition, receive on-the-job training by experienced investigators on several accidents. Relevant reference material is available, and informal interaction among investigators and specialists is encouraged.

Malcolm Brenner is a senior human performance investigator with the National Transportation Safety Board (NTSB), Washington, D.C. Prior to joining the Safety Board in September, 1986, he served as a scientific consultant to NASA and the U.S. Air Force for human performance research, and as an expert witne s on human performance issues for the U.S. Senate, the U.S. Department of Justice, and for private litigation resulting from aviation accidents. He received a Ph.D. degree in Psychology from the University of Michigan. Dr. Brenner is a private pilot. (10U

TRAINING THE INVESTIGATOR

By Mr. Peter Harle (CANADA)

While the aviation community is adjusting to the importance of human factors in accident prevention, to date there has been little coherent effort to provide accident investigators with the requisite knowledge and skills to deal with human performance issues in a systematic way. Even when investigators do receive special training, the tendency has been to focus on the performance of those individuals closest to the operation at the time of the accident or incident.

Increasingly, an awareness is growing that the aviation system is plagued with accident-conducive circumstances. These may be the product of inadequate decisions at the highest levels in terms of equipment acquisition or design, of improper maintenance or operating procedures, of training or scheduling shortcomings, of cost-cutting resource allocations, of communications failures throughout the organization or industry, of psychological or other pre-conditions that we operate with daily, etc.

If the generalist investigator is to meet the challenges of investigating the Human Factors, they require relevant training in the basic principles; eg. the interdisciplinary nature of human factors, fundamental areas of examination, data that should be collected, data sources and collection methods including interview techniques, analytical techniques, etc. They must also learn about the types of specialists that are available to assist in the investigation of human factors, where they can be found and when it would be appropriate to employ them.

The Transportation Safety Board of Canada has developed and is implementing a course to specifically prepare Canadian accident investigators to systematically examine the total context in which an individual's performance can trigger an accident situation. In addition to enhancing their basic knowledge of human factors, the course aims to develop their skills in identifying and analysing safety deficiencies in human performance, in drawing reasonable inferences from the investigation as to cause and contributing factors, and in recording relevant human performance data for macro-analytical purposes. The training program is a one-week, residential course with a mixture of classroom presentations and practical exercises conducted in syndicates.

By better understanding the context in which normal, healthy qualified personnel find themselves facing an accident situation, effective measures can be developed to reduce systemic safety deficiencies and thus reduce the risk that an individual can create a triggering event that will slip through the inherent defences in the aviation system. This paper examines how the TSB is meeting this challenge.

Peter Harle is a graduate mechanical engineer and a former military pilot. For 26 years, he served in Canada, the United States and Europe in pilot training and air operations. Retiring in 1985 as a colonel, he became an investigator and safety analyst with the former Canadian Aviation Safety Board. Today, he is the Director, Accident Prevention in the Transportation Safety Board of Canada. He is currently responsible for the analysis of safety deficiencies in the marine, rail, commodity pipeline and aviation modes of transportation, with particular emphasis on the analysis of human performance issues.

DEVELOPING HUMAN FACTORS SKILLS

MORNING SESSION CHAIRPERSON:
DR. NIKOLAI STOLYAROV (RUSSIAN FEDERATION)

Dr. Nikolai Stolyarov (RUSSIAN FEDERATION)

Dr. Nikolai Stolyarov is the Director of the Ergonomical Department of Russia Scientific Research Institute Air Navigation. He is the head of science development of Human Factors problems in Russia Civil Aviation and is the author of several training programs for flight crew members. He graduated as "Candidate of Technical Sciences on Operations of Air Transport" and "Doctor of Technical Sciences on Ergonomical Questions". He worked for the Tupolev Design Bureau in development of military and civil aircraft. Mr. Stolyarov is a member of the Bilateral Russian-American Co-operation in the field of Aviation Medicine and Human Factors. He is also a participant in the ICAO Flight Safety and Human Factors Study Group.

HUMAN FACTORS TOPICS IN CANADIAN PRIVATE PILOT TRAINING

By Insp. Arlo Speer (CANADA)

Instruction given to Private pilots is fundamental to future pilot performance. Human Factors training must become integral to training at the Private Pilot level. Instruction in Human Factors has been a part of effective instruction for years; it is now being formalized. Mr. Speer will outline Canadian initiatives for the integration of physiology and psychology (including pilot decision-making) into private pilot training. He will review Canadian desires for research that (1) identifies Human Factors skills for various pilot licences, (2) determines effective strategies for teaching and evaluating Human Factors, and (3) increases instructors' knowledge of how to incorporate Human Factors training into all courses.

Arlo Speer is Superintendent of Flight Training with Transport Canada. He holds a Masters degree in Education specializing in Measurement and Evaluation. He completed graduate work in curriculum design, teacher education and supervision and is currently pursuing doctoral studies in performance testing and certification testing. Mr. Speer has served as a pilot, flight instructor, classroom teacher, high school administrator, and college tutor in teacher training. He has operated flight training units in Canada and served as a Transport Canada field inspector for eight years.

THE DEVELOPMENT OF HUMAN FACTORS SKILLS AND PROFESSIONAL ATTITUDES

By Dr. B. Schär (SWITZERLAND)

For SWISSAIR, the HAD programme serves to ensure that pilots are capable of guaranteeing safe, reliable flights thanks to optimum cockpit resource management (CRM).

At SWISSAIR, our flight training and recurrent training programs of our pilots have long included elements acknowledging the need for a balance between technical and non-technical skills.

Among elements of our training program that take the human factor into consideration are: Line oriented Simulation (LOS), Line Oriented Flight Training (LOFT), safety awareness programs and combined cockpit/cabin emergency courses.

With the aim of finding a comprehensive, systematic solution, the HAD CONCEPT was approved in 1991. The HAD Concept is composed of three main elements:

1. Elementary Training during basic instruction for trainee pilots attending the SWISS AIR TRANSPORT SCHOOL. This training delivers fundamental knowledge and establishes attitude and behaviour patterns for the entire career of the airline pilot.

2. Training of the Trainers, i.e. the ground and flight instructors. The rationale for this part of the program is that the success of the HAD Training rests on the availability of capable and inspirational instructors.

3. Regular and specialised HAD Refresher Courses for all cockpit crew at 2-year intervals. For SWISSAIR, this repeated training on human factor skills is a prerequisite to ensure a lifelong adequate level of proficiency.

The Concept's major characteristics are:

— It is embedded within corporate management (corporate commitment). Hence, the program is granted considerable significance.

— Standardised requirements and company-specific needs are taken into consideration (e.g. corporate culture, management principles).

— The program is practice-oriented and integrated into other aspects of training and deployment.

— The program is clearly geared toward lifelong, continual development.

— Input is drawn from specially selected line pilots as co-trainers, and next-in-line superiors to Fleet Chief Pilot and Chief Flight Instructor.

— Course content is flexible, reflecting to developments of modern technology.

— Responsibilities are clearly designated. Head, Flight Crew Training is responsible for Elementary Training and Training of the Trainers. Head, Cockpit Crew is responsible for the HAD Courses for line pilots.

— A management committee ensures the coordination and administration of the overall program.

As a comprehensive, integrated program HAD represents an innovation, the need for which is undisputed. It serves as a vehicle for many important changes. Moreover, it is complex, difficult and tricky to implement.

Through pragmatic, practice-oriented application, SWISSAIR is confident of being able to implement this ambitious programme successfully.

The program reflects international developments and trends. SWISSAIR is prepared to make its program available for the benefit of safety and prosperity of international civil aviation.

Dr. Beat Eduard Schär was born on 31 December 1944 in Solothurn, Switzerland. After having obtained his Military and Civil Professional Pilot licence/Flight Instructor in 1968 and 1969, he graduated from the University of Berne with an MBA (1977) and Ph.D. (1983). He flew for the Air Force as a Flight Instructor (1967-1990), Chief Flight Instructor (1977-1984), Commandant Pilot Schools Swiss Air Force (1986-1990) and Commandant Surveillance Wing Swiss Air Force (1990-1991). He worked also since 1967 as a Civil Flight Instructor, and he is working now since 1 July 1991 as the Head of Flight Crew Recruiting and Training of SWISSAIR.

CREW RESOURCE MANAGEMENT TRAINING - PAST, PRESENT & FUTURE

By Mr. Douglas Schwartz (USA)

When ICAO last convened a Flight Safety and Human Factors Symposium in St. Petersburg three years ago, I had the privilege to report on the history and use of Crew Resource Management (CRM) training in the international airline community. That presentation chronicled three generations of CRM training spanning a ten year period. The paper concluded with predictions of what the future held for CRM training.

The paper to be delivered in Washington will briefly review that history. It will then focus on the period since the meeting in St. Petersburg which has seen a flurry of activity in the CRM world. Among recent events that will be addressed ...

The term Cockpit Resource Management has been replaced with the term Crew Resource Management implying a broader context for the training than originally intended.

The consensus that human factors training is important has become more focused. Today there is growing agreement that while flight crew members need a body of technical knowledge and skill to perform effectively, they also require a body of non-technical knowledge and skill as well. CRM training has become the vehicle to fill this void.

It has become clear that a CRM course alone is inadequate to address the needs of the operational community. Today, we think in terms of a CRM training system that will introduce, foster and reinforce the use of CRM knowledge and skills on the flight line. This systemic approach more carefully defines long term objectives, measures progress toward those objectives and invites stronger organizational commitment.

The prevalence of automated technologies in todays cockpits, changes in crew compliments, and multi-cultural dimensions to crew pairings have also put new expectations of the role of CRM training.

These, and other facets of the current state of CRM training will be explored. The paper will conclude with a brief discussion of where CRM will go in the future, suggesting that perhaps it will disappear, as the "technical" and "human factors" components of crew training merge into one.

Douglas Schwartz is the Deputy Director of Flight Standards, Flight Safety International (FSI). He began his flying career in 1974 and has been with this company since 18 years as simulator instructor, flight instructor and training center manager. Currently, he is responsible for co-ordinating flight and training standards among FSI's network of pilot training centers. He is also responsible for design, implementation and delivery of CRM training programs and has worked with CRM for ten years. He is a member of the Flight Safety Foundation International Advisory Committee; and the Air Transport Association AQP Committee. He is also a frequent contributor to the ICAO Flight Safety and Human Factors Regional Seminar Programme.

CRM PROGRAM DEVELOPMENT: A TIME FOR INTERACTION

By Mr. J. Norman Komich (USA)

For over a decade now, the aviation industry and the airlines in particular, have all been great proponents of CRM Training. There have been a plethora of papers presented on the need for and benefits of formal CRM Training. However, and most unfortunately, there is little formal guidance on HOW to conduct such training; there is no single common reference at the Library of Congress titled "CRM Program Development: Years One Through Ten." It has basically been left to the ingenuity of the individual program developer with references from a few dedicated psychologists in academia. While effective in the initial stages of a CRM program, such an approach ultimately suffers from the law of diminishing returns when restricted to just those individuals within one company.

Keeping recurrent training fresh, stimulating, and productive, training new captains and first officers, incorporating flight attendants, training check airmen, effectively developing LOFT Scenarios, training CRM Facilitators, and most importantly, treating the recalcitrant pilot who is probably the biggest threat to aviation safety but who can pass his periodic checkrides with metronomic regularity are some of the issues that are currently being addressed at many air carriers. Yet there is little or no interaction between carriers on how to <u>most</u> effectively address these issues. The resultant parallel reinventions of the wheel are too costly in time and effort in keeping the margin of safety in commercial aviation as high as it can be. There is a need now throughout the international aviation arena to share what works (The Good), what doesn't work (The Bad) and how to effectively handle the Recalcitrant Pilot (The Ugly) in CRM Programs. This paper describes the problems and provides some solutions.

Mr. J. Norman Komich is a line pilot with a major air carrier where he is the CRM Program Developer. He has attended eight other CRM Programs and assisted in the development of CRM Programs for three other air carriers. Since 1985, he has spoken on three CRM issues at the Ohio State International Aviation Psychology Symposium and in 1991 he conducted a workshop on "CRM Scenario Development: The Next Generation".

CRM: FEEDBACK AND APPRAISAL SYSTEM

By Ms. P. Antersijn and Ms. M. Verhoef (NETHERLANDS)

Taking "non-technical" training seriously, it is important to regularly evaluate the training package/approach. In 1987/88 KLM started to develop a new approach: structurally integrate non-technical training in the training/counselling process of pilots / F/E:

1. Non-technical training should not be a once-only activity.
2. Instructors must have the necessary tools (consequences instructors training)
3. Every pilot / F/E must know what is expected from him/her.
4. Responsibility of management in this, and acceptance of all pilots / F/E's, is essential.

The Feedback & Appraisal System (FAS) plays a crucial role when counselling non-technical skills. The FAS consists of five main categories (WORK ATTITUDE, INFORMATION MANAGEMENT, LEADERSHIP, STRESS MANAGEMENT, CO-OPERATION) with 14 subcategories. Of each subcategory a short definition, the matching behavioral components and a description of the desired/undesirable behaviour is given. On 1 July KLM started a try-out with this system. The first results will be presented during the symposium.

*After her study Educational Technology at the Technical University Twente in the Netherlands, **Patricia Antersijn** entered KLM Flight Operations Division in 1987. To familiarise herself with the cockpit environment she completed the A310 and 747-300 groundschool training. In her job she has, among other things, done research into the field of Human Factors and Cockpit Resource Management. She is one of the participants who are responsible for the new set-up of the Crew Management Courses, the development and introduction of a Feedback and Appraisal System for non-technical skills for cockpit crew members and the development of a new training for groundschool, simulator and route instructors. At the moment she is working as a staff member of the Flight Crew Training Centre.*

***Marieke Verhoef** studied Educational Technology at the University of Amsterdam in the Netherlands. During that time she did research on how to improve learning performance. She entered KLM in 1987 as cabin attendant. During that period she became familiar with the line operation and crew scheduling etc. In 1989 she moved to the training department and was responsible for the development and execution of a management course for the cargo department, and a station managers course. In 1990 she joined the KLM Flight Crew Training Centre. To get familiar with the cockpit environment, she attended the A310 groundschool and simulator training. She participated in the development of the Feedback and Appraisal System for non-technical skills for cockpit crew members and is also responsible for the development of a complete new set-up for the training of groundschool, simulator and route instructors. At the moment she is working as a staff member of the Flight Crew Training Centre.*

DEVELOPMENT OF HUMAN FACTORS SKILLS AND PROFESSIONAL ATTITUDE OF OPERATIONAL PERSONNEL IN KOREAN AIR TRANSPORT INDUSTRY

By Prof. Soon-Kil Hong, Ph.D. (KOREA)

The paper briefs the major aviation accidents and their causes during the last 30 years in Korea. The paper discusses the present status of human factors training for operational personnel to improve flight safety by the two flag carriers, Korean Air and Asiana. The paper also considers the planned efforts to develop human factors skills and attitudes of professional operational personnel by Korea Air and Asiana. The paper particularly studies whether there should be any different human factors training because of different cultural norms (Oriental Culture Confucianism: vs. Western Culture: Christianism). The preliminary research demonstrates that (1) The qualification of captain as team leader is the most important factor and (2) To improve effective teamwork and co-ordination of cockpit crews, personal relationship among crew members based on schools (educational background), military experiences, native places, seniority and etc., should be carefully considered.

Born on March 15, 1942 at Chong-Ju City, Korea. B.A. and M.A from Seoul National University. M.A. and P.h.D. from the George Washington University (Aviation Policy and Law). Experienced in aviation industry and research during 20 years (General Manager of International Relations, Planning, Marketing, Hong Kong and Washington, D.C., of Korean Air). Represented Korean Government and Aviation Community at numbers of multilateral and bilateral conferences such as ICAO, IATA, OAA, Korea-US air talks and etc. Presently Professor and Chairman, Department of Aviation Administration, Hankuk Aviation University. Executive Director of Korean Association of Air Law. Adviser to Ministry of Transportation and Korea Airports Authority. Wrote four books and many articles including Aviation Policy-Making in Korea in English (1990).

AFTERNOON SESSION CHAIRPERSON: MR. JAMES P. STEWART (CANADA)

Mr. James P. Stewart (CANADA)

Mr. James P. Stewart joined the Department of Transport as an aircraft accident investigator in 1981 after a twenty year career with the Royal Canadian Air Force and the Canadian Armed Forces. In the military, Mr. Stewart accumulated over 7000 hours flight time as a crew member and pilot on a number of different aircraft types, including large transport aircraft.

For six years Mr. Stewart was employed by the military and Transport Canada as an aircraft accident investigator. In 1984, Mr. Stewart joined the newly formed Aviation Safety Programs Branch of Transport Canada as an accident prevention specialist. Later that year he was appointed Chief, Aviation Safety Analysis and Research. In 1987, Mr. Stewart was appointed Director, Aviation Safety Programs. With the formation of the System Safety Directorate on 1 April, 1991, Mr. Stewart was appointed Director General, System Safety.

Mr. Stewart has received specialist safety training from the University of Southern California, the United States Air Force, the Canadian Armed Forces and Transport Canada. He is the President of the Canadian Society of Air Safety Investigators and Canadian Councillor to the International Society of Air Safety Investigators. Until his appointment as Director General, System Safety, Mr. Stewart served as the Canadian representative to the International Civil Aviation Organization Human Factors Study Group. He has been published in various international safety journals and spoken at numerous international safety seminars.

AIM, AIRCREW INTEGRATED MANAGEMENT A MANUFACTURER'S EXPERIENCE IN CREW RESOURCE MANAGEMENT

By Mr. Eddy L. Racca (FRANCE)

For Airbus Industrie and Aeroformation, since the beginning of the launching of the first Airbus, the paramount idea has been to obtain the best safety.

To do so, we have obviously used all the tools given by the technology, and also from the first transition courses given in 1972 with the first Airbus A300, we tried to integrate as much as possible, the Human Factors aspects within the technical ones.

In this context, we decided to do again better in 1990, and to introduce in our transition courses, a Crew Resource Management module.

Our CRM course is named AIM, Aircrew Integrated Management, as it is fully integrated within the technical training of the transition course for crew members, throughout the five weeks they spend in our center.

It is the first attempt of an aircraft manufacturer to address in such a way, the Human Factors component of crew performance in the customer training.

In this paper, we will describe :

- the evolution of our concepts of Human Factors throughout the years

- the process of implementation of this course, that has been a joint effort between Flight Safety International and Aeroformation

- the content of course

- the feedback from the trainees and the impact of AIM on the results at the end of the transition course

- the analysis of the survey conducted with the help of the University of TEXAS (CMAQ = Cockpit Management Attitude Questionnaire)

- the projects of extension of AIM to the other categories of trainees

Mr. Eddy L. RACCA born in 1934, completed his initial studies in Marseille, France, then in Paris at the French National School of Aeronautics and Space. He joined the French Flight Test Center of Istres in November 1960 as an Air Force officer, then, in December 1961 as a civilian. He was graduated as a flight test engineer by the Flight Test Pilots School of Istres in July 1963. From this date to March 1988 he acted as a Flight Test Engineer in charge of arresting barriers tests, then of civil aircraft airworthiness, going from the gliders and light aircraft to the corporate aviation airplanes and commercial airplanes. As such, he flew 6.000 hours as an engineer and 2.550 hours as a pilot, on 278 different types of aircraft, with 428 different pilots (a good preparation for the human factors !). In April 1988 he joined Aeroformation, a subsidiary of Airbus Industries, that implements the training of Flight Crew members and maintenance people of Airline buying Airbus airplanes, in charge of Human Factors studies department, and is now Senior Director General Research. His areas of interest are, among others, Cosynus the data base system for trainees, AIM, the Aeroformation's CRM course fully integrated in the transition course for the Airbus aircraft crew members, and relations with university for different researches in the area of training, crew communication, etc.

A HUMAN FACTORS COMMITTEE

Capt. Flemming Kirkegaard

The paper covers the organizational set-up, composition and function of a Human Factors Committee an a smaller civil aviation administration. The purpose of the committee is to advice the Director Aviation Inspection Department on any Human Factors related subject which may have a bearing on flight safety.

The committee numbers 5 members from various parts of the aviation industry.

The committee has discussed the most often recorded cause factor in aircraft accidents - deviation from basic operational procedures - and concluded that a strong defence against deviation might easily be established.

Captain Flemming Kirkegaard has flown for 33 years as a fighter pilot/flight instructor in the airforce and captain in SAS. He has 15,000 hours on medium and heavy aircraft. He has been a chiefpilot on DC-9/MD-80 aiecraft in SAS. He is chairman of the Danish Civil Aviation Administrations Human Factors Committee and is flying MD-80.

THE DEVELOPMENT OF HUMAN FACTORS SKILLS AND PROFESSIONAL ATTITUDES

By Capt. Hans Sypkens (IFALPA)

IFALPA thinks of training for Human Factor Skills and developing Professional Attitudes as of high value. Worldwide developments have come a long way but still we can improve a lot.

At the same time however we recognise that training, how necessary though, is only one part of the "aviation system" in the effort of maintaining and improving flight safety.

There is some kind of paradox here. The better training pilots receive, e.g. by enhanced Human Performance training, the better they can cope with existing deficiencies present in the "aviation system". In other words, we create a Super Keeper able to stop more and more mistakes made earlier in the game. However this does not help much in the end when not addressing at the same time the latent failures in the organisation, including the decisions which led to them. Not having such a strategy will produce a very busy Keeper who indeed needs all of his new learned skills.

This is not an argument against such programmes as CRM and LOFT, on the contrary. But a strategy not eliminating latent failures will set up pilots to make errors in spite of such training.

IFALPA recognises the need of formal education in all aspects of Human Factors for Ab-Initio pilots. We are convinced of the large positive effects when this education is fully integrated in the first years of the basic training. All successive training has to consolidate or enhance this basic training. The objective being that in the end all training is "Human Performance Impregnated". Even when starting today it still takes a whole career's time to train every pilot in this manner. In the meantime we need Human Factors "conversion" courses of an unfortunate duration of a couple of days or weeks. In this view the CRM courses as we know them today are not the permanent solution.

Consequently IFALPA thinks Recurrent Training in Human Factors Skills is very important. We do, as with technical skills, need feedback on such a skill as decision-making or feedback on leadership style to improve ourselves. Both examples are shown in behaviour patterns as with many other "non-technical" matters. Since we are looking for effective behaviour patterns in the cockpit, at the same time knowing that behaviour can be observed and measured, it is most promising to receive feedback on behaviour components during debriefings.

J.G. (Hans) Sypkens studied Mechanics for four years at the High Technical School. Besides line-flying on the DC-10, a Flight Instructor and Type-rate Examiner on this type of aircraft. CAA examiner. Served the Human Performance Committee of IFALPA for eight years of which four years as Vice-Chairman and the last two years as Chairman. Founding member of the Dutch Human Factors Advisory Group (HUFAG). Chairman of the "non-technical" Working Group of the local CAA. Member of a KLM Working Group developing a Feedback and Appraisal System for cockpit behaviour patterns of pilots.

HUMAN FACTORS AND TRAINING ISSUES IN CONTROLLED FLIGHT INTO TERRAIN (CFIT) ACCIDENTS AND INCIDENTS

by Capt. Roberto Arostegui (ARGENTINA) and Capt. Daniel Maurino (ICAO)

Controlled flight into terrain (CFIT) occurrences are a topmost concern within the international aviation safety community. Recent statistics suggest that close to 45% of aircraft losses during the last ten years can be accounted under this category. This has led major international organizations, including the International Civil Aviation Organization (ICAO), the Flight Safety

Foundation (FSF) and the International Air Transport Association (IATA), to multiply their endeavours to reduce CFIT accidents and incidents.

Proposals to reduce CFIT occurrences rest on the time-honoured, three-legged stool aviation has favoured for decades: engineering and design, regulation and enforcement, and training, including Human Factors training, or any combination of these approaches thereof. These piecemeal solutions are mostly directed towards operational personnel. Human Factors is in particular one area where misconceptions about potential solutions may abound. It is essential to put the Human Factors issues of CFIT occurrences and their training solutions into context to avoid such misconceptions as well as flawed allocation of resources as a consequence of partial solutions.

This paper takes as point of departure that CFIT accidents and their potential solutions should not be considered as particular or isolated events, but rather within the greater context of the aviation system within which they occur. It is further argued that unless the system supports those who have the last opportunity to provoke or avoid CFIT occurrences --pilots and controllers-- design, regulation and training will have limited success. A system approach to the understanding of the causes of CFIT occurrences is advanced as essential to avoid piecemeal approaches to reduce such occurrences. A contemporary, system-oriented approach to accident causation and prevention must be the unchallenged partner to design, engineering and training in the quest for reducing CFIT occurrences.

***Capt. Roberto Arostegui** is Vice-President, Flight Training, Aerolineas Argentinas, and as such the Manager for the airline's Flight Training Center in Buenos Aires, Argentina.*

Capt. Arostegui started his flying career as a naval aviator in the late sixties. During his tour of duty as naval officer, he flew transport and search and rescue missions and he was also an instructor pilot at the Naval Academy. He joined Aerolineas Argentinas in 1975, where in addition to his flying duties, he has held several training and management positions. In addition, he was President of the Argentine Airline Pilots Association for the period 1982 to 1984.

His experience includes more than 10 000 hours, with type ratings as Captain in HS-125, Douglas DC-3, Grumman Albatross HU 16B, Fokker F28, Boeing B737, Boeing B727 and Mc Donell Douglas MD80.

***Captain Dan Maurino** is the Secretary of the ICAO Flight Safety and Human Factors Study Group. After obtaining a degree in education, he joined Aerolineas Argentinas, where he held several management positions, including that of Training Manager for the airline.*

In 1988 he joined CAE Electronics in Montreal, Canada, to participate in a flight simulator training research programme. In May 1989, he joined ICAO with the responsibility of developing and implementing the Organization's Human Factors programme.

Dan is a member of the Human Factors Society (HFS) and of the International Society of Air Safety Investigators (ISASI).

ENHANCING THE IMPACT OF HUMAN FACTORS TRAINING

By Mr. H. Thomas Heinzer (USA)

New training techniques are emerging with promise measurable increases in crew performance in terms of "human factors". Such techniques extend the results of such training beyond that previously available from so-called "awareness" training. At the same time, new training regimens are being used to moderate the impact of organizational influences which can contribute to crew-preventable accidents. The two kinds of training, in concert, offer the prospect of significantly reducing the incidence of human-preventable accidents.

Mr. Heinzer serves as Director, Training Standards for SimuFlite Training, International which provides Advanced Simulation Training for Airline, Corporate and Military Clients. He is responsible for Standardization, New Training Development and Government Affairs for SimuFlite. He brings 20 years of Instructing and Training Management experience in addition to his 4 000 hours of Corporate, P.135 and Instruction time to his present position. He earned a B.S. in Physics from Georgetown University, and a Masters in Business Administration from Florida Technological University.

Tom serves on the Air Carrier Working Group of the ARAC Training and Qualification Sub-committee, ATA's Advanced Qualification Program Working Group and has been an active member of GAMA's Safety Affairs Committee for six years.

HUMAN FACTORS RESEARCH DATA APPLIED TO THE TAKEOFF SAFETY TRAINING AID

By Capt. William C. Roberson and Dr. William D. Shontz, Ph.D. (USA)

The Boeing Company has led a group of airframe manufacturers, airlines, pilot groups and government/regulatory agencies in developing the *Takeoff Safety Training Aid* that has been distributed to a large portion of the airline industry. In support of the development of this training aid, a simulator study was useful in obtaining a better understanding of the areas in which crew performance can be improved. The study also provided a baseline of performance that could be used to confirm that the use of the Aid does provide improved performance.

The study was conducted in a B737-300 full flight simulator at the Boeing Customer Training facility to evaluate pilot decision making and performance under various situations in which decisions on whether or not to reject a take off had to be made and executed. A total of eight (8) situations were defined in which Go/No Go decisions had to be made near V1 speed. Subjects included 24 Boeing instructor pilots and 24 line pilots from five different airlines. The sequence of events the pilots met was carefully balanced across the subjects to control for learning effects. The results of the study are reported as quantitative data on RTO decisions, stopping performance, and procedure accomplishment plus a summary of data derived from post-run debriefings of the airline pilots. Lessons learned, conclusions, and recommendations for RTO training are presented.

How this study was used to develop example training scenarios and how this new training has been incorporated into simulator training will be reviewed.

***Captain William C. Roberson**, Senior Instructor Pilot, Flight Crew Training, Boeing Commercial Airplane Group, maintains instructor currency in the 737, 757, and 767, and was co-manager of the Takeoff Safety Training Aid development program.*

Bill received his bachelor's degree in Aeronautical Engineering from the U.S. Air Force Academy in 1973 and his master's degree in Aeronautical and Astronautical Engineering from Stanford University in 1981. He has also attended flight test courses at the University of Tennessee Space Institute.

Bill is a command pilot in the U.S. Air Force Reserve flying the C-141.

In addition to flying jobs, Bill also spent four years as an Assistant Professor of Aeronautics at the USAF Academy teaching aircraft performance, stability and control, aircraft design, and flight test. During this time, he continued to keep up his flying by instructing in various light aircraft along with the DH-6, Twin Otter.

***Dr. William D. Shontz**, Ph.D., is the technical lead on several projects within the Systems Awareness Program which he manages. The projects involve development and testing of advanced flight deck systems concepts.*

Bill received his Ph. D. degree in Experimental Psychology from Iowa State University in 1967 and his M.S. degree in Industrial Psychology from ISU in 1959. He also was a medium transport pilot in the Air Force.

Dr. Shontz has 12 years experience conducting human factors studies and human performance research in aerospace and commercial airplane companies. He also has 18 years experience teaching and conducting research in applied behavioral science topics.

HUMAN FACTORS TRAINING FOR AUTOMATION

MORNING SESSION CHAIRPERSON: PROF. EARL L. WIENER, PH.D. (USA)

LIFE IN THE SECOND DECADE OF THE GLASS COCKPIT

by Prof. Earl L. Wiener, Ph.D. (USA)

As we enter the second decade of highly sophisticated airline cockpits, it would seem wise to take stock of the lessons learned, and the problems yet to be solved.

First always is safety. The glass cockpit aircraft have distinguished themselves with the best safety start-up period in air transport history. At the time of this writing, there has never been a serious accident involving a U.S.-operated glass cockpit aircraft. Still safety problems remain, and the professions cannot relax their vigil. Problems of mode confusion, possibly of situational awareness, and of locally excessive workload still must be addressed by both the research and the operational community.

Training for advanced technology aircraft is an area that has still not been worked out to the satisfaction of the airlines, particularly for pilots transitioning to glass aircraft for the first time. Some novel solutions, including pre-ground-school introduction to aircraft automation (IAA), pioneered by Delta, are now being introduced by other air carriers, and appear to be quite effective.

Crew coordination and CRM for the advanced cockpits has only recently been examined by the research community. As this research matures, it will probably point the way for better management in the cockpit. It is clear that the glass cockpits tend to be "management intensive". How to handle this phenomenon is less clear.

Cooperation between the research community and the user community has been excellent. In the decade ahead, researchers will have to confront more of the "fuzzy" problems of modern flight, such as situational awareness, complacency, and the influence of automation on crew coordination and communication.

Earl L. Wiener is a professor of Management Science at the University of Miami. He received his B.A. in psychology from Duke University, and his Ph.D. in psychology and industrial engineering from Ohio State University. He served as a pilot in the U.S. Air Force and U.S. Army, and is rated in fixed wing and rotary wing aircraft.

Since 1979 he has been active in the aeronautics and cockpit automation research of NASA's Ames Research Center. Dr. Wiener is a fellow of the Human Factors Society and the American Psychological Association, and has served as president of the Human Factors Society. He currently serves on NASA's Aerospace Research and Technology Subcommittee, and the FAA's Research, Engineering, and Development Committee.

He is the co-editor (with David Nagel) of Human Factors in Aviation, published in 1988 by Academic Press, and a forthcoming book, Cockpit Resource Management (with Barbara Kanki and Robert Helmreich), also from Academic Press.

MANAGING THE MODERN COCKPIT — A MANUFACTURER'S VIEW

By Capt. C.L. Ekstrand (USA)

The last decade has seen the introduction of many high-technology airplanes into the air transportation system. These high-tech airplanes have typically included flight decks with a highly integrated Flight Management System (FMS) which among other elements, include Flight Management Computers (FMC's), electronic displays, advanced capability autopilot/flight director systems, and centralized crew alerting systems. Some allege they have also introduced a host of problems in terms of effectively utilizing the nw technologies. It has been suggested they are, on balance, taking the pilot out of the loop.

Some detractors would suggest that we need to return to less sophisticated flight decks. Others say we need to make significant changes in the new technologies to fully meet the needs of pilots.

Available data, however, gives little support to the arguments of those who would seek to undo what has been done or suggest significant design change is necessary. However, not all is well. High-tech airplanes have provided many tools which have potential to be a detriment if not properly used, resulting in an environment of complacency where pilots allow themselves to get "out of the loop".

There are many factors which are essential in assuring that we effectively and responsibly utilize the vast capacity provided by high-tech flight decks. No factor is more important, however, than the operating strategies that flight crew employ in use of automation and the related training that assures the strategies are appropriately applied.

Highly successful operating strategies and training must recognize and respond to needs of new technology airplanes and to changes in the operational environment. The near life-like reasoning capability of the FMC becomes much like a third person on the flight deck and, if misused, disrupts the desirable man/machine relationship where humans work effectively together to interface with the machine. Because of this potential the man/man/machine relationship must be consciously and deliberately managed and trained-to in order to optimize the outcome.

This paper examines perceived problems with high-tech flight decks and examines opportunities for improvement through operating strategies and training.

Captain Chester "Chet" Ekstrand, is currently Director - Flight Training and Industry Regulatory Affairs for the Customer Services Division of the Boeing Commercial Airplane Group. He has responsibility for flight crew and flight attendant training, as well as airline support responsibilities including development of airplane operating and training manuals. Additionally; he is responsible for liaison with regulatory authorities and industry groups on issues related to the inservice operation of airplanes.

Chet began his Boeing career 26 years ago and has been qualified in one or lore crewmember positions on the 727, 737, 747, 757 and 767 airplanes. Prior to assuming his current position in October of 1991, Chet has held positions as Instructor Flight Engineer, Instructor Pilot, Assistant Chief Pilot - New Airplanes, Chief Pilot - Flight Training and Director - Flight Crew Operations.

In addition to training airline crews, Chet has been extensively involved in flight crew related technical activities including flight deck design and flight test. He has also been involved in industry activities and issues, particularly those associated with flight safety. He was the prime Boeimg pilot focal point for development of the FAA Windshear Training Aid and had overall responsibility for the development of the recently completed Takeoff Safety Training Aid.

FUNDAMENTAL ENGINEERING TRAINING OF FLIGHT PERSONNEL AS A MEANS TO MAKE HUMAN FACTORS MORE ACTIVE IN AVIATION

By Dr. P.V. Nazarenko and Dr. M.F. Davidenko (RUSSIAN FEDERATION)

The increasing complexity of the design of a new generation of aircraft, the striving for a reduction in operating costs by reducing the number of crew members and the implementation of new technologies in aviation require intensified fundamental engineering training of flight personnel which makes it possible to train successfully operators of flying automated electronic systems. A new system of flight personnel instruction, which combines the fundamental, humanities, general scientific, engineering and professional training of flight engineers and pilots, has been implemented at the Flight Faculty of the Kiev Institute of Civil Aviation Engineers. At all stages of instruction, there is goal-oriented training in the area of the influence of human factors on flight safety. The new concept of flight personnel training was successfully approved over a period of 15 years of experience in instructing flight engineers for top-of-the-line aeroplanes. The concept has now been transformed into a training system for pilot-engineers for a new generation of aircraft.

__P.V. Nazarenko__, Professor, Doctor of Technical Sciences, Head of the Kiev Institute of Civil Aviation Engineers.

__Michail F. Davidenko__ is Head of Flight Safety Department, Dean of the Faculty at the Kiev Institute of Civil Aviation Engineers. He graduated from the mentioned Institute in 1954, then worked as an engineer at Aviation Enterprises. While continuing his post graduate studies, which led to a Candidate of Science Degree in 1966, he pursued his technical activities in the field of Aircraft Maintenance. M. F. Davidenko received scientific title of Professor in 1990.

His career as a scientist and educator is closely connected with the elaboration of Human Factor problems in flight safety. He has actively promoted flight engineers and pilot-engineers training on the concept of engineering knowledge and aircraft piloting experience.

THE OTHER SIDE OF AUTOMATION — A CHALLENGE FOR PILOT TRAINING

By Capt. Dieter Schlund and F/0 Martin Wyler (SWITZERLAND)

1. Starting point

In order for pilots to be properly trained for work in modern cockpits, it is first necessary to explore and determine the technical characteristics of the Advanced Technology Flight Deck and its effect on the crew.

2. Characteristics of the advanced technology flight deck

The most outstanding features of the modern cockpit are the computation and display of flight data, user-friendly controls, and a high degree of automation. For the crew, this means both a greater level of situational awareness and a reduction in workload. All in all, the technological advances have made for more efficient flight operation.

Less obvious are the negative effects of technological advance, which can be described as new risk factors. These can be summarized as follows:

- The increasing complexity of modern systems, one effect of which is to hinder the analysis of unforeseen errors.

- An uneven workload during a flight, one effect of which is to heighten monotony, thereby creating an opening for negligence. On the other hand, a sudden necessity to deviate from the programmed routine may create an unexpectedly heavy workload.

- The deficiencies of software controlled systems, which increasingly dictate flight operation and sometimes present us with supposedly digital precision derived from erroneous data banks.

- The erosion of good airmanship, which must be understood as a human reaction to the design of the Advanced Technology Flight Deck.

3. Consequences for training

The immediate priority is to raise cockpit crew awareness about the risks identified above. As these are problems inherent in the system, they are not necessarily obvious to those affected.

New avenues will need to be explored in training. The theory aspects need to be expanded to include computer technology and system networks as independent subjects.

Complex systems need to be learned in a dynamic environment, for which computer based training and simulators are very well suited. Integrated training, i.e. combining theory and practice, is the ideal approach.

In order to learn about the various systems, training in resource management is essential. SWISSAIR believes that implementing training in resource management and human aspect development (HAD) as a partial substitute for line checks better serves the interests of flight safety.

Finally, initial and recurrent training must be conducted in such a manner that pilots have full confidence in their basic flying skills.

***Capt. Dieter Schlund** was born on 29 February 1944, in Zurich, Switzerland. He graduated as a pilot from the Swiss Civil Aviation School in 1967. His career with SWISSAIR began in 1968 as First Officer on DC-9, CV-990 Coronado and DC-10. Then he was upgraded as Captain on DC-9 (1976) and Fokker F100 (1987). In addition to flight service, Capt. Schlund has performed various duties such as route check, simulator and flight instructor. He also assumed management functions for SWISSAIR since 1979, and is now the Head of Cockpit Crews and Chief Pilot since 1988.*

***Martin Wyler**, born May 6, 1954 in Lucerne, Switzerland. Gymnasium for economics and study in economics at university of Zurich. Trained as a military pilot. Seven years full time military pilot, mostly as a flight instructor (Switzerland also knows the militia airforce system, similar to the US National Guard reserves). For three years member of the Swiss Air Force Aerobatic Team "Patrouille Suisse". Since 1991 commander of a F-5E reserve squadron.*

Since 1983 first officer with SWISSAIR, initially on McDonnell-Douglas DC-9-30 and -50, on Fokker F100, since 1992 on MDC MD-11. Member of cockpit management: one year as deputy chief pilot Fokker F100, since 1990 assistant head cockpit crews.

TRAINING FOR COMPUTER ASSISTED FLYING (CAF)

By Capt. Matti Sorsa (IFALPA)

IFALPA wishes everybody to understand that training has no independent value as such. Training is a part of the system where earlier decisions concerning hardware and software design of the equipment, procedures and company policies behind them and the over-all socio-economic climate will dictate most of the end result, flight safety.

Computer Assisted Flying (CAF) is a term we in IFALPA prefer for automation. The basic function of the pilot has not been changed too much. The pilot is still the human tasked to be responsible for the safe and economic execution of the flight. It is relatively easy to test this claim. You only have to think of the possibilities of the pilot not to operate in a safe or economic manner. Thus, as ever, it all ultimately rests on the shoulders of the pilots. Technical assistance has changed a lot during the years, of course. At the moment the order of the day is the assistance provided by computers. We think that CAF is an accurate term to describe what we are talking about.

When components change in any technological system, training should reflect that change. It would be simplistic to approach this requirement by demanding that training should be directed at these new components only; in this case computers and their effect on the autopilot. CAF demands a totally different way of thinking. Due to its inherently totalistic nature we think it is essential that training is not concentrated on the software and hardware as such. As the concept of operating aircraft is so deeply affected it should be taken into account from the beginning. Thus, in practice, training for CAF should be integrated with the effects of this level of technology on the essential functions of decision-making and communication as well as leadership concepts.

Training upwards along these lines requires that the training systems uses intelligently and economically the CBT (Computer Based Training) and FTD (Flight Training Device) opportunities. Perhaps the most important phase of the CAF training are the familiarization flights on the line. It cannot be over emphasized how important it is to select the right people for the role of the route instructors.

It is understandable that especially in the case of the manufacturers' training the emphasis is on the positive and advanced aspects of CAF. It is however operationally important to learn well when you should not use some specific level of automation. In fact there are two kinds of redundancy, voluntary and involuntary.

We pilots in IFALPA feel that flying advanced airplanes, flying assisted by computers, requires a truly wholistic training approach. The operational implications of the various levels of the automation chosen or available for use should be made clear from the start.

Captain Sorsa is an active Airline Pilot flying Finnair MD-80 aircraft. He received a Master's degree in applied psychology from Helsinki University and specialized in Aviation Safety and Human Factors. He has been actively developing Human Factors training and the application of Human Factors in accident investigation. Captain Sorsa is a member of the IFALPA Human Performance Committee and IFALPA's representative in the ICAO Human Factors Study Group. He has been an active member in Western European Association for Aviation Psychology and a Secretary of WEAAP's 1985 Conference.

IMPROVING THE PROCESS OF THE SELECTION AND TRAINING OF CONTROLLERS IN AUTOMATED ATC SYSTEMS

By Dr. E.L. Kan and Dr. I.G. Yunatova (RUSSIAN FEDERATION)

On the basis of a large number of actual medico-physiological and psycho-physiological data, comprehensively characterizing the particular features of ATC controllers' activities, the existence of professional intellectual-emotional stress in this category of workers in the ATC process is formulated and validated. The concepts of physiological reserves, tolerance and effectiveness of adaptation to this stress are identified. Specialized technical devices have been developed to identify medico-physiological and psycho-physiological qualities which are important professionally for working in automated ATC systems. A computer set of diagnostic tests using modern software has been developed and implemented. Automated psycho-diagnostic hardware has been developed and approved for the operational assessment of the level of development of the professionally important qualities of an ATC controller. The possibility of developing these qualities in the controller instruction and training process is validated. It is recommended that prolonged professional selection be conducted. This makes it possible to relax the criteria for the preliminary professional selection of school-leavers and of candidates who wish to transfer to work in automated systems. This is advisable given the low competition for educational institutions and the implementation of an individual approach when allocating graduating students around airports with different levels of complexity and according to the degree of automation. The results of the study performed make it possible to formulate approaches vis-à-vis the process of training specialists and their work in automated ATC systems.

AFTERNOON SESSION

CHAIRPERSON: DR. WILLIAM T. SHEPHERD, PH.D. (USA)

Dr. William T. Shepherd, Ph.D. (USA)

Dr. Shepherd is manager of FAA's Biomedical and Behavioral Sciences Branch in the Office of Aviation Medicine. He is responsible for the Washington Headquarters Aviation Medicine research program dealing with such topics as air traffic controller performance and protection of general aviation aircraft occupants in accidents. Dr. Shepherd has B.S. and M.S. degrees in aerospace engineering and received the Ph.D. in psychology from the University of Connecticut. He is a member of the Human Factors Society and the Aerospace Medical Association. He is also a commercial pilot with instrument, flight instructor and multi-engine ratings.

PILOT'S STRATEGIES OF CREW COMMUNICATION IN ADVANCED GLASS COCKPITS — A MATTER OF EXPERTISE AND CULTURE

By Ms. Claire Pelegrin and Dr. René Amalberti, Ph.D. (FRANCE)

The strategies of crew coordination of 40 Airbus A320 trainees representing several airlines from different continents have been analyzed during their regular training courses on the A320.

The experiment was sponsored by the French Civil Aviation Authorities (DGAC) and have been jointly conducted by several National Research Labs in order to observe and record the differences in crew coordination according to the level of expertise and some cultural factors such as the command of English or the use of gestures.

Each crew has been simultaneously filmed from three different angles, during two simulator training sessions, one at the beginning of the Full Flight Simulator training phase (FFS) and one at the end of this FFS phase just before the final check.

The analysis of sessions (horizontal analysis) systematically considers verbal communication, gestures, and overall scanning of the two pilots. A classification of the methods of communication and the resulting strategies of crew coordination emerge from this analysis. This classification serves as a tool for comparing English native speakers and non English native speakers, especially considering the change in the ratio between verbal and non verbal communication.
A second analysis (vertical analysis) compares the changes in communication strategies due to progress in training (between-session comparison).

Results show various patterns of crew coordination deviating to a greater or lesser extent from the laid-down procedures. What is important to consider is that these deviations are rarely due to an intrinsically weak professional level of pilots, but result more often from three external factors : poor command of English, glass cockpit effect (change in task sharing and in the instrument panel), and individual style of communication (which depends both on individual traits, cultural factors and on the level of confidence in the other pilot).

A final discussion of these results may introduce some changes in training methods and subsequent improvements in flight safety.

*At first, **Claire Pelegrin** specialized in human sciences. Various experiences in psychomotor skill, in the field of public relations and organization were a good approach to the study of human behaviour. She joined Aeroformation in 1988 in the General Research Department and deals more particularly with the improvement of training from a human point of view. Concerning the human aspect, she is in charge of COSYNUS (data acquisition system for aiding pilot training) aimed at improving the pedagogical approach. On the other side, a data basis gathering trainees opinions aims at improving the training performance. She also is involved in the training team for AIM (Airbus CRM course). She also takes part in research programs held by research centers and universities.*

***Dr. René Amalberti**, Medical doctor, Ph.D. Cognitive Psychology, Deputy-head of Aerospace Ergonomics Department of CERMA (Centre d'Étude et de Recherches de Médecine Aérospatiale), Associated Professor University Paris VIII. Two books and over 100 national and international papers published. Project-manager, Head of the research program on human factors aspects of intelligent assistance in military cockpits (French Pilot's assistant program). Consultant Aeroformation-Airbus for A320 pilot training. Consultant Human factors for the French Aviation Authorities ("Bureau des Enquêtes Aériennes" National enquiry board office). Lecturer at the OCAI international turning seminar on "Human factors in aviation". Co-responsible for the French-American military cooperation on Advanced cockpits (virtuals cockpits).*

COMPUTER-BASED APPROACHES FOR ENHANCING HUMAN PERFORMANCE IN AVIATION MAINTENANCE

By Dr. William B. Johnson, Ph.D.(USA)

Advanced technology computer hardware and software provides opportunities to enhance the performance of aviation maintenance technicians. Maintenance tasks require that the technician be properly trained and have access to technical information appropriate for each aircraft. Therefore, improved training and information access is likely to enhance human maintenance performance.

This paper describes the concept of integrated information systems for maintenance environments. These systems capitalize on expert-system software technology to deliver simulation-based training and real time job-aiding for troubleshooting. The systems operate on small desktop and portable computer hardware. In addition, the systems are being designed to use "Pen" computers, that require no keyboard and use a pen to write on the computer screen. The pen technology will permit easy access to technical documentation as well as a convenient means for the technician to complete required documentation of maintenance.

The paper and presentation will show specific examples of operational integrated information systems.

Dr. William B. Johnson is the Vice President of the Information Division for Galaxy Scientific Corporation in Atlanta, Georgia, USA. He is the Galaxy program manager for the Human Factors in Aviation Maintenance research program sponsored by the FAA Office of Aviation Medicine.

Dr. Johnson received his Ph.D. in Education from the University of Illinois. He is an Airframe and Powerplant mechanic and a pilot. He has over twenty five years experience in the development and delivery of vocational and technical education materials in secondary schools, universities, and a variety of industrial and military environments. He has over seventy publications related to the use of computers in technical training and working environments.

INSTRUCTIONAL QUALITIES OF A SIMULATOR AND HUMAN FACTORS

By Dr. L.M. Berestov and Dr. G.A. Meerovich (RUSSIAN FEDERATION)

Up until recently the measure of the efficiency of simulators has been whether the achieved flight performance and other characteristics have been equal to those of the original aeroplane. This principle is the basis of standards for simulators, for example, the FAA AC 120-40B standard. As a result of research performed at the Flight Research Institute, another, we think, more progressive principle is proposed - in addition to the requirements mentioned above - that is whether the piloting skills acquired on a simulator are equal to those developed when instruction is given in flight on the same aeroplane. The principles of direct assessment of instructional qualities do not contradict the principle of the equivalence of performance, but rather they must be considered as corresponding to a higher level of simulator evaluation. Such is the opinion of the participants of the Working Group on the development of international standards for aircraft simulators.

The instructional qualities can be formalized and quantitatively determined on the basis of the so-called "piloting references"; these are to be determined during the certification testing of an aircraft. Their substance, tolerances and methods of experimental assessment will be described in detail in the paper.

An important role in the development of the simulator instructional qualities is played by the information field of the instructor's console. The information field includes, on the one hand, the piloting references for continuous and discrete control procedures and, on the other hand, the actual piloting parameters. A comparison of the actual parameters with the piloting references makes it possible for the instructor not only to monitor operationally with a high degree of precision the actions of the person being taught, but also to control the training effectively. In this way the principle of formalizing the instructional properties, which is used to improve the simulator, makes it possible to increase substantially the quality of the training process. As a result one notes a reduction in the negative influence of human factors not only on the pilot, but also on the instructor. The paper intends to cover in deal the results of many years of research which has made it possible to optimize the information field of the instructor's console.

The last part describes the results of research on an important aspect of piloting skills, that is ensuring the interaction of crew members. Here parameters such as the characteristics of separate piloting, the identification of the pilot performing certain specific procedures and, finally, the monitoring of conversations on the basis of acoustic references, are illustrated.

***Dr. L.M. Berestov** is currently Deputy Director for Science at the Flight Research Institute of the Russian Federation Aviation Industry. He has been working at the Institute since 1957 upon graduating from Moscow Aviation Institute. His research interests are in flight dynamics, identification, in-flight simulation, organization and methods of flight testing and certification, airworthiness requirements development. He is Professor of Moscow Aviation Institute. In 1990 he was awarded the honorary title of Honoured Man of Science and Technology. He has been a member of the USSR Delegation at the last three ICAO Assemblies, and taken part in the ICAO Flight Safety and Human Factors Study Group. Dr. Berestov has published five books.*

***Dr. Georgy Meerovich** is working at the Flight Research Institute since 1947. He is a prominent specialist in the field of flight testing, certification, flight simulator development, human factors. He defended his candidate thesis on the ejection dynamics in 1954 and received his Doctor of Science in methods of flight testing for airplane effectiveness evaluation in 1969. He is Professor of Moscow Physical and Technology Institute. Since 1954 he is Head of the Laboratory for Training Methods and Aids, a member of the Working Group for developing international requirements to flight simulators. He has published a number of books including Large System Effect, Flight Simulators and Safety of Flight, Certification Tests.*

TAXONOMY AND MODELS FOR HUMAN FACTORS ANALYSIS OF INTERACTIVE SYSTEMS: AN APPLICATION TO FLIGHT SAFETY

By Dr. P. Carlo Cacciabue and M. Pedrali (ITALY) and E. Hollnagel (DENMARK)

This paper discusses how the problem of handling human erroneous behaviour can appropriately be studied by a framework that comprises four modelling phases, namely: the consideration for a paradigm of human behaviour; the development of a taxonomy for the consideration of human erroneous actions, which maintains a logical connection between causes-manifestation and consequences of human erroneous behaviour; 3) the evaluation of appropriate tables of the taxonomy and correlation with the working environment able to account for the actual domain of analysis and the Human-Machine Interaction (HMI) process; and 4) the assumption of a human factor approach offering different levels of complexity for tackling a variety of problems.

Such type of analysis can be carried out either in a retro-spective or in a pro-spective way. In this manner, the evaluation of already occurred events (retro-spective) can be performed identifying the detail link existing between the actual working environment and the model/taxonomy framework. Similarly, the study of hypothetical future events (pro-spective can then be dome in a consistent manner with the dynamics of the HMI and the reality of the work domain.

The current research and development of the taxonomy, as far as theoretical work is concerned, is well advanced. The application to real working domain has been focuses as civil aviation and the study of a real accident case has been performed using the retro-spective approach. Such study case will be described and discussed in detail, showing how the feedback deriving form the analysis of real cases is fundamental for the formulation of sound modelling paradigms for safety and reliability type studies.

P. Carlo Cacciabue, Commission of the European Communities, Joint Research Centre, Institute for Systems Engineering and Informatics, Ispra, Italy.

OVERCOMING OBSTACLES IN THE APPLICATION OF RESEARCH TO PRACTICE IN THE AVIATION ENVIRONMENT

By Dr. Thomas McCloy and Dr. Mark Hofmann (USA)

First, this paper will provide examples of research results which have been put into practice in the aviation environment. These examples may apply to jobs, procedures, and/or design. Second, this paper will discuss factors that are important when introducing new things or ways of doing business, i.e., "change." This will include factors as seen from various perspectives such as operators, maintainers, investors, etc. Third, this paper will relate these factors back to the examples previously discussed where research results reached practice. Fourth, this paper will provide a list of factors which, if addressed, will enhance the success of applying research to practice in the aviation environment.

Dr. Tom McCloy *received his pilot wings through the United States Air Force Undergraduate Pilot Training Program. He has a variety of aviator experience, including combat and noncombat, jet and propeller, fixed and rotor wing aircraft. He was a Professor of Human Factors at the United States Air Force Academy, and taught human factors engineering at the Air Force Test Pilot School. Tom is currently a Scientific and Technical Advisor for Human Factors with the Federal Aviation Administration. In this capacity, his primary focus is coordinating research efforts in support of the National Plan for Aviation Human Factors, and facilitating the implementation of their results into the operational community.*

Dr. Mark Hofmann *has been in the human factors business in various capacities within the Department of Defense for many years. In his last assignment, he served as the Associate Director of the U.S. Army Human Engineering Laboratory. Mark is currently a Scientific and Technical Advisor for Human Factors with the Federal Aviation Administration (FAA). In this capacity, his primary focus is to assist the FAA in maintaining a responsive Human Factors program.*

APPENDIX A - PRESENTATION OF PAPERS

DEVELOPING HUMAN FACTORS KNOWLEDGE

HUMAN FACTORS TRAINING FOR OPERATIONAL PERSONNEL

Neil Johnston[1]

(Ireland)

Introduction

When I sat down to prepare this paper I first looked back through my old notes and correspondence, dating back to the early 1970s. 1975 marks the first reference to my long-held belief that there was a need for human factors training for operational personnel. That particular reference was in internal IFALPA[2] correspondence, and it was in an IFALPA capacity that I lobbied over subsequent years for the incorporation of suitable human factors training into the pilot training and licensing system.

The latest revision to ICAO Annex I (Personnel Licensing), effective November 1988, established an international requirement for licence applicants to demonstrate suitable human factors knowledge at the ***ab initio*** pilot training stage. Given the preceding comments, it will come as no surprise that I strongly supported and endorsed this ICAO initiative.

It was a particular pleasure to be subsequently invited to represent IATA[3] at the then newly formed ICAO Flight Safety and Human Factors Study Group. As a member of that group I produced the first draft of ICAO Human Factors Digest Number 3, **"Training of Operational Personnel in Human Factors"**[4]. I make these remarks to establish that I am not an entirely neutral participant when discussing this particular subject!

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[1] Aerospace Psychology Research Group, Trinity College, Dublin 2, Ireland.

[2] International Federation of Airline Pilot Associations

[3] International Air Transport Association.

[4] ICAO Circular 227-AN/136, 1991. This was third in a series of Human Factors Digests published by ICAO. To date a total of eight Digests have been published.

In this paper I seek to explain why I believe that human factors knowledge has an important role to play. I provide some information on how this new training is being received by trainee pilots. The primary emphasis here is on human factors knowledge training for pilots. However most of the discussion can be applied to others in the operational environment, including air traffic controllers and dispatchers.

Human Factors - Knowledge or Skills?

It is an enduringly well established and repeated fact that human failure is the predominant contributory factor in aviation accidents and incidents. Equally enduring is the plaintive question "but what can we do about it?"

I remember my surprise when I first discovered that academic psychology had long known the nature of visual and other illusions while I, as an airline pilot who was potentially susceptible to various life threatening illusions, had received little information about those illusions, nor about those circumstances in which they might occur. My interest in human factors training for operational personnel dates from that time.

However, it must be immediately conceded that a decision to send all pilots on an undergraduate course in aviation psychology is no solution. Indeed it has long been a matter of debate as to which aspects of human capabilities and limitations should - or could - be successfully addressed by training. For instance, an immediate riposte to my visual illusions example above might be as follows: "knowing about the nature of visual illusions, and about the underlying psychological processes, provides little protection from their more insidious effects - greater preventative value has been achieved over the years by improvements in infrastructure (such as the introduction of VASI's) and through the rigorous application of Standard Operating Procedures and Standard Callouts".

Thus we have here two rather different perspectives. A very crude generalisation can be made at this point, namely that there has been a tendency in North America to favour the latter argument, focusing on the development of infrastructure and applied cockpit skills, while other areas of the world - most notably Europe - have tended to emphasise the acquisition of basic knowledge. This general European orientation and emphasis on basic knowledge is reflected by the fact that the ground-school training for airline sponsored CPL/IR[5] training in Europe often requires 1,000-1,400 hours of study, whereas one can obtain the same basic licence in the U.S. after considerably less ground study (Johnston, 1989).

[5] Commercial Pilot's Licence and Instrument Rating.

It thus comes as no surprise to hear that one of the very first knowledge-based Human Factors courses for operational personnel, KHUFAC - the **K**LM **Hu**man **F**actors **A**wareness **C**ourse - was produced by a leading European airline, KLM. The theme of the KHUFAC course was ***"education is the key"***. KHUFAC was developed as a course for established airline pilots and it received mixed reviews. Some felt that it gave pilots "a new language and understanding", while others felt it was overly academic in its approach and lacked an applied focus.

The European Civil Aviation Conference (ECAC) responded promptly to the 1988 ICAO Annex I human factors training requirement, producing a detailed syllabus for their course on Human Performance and Limitations (HPL). The United Kingdom was the first European country to mandate, for pilot licensing purposes, a pass in an examination associated with an HPL course (Barnes, 1993).

On the other hand, it was a leading U.S. carrier, United Airlines, which developed and introduced the first CRM course. CRM has always had a highly applied emphasis. Indeed in the following years, as we have advanced into third and fourth generation CRM courses, the emphasis on applied and practical issues has increased steadily, along with the sophistication of CRM training. Similarly, it was the governments of the United States and Canada who pioneered and sustained the Pilot Judgment and Aeronautical/Pilot Decision Making programmes, each of which has an equally applied focus. The developing trend to AQP (Advanced Qualification Programmes) is another U.S. initiative which shows great operational and training promise.

These points having been made, it must be immediately stated that the picture I have painted here could be misleading in certain respects. For instance, it is a paradox that it is only in countries such as the United States, Canada, New Zealand and Australia that one can obtain a university qualification in aviation psychology. There are no such courses at any university in Europe and, until recently, (January 1993) there had never been a Professor of Aviation Psychology in Europe! On the other hand the proposal by the European JAA[6] for 30 hours of mandatory Multi-crew Cooperation (MCC) Training as part of the CPL/IR syllabus, is a unique and highly applied innovation in the area of applied human factors and resource management skills (Johnston, 1993a; Joint Airworthiness Authorities, 1992).

Why Should Pilots have to Know about Human Factors?

Thus, as with all crude dichotomies, there are a number of

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[6] Joint Airworthiness Authorities.

inconsistencies to be found in my characterisation above. Perhaps the best way of resolving these differences, at least for the purposes of this discussion, is to first observe that we are comparing different licensing, training and operating environments - each with their unique local cultures, operational needs and solutions. However, I do think we may each need to learn a little from each other, and perhaps the best way forward is to integrate the better aspects of each system.

When we discuss human factors knowledge - in other words the learning of facts and theories relating to human capabilities - it is important to clearly differentiate between the needs of the aspiring pilot and the needs of those who are already qualified as pilots. Qualified pilots are typically pragmatic and they tend to be opposed to the acquisition of abstract knowledge which lacks immediacy and an applied focus. On the other hand, most qualified pilots will initially look with some sympathy at applied training which appeals to their sense of professionalism, and which aims to increase their competence as a pilot.

In this discussion the focus is <u>entirely upon pilots undergoing training for the issue of their licence</u> - the ***ab initio*** pilot. The argument I wish to promote is simple - if we feel that such pilots need to know and understand facts and theories about meteorology, aerodynamics, navigation, and so forth, then they should equally be expected to know and understand basic human factors, as this relates to their safe and effective functioning within the aviation system.

We have been prepared for decades to mandate hours of study for technical subjects, but have denied the relevance, importance or practicality of training in human factors. Until relatively recently this, in fact, was very much the conventional wisdom. It remained the conventional wisdom for years because of diverse arguments. Two key arguments against the recent Annex I revision were, (i) that pilots would reject any such training as being irrelevant, and, (ii) that it was impossible to specify training in human factors because there was no agreed definition of the term human factors, and no agreement as to its constituent elements.

Both of these arguments originate from another era and are invalid. Consider the first argument, that pilots would reject such training. So far two courses of ***ab initio*** pilots from my airline (Aer Lingus) have undertaken the Human Performance and Limitations (HPL) course as part of their CPL/IR training in the United Kingdom (at Air Services Training, Perth, Scotland). I can certainly testify that they enjoyed their training and felt it was very relevant.

I have spoken to both classes at some length and only one pilot expressed any reservations - and that was to the length of the course, rather than the content. More revealing was the general belief that the HPL course covered information which they felt was an integral part of becoming an airline pilot. They found it difficult to believe that previous generations of pilots had not had the benefit of such training. Indeed, this is an interesting reaction in itself. These pilots felt that the knowledge they had gained on the course was an essential part of the knowledge required of any professional pilot. My understanding from enquiries made to a number of U.K. training schools is that such sentiments are shared by most trainees.

Regarding the purported impossibility of defining Human Factors, I can only observe that a working definition is to be found in ICAO Human Factors Digest number 1[7] **"Fundamental Human Factors Concepts"**:

> Human Factors is about people: it is about people in their working and living environments, and it is about their relationship with equipment procedures and the environment. Just as important, it is about their relationship with other people. It involves the over-all performance of human beings within the aviation system. Human Factors seeks to optimize the performance of people by the systematic application of the human sciences, often integrated within the framework of system engineering. Its twin objectives can be seen as safety and efficiency.

Furthermore, in ICAO Human Factors Digest Number 3[8] an entire outline training HPL syllabus has been specified and the Appendices contain information on several additional syllabi. Paradoxically, given the claimed difficulties in defining and teaching human factors subjects, the FS&HFSG found a widespread international consensus as to the essential content of an appropriate HPL training course.

Both of these ICAO sponsored solutions to supposedly intractable problems of definition and application testify to the fact that a lot can invariably be accomplished if we actually get down to a task - rather than arguing *ex ante* about the viability or feasibility of that task!

Human Factors Training: ICAO Initiatives

Recent ICAO initiatives in the area of human factors training for operational personnel followed the publication in 1988 of the Eighth Edition of ICAO Annex 1 (Personnel Licensing). Annex I now

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[7] ICAO Circular 216-AN/131, 1989.

[8] ICAO Circular 227-AN/136, 1991.

mandates a Human Factors knowledge requirement for each category of flight crew licence holder, namely;

> **".... human performance and limitations relevant to...(*the licence being issued*)".**

This knowledge requirement has the same status as knowledge required in respect of any other part of the traditionally accepted pilot training syllabus. It thus requires that pilot training establishments prepare and implement an appropriate training syllabus. Licensing authorities must equally prepare an examination in Human Performance and Limitations (HPL). The implications of this are reviewed in Johnston and Mauriño (1990).

It should also be noted that the Annex 1 requirement for the successful demonstration of human factors skills was also augmented. For instance, the holder of an Airline Transport Pilot Licence must henceforth;

"demonstrate the ability ...to...

(c) **exercise good judgement and airmanship,...**

(f) **understand and apply crew co-ordination and incapacitation procedures; and**

(g) **communicate effectively with the other flight crew members."**

The new JAA proposal for MCC (Multi-Crew Cooperation) training at the CPL/IR training stage is one response to the developing Annex I emphasis on human factors skills training.

Another important ICAO initiative was the formation of the Flight Safety and Human Factors Study Group (FS&HFSG). This acts as an international forum for discussing issues relating to human factors in aviation. ICAO has also published a number of Human Factors Digests, based upon the deliberations and work of the FS&HFSG. A number of world symposia and regional seminars on Human Factors have also been initiated (Mauriño, 1993).

In responding to the Annex I knowledge requirement the FS&HFSG developed the third in its series of Human Factors Digests, titled **"Training of Operating Personnel in Human Factors"**[9]. The general subject content of Digest 3 is outlined in the following section; for detailed information readers are referred to Digest 3 itself.

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[9] ICAO Circular 227-AN/136, 1991.

What do Pilots Need to Know about Human Factors?

A general survey within the aviation industry led the ICAO FS&HFWG to conclude that approximately 35 hours of training would be required to adequately address the proposed human factors training syllabus. A minimum training time of 20 hours was suggested. Judging from recent experience in the United Kingdom, it would appear that 25 hours of training is more than sufficient to reach a good standard of HPL training. U.K. training schools also report that 12-14 hours suffices for experienced pilots who are upgrading from an existing licence to a higher licence (OATS, personal communication, November 1992; AST, personal communication, March 1993).

The following outlines the general subject areas suggested for HPL training in ICAO Human Factors Digest 3. The percentage of the total time to be devoted to each module is suggested in Digest 3, in order to assist training establishments achieve training balance across the syllabus;

Module 1	Introduction	5%
Module 2	The Human Element (Physiology)	20%
Module 3	The Human Element (Psychology)	30%
Module 4	The Human Element (Fitness)	5%
Module 5	Pilot: Equipment	5%
Module 6	Pilot: Software	10%
Module 7	Interpersonal Relations	15%
Module 8	Operating Environment	10%

The ICAO FS&HFSG envisaged that HPL training would be as practical and applied as possible. In Digest 3 it is strongly emphasised that HPL training is not intended as an academic exercise, and that an operational orientation to training is essential. In this regard, feedback from the Aer Lingus trainees referred to above indicates that they found the operational examples and "war stories/hangar talk" to be of special value and assistance during their HPL training.

The two key considerations in achieving a practical and operational orientation to HPL training are; (i) the qualifications of the instructors and, (ii) the nature of the examination. The ICAO FS&HFSG felt that instruction should generally be accomplished by existing flight and ground instructors and that the HPL examination should not have the effect of turning HPL training into an academic exercise. Both of these recommendations were followed when the U.K. training and examination were first developed, though some concern has been expressed about the abstract nature of a few recent examination questions.

Evaluating HPL Training

A clear differentiation was made in Human Factors Digest 3 between examining or assessing human factors knowledge and human factors skills. As a general statement it can be said that the FS&HFSG felt that ***knowledge*** of facts and theories - "declarative knowledge" - is suitable for examination. There appears to be a general consensus, even amongst pilot trainees, that the discipline of preparing for an examination or test in HPL is essential. A multiple choice test seems to be the evaluation method of choice; a number of typical questions are provided in Appendix 1.

On the other hand, it was generally agreed by the ICAO FS&HFSG that teaching and evaluating human factors ***skills*** requires much greater subtlety. Adult learning methods (Telfer, 1993) and experiential teaching techniques are more appropriate to teaching applied human factors skills. Success in using these techniques necessitates an open learning environment and an operational orientation to the training. Such an environment is incompatible with the dictates of a concluding examination or test. Not least of the reasons for this is that trainees frequently seek to tailor their performance and responses to their ***perception*** of what is required to pass the test, or to please the instructor. Whatever else this may do, it is most unlikely to lead to sustained experiential learning - itself the key training objective (Johnston, 1993b).

Teaching HPL - Experience and Issues Arising

In conducting my research for this paper, I spoke to various U.K. training schools and instructors. Several indicated that their interest in HPL training was initially driven solely by the U.K. CAA licensing requirement. Many attended the first instructor training course in a highly sceptical frame of mind. It was interesting to discover that a number of instructors who were initially sceptical about the desirability and feasibility of HPL training have since become very positive about its value and importance. I feel that this is an interesting and instructive development. Certainly the Aer Lingus trainees, to whom I referred above, found their instruction enthusiastic and relevant.

Some interesting observations were made regarding the impact of culture, notably in circumstances where trainees come from an authoritarian culture. Certain aspects of human factors training, readily accepted by Western students, may be less appealing to students from other societies, indicating that flexible delivery of HF training can be important. For instance, the gender-free orientation in most western societies is not the norm in many other societies. Certain CRM principles may be viewed as a challenge to the natural social order in some societies and some care during instruction may therefore be appropriate (Johnston, 1993c). There are also some indications that the actual HPL examination performance of such trainees may differ from that of trainees from western societies.

Basic *ab initio* training is conducted in accordance with the provisions of ICAO Annex I. Historically these Annex I provisions have emphasised an individualistic approach to training - not least because each licence is issued to an individual, who must demonstrate personal competence. There are, however, some signs that our *ab initio* training methods may have to change somewhat to make them compatible with the increasing trend to emphasise the CRM and teamwork aspects of crew performance - and especially in the light of the teaching content in HPL courses. This represents a new and growing challenge for training establishments.

One of the interesting developments which followed publication of the new Annex I HPL requirement has been the publication of an increasing number of textbooks on human factors in aviation. A number are listed in the bibliography at the end of this paper - although this does not seek to be definitive. Some of these texts are exclusively directed to the HPL examination syllabus, while others are sophisticated and interesting introductions to human factors in aviation. One U.K. training school has developed an attractive workbook on HPL, in which there is a combination of diagrams, teaching text and blank spaces in which trainees fill in their answers to various questions on applied aspects of human factors (AST, personal communication, October, 1992).

A number of university based pilot training courses, which include training for the CPL/IR, have been implemented in recent years, with human factors fully integrated throughout the training syllabus (Hunt, 1993; Telfer, 1993). Similar courses are available at several universities in the United States. A developmental approach to the human factors knowledge requirement is being pursued in Canada (King, 1993), while the draft JAA pilot licensing requirements suggest that human factors training will play an ever increasing role in Europe (Johnston 1993a; Joint Airworthiness Authorities, 1992).

Is Acquiring HPL Knowledge An Isolated Act of Rote Learning?

I referred above to feedback from Aer Lingus trainees who have undertaken HPL training, and who found the supplementary "war stories" or "hangar talk" to be of special value and assistance during their HPL training. It is easy to disparage such comments, since we all know that generations of students from all walks of life have preferred "idle chat" to real learning. But an important issue is raised here - namely, is such hangar talk really "idle"?

I was alerted to the fact that there was much more to this "idle chat" during a number of ostensibly factual lectures on Standard Operating Procedures (SOPs). I conducted these lecture/discussions during the MCC "bridge" training course conducted by Aer Lingus for pilots joining the airline (Johnston, 1992). My lectures consisted of a brief review of SOPs, starting with a background justification, followed by a general run through the Aer Lingus SOPs we use in our MCC simulator training.

Most of our MCC training is conducted as a classroom dialogue and I noticed after a number of courses that much less attention was initially paid to the actual procedures than to considerations about the context in which the procedures were used and, specifically, when they would - and would not - apply. In the beginning I kept returning to the facts, namely the substance of the SOPs, feeling that the trainees were missing the point. Eventually I concluded that it was I who was missing the point. For, to the trainees, the "facts" about our SOPs, and the merits of memorising them, were only relevant after they came to some understanding about the social and operational context in which their learning was to be applied.

I feel that this is a key point, and it has caused me to revise somewhat the views I previously held on human factors training for operational personnel. The reader may consider that I am overstating an obvious point. However, if it is really obvious and important, I must then ask why we fail to draw the necessary conclusions for training practice and move to regularise and formalise the consequent training implications across the entire aviation training spectrum?

I still feel that factual knowledge about HPL is of considerable importance, but it is equally clear that learning facts - declarative knowledge - cannot be isolated from the understandings of trainees regarding the operational pertinence of those facts. In the words of Lave and Wenger "...learning is an integral and inseparable aspect of social practice" (Lave and Wenger, 1991). Learning, or knowing, various facts about human factors cannot be considered independently of the trainee's ability to recognise their operational relevance and understand how they should be applied. In Lave's terms (Lave, 1988) we are dealing here with a dynamic encounter between the trainee and his understanding of the nature and demands of the operational environment.

The trainee is moving through a long training process - of which HPL training is but one part - and this will play an inevitable part in changing him or her from novice to expert. In Lave and Wenger's terms, our trainees are apprentices in a "community of practice" and it is through "legitimate peripheral participation" in the activities and understandings of that community that their cognition - and hence their future practice - is shaped.

Among the skills we associate with the transition from neophyte to skilled practitioner is the ability to recognise the relevance of knowledge, combined with a contextual understanding as to how that knowledge can be appropriately and successfully invoked. Part of our aviation "apprenticeship" thus constitutes learning the dialectic between our repertoire of acquired skills and knowledge, and the subsequent application of that knowledge in operational settings. I think it follows that such considerations merit particular attention when HPL training is developed and delivered.

Conclusion

The available evidence suggests that the latest ICAO initiatives on human factors training for operational personnel are meeting with considerable success. The experience of those who have implemented and received HPL training endorses this. When we consider the training needs of *ab initio* pilots, the seamless transition from human factors knowledge to applied human factors skills is undoubtedly an issue of key importance. Having established an adequate base of human factors knowledge at the *ab initio* level, finding better methods of training and developing human factors skills represents a major training challenge for the future. Only when we have successfully integrated human factors knowledge and skills across the entire aviation *ab initio* and recurrent training system can we truly claim to have properly addressed the human factors training challenge.

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References and Select Bibliography

Barnes, R. (1993). Human Performance Limitations Requirements: The United Kingdom Experience. In Proceedings of the ICAO Human Factors Symposium, Washington, D.C., April 1993. Montreal: International Civil Aviation Organisation.

Campbell, R.D. and Bagshaw, M. (1991). Human Performance and Limitations in aviation. Oxford, UK: Blackwell.

Green, R.G., Muir, H., James, M. Gradwell, D. and Green R.L. (1991). Human Factors for Pilots. Aldershot, UK: Avebury.

Hunt, G.J.F. (1993). Knowledge Systems that integrate Human Factor competencies in job performance. In Proceedings of the ICAO Human Factors Symposium, Washington, D.C., April 1993. Montreal: International Civil Aviation Organisation.

International Civil Aviation Organization. (1989a). Human Factors Digest No.1: Fundamental Human Factors Concepts. Circular 216-AN/131. Montreal, Canada: Author.

International Civil Aviation Organization. (1989b). Human Factors Digest No.2: Flight Crew Training: Cockpit Resource Management and Line-Oriented Flight Training. 217-AN/132. Montreal, Canada: Author.

International Civil Aviation Organization. (1991). Human Factors Digest No.3: Training of Operational Personnel in Human Factors. Circular 227-AN/136. Montreal, Canada: Author.

Johnston, A.N. (1989). A review of airline sponsored *ab initio* pilot training in Europe. In Proceedings of the Fifth International Symposium on Aviation Psychology (pp. 33-38). Columbus, Ohio: Ohio State University, Department of Aviation.

Johnston, A.N. (1992). Airline "Bridge" Training. In Report of the 8th. General Flight Training Meeting, Stockholm. Montreal: International Air Transport Association.

Johnston, A.N. (1993a). Human factors training for the new joint European pilot licences. In Proceedings of the Seventh International Symposium on Aviation Psychology. Columbus, Ohio: Ohio State University, Department of Aviation.

Johnston, A.N. (1993b). LOS/LOFT debriefing skills and techniques. In Proceedings of the Seventh

International Symposium on Aviation Psychology. Columbus, Ohio: Ohio State University, Department of Aviation.

Johnston, A.N. (1993c). CRM: Cross-cultural perspectives. In Wiener E.L., Kanki, B.G. and Helmreich, R.L. (Eds.). Cockpit resource management. San Diego, CA: Academic Press, Inc.

Johnston, A.N. and Mauriño, D. (1990, May). Human Factors training for aviation personnel. ICAO Journal, 16-19.

Joint Aviation Authorities. (1992). Flight Crew Licensing Proposals for the Joint Aviation Authorities. Fourth Draft, July 1992. JAA: Hoofddorp, Holland: Author.

King, J.H. (1993). Implementation of Human Factors knowledge requirements in Canadian flight training system. In Proceedings of the ICAO Human Factors Symposium Washington, D.C., April 1993. Montreal: International Civil Aviation Organisation.

Lave, J. (1988). Cognition in practice: mind, mathematics and culture in everyday life. Cambridge University Press.

Lave, J., and Wenger H. (1991). Situated Learning. Cambridge University Press.

Mauriño, D. (1993). Cross-cultural perspectives in Human Factors training: The lessons from the ICAO Human Factors Program. In Proceedings of the Seventh International Symposium on Aviation Psychology. Columbus, Ohio: Ohio State University, Department of Aviation.

Telfer R. (1993). Human Factors in learning and instruction. In Proceedings of the ICAO Human Factors Symposium Washington, D.C., April 1993. Montreal: International Civil Aviation Organisation.

Trollip, S.R., and Jensen, R.S. (1991). Human factors for general aviation. Colorado: Jeppeson Sanderson.

Wiener E.L. and Nagel, D.C. (Eds.). (1988). Human factors in aviation. San Diego, CA: Academic Press, Inc.

Wiener E.L., Kanki, B.G. and Helmreich, R.L. (Eds.). (1993). Cockpit resource management. San Diego, CA: Academic Press, Inc.

APPENDIX I

Typical test/examination questions on Human Performance and Limitations used in the United Kingdom.

1. To avoid the risk of decompression sickness, it is recommended that you do not fly within.... hours of diving using compressed air at a depth in excess of.... :

(a) 12 hours : 24′ (b) don't fly at all
(c) 24 hours : 30′ (d) 30 hours : 24′

2. The time available to a pilot to recognise the development of HYPOXIA and to do something about it is termed the time of useful consciousness. This is approximately.... at 30,000 feet:

(a) 5 seconds (b) 1 minute
(c) 5 minutes (d) 20 minutes

3. On a go-around you experience a pronounced pitch-up feeling. You recognise this as.... illusion and rectify it by.... :

(a) a saccadian : keeping the head still
(b) an optical : using visual cues
(c) an echoic : closing eyes momentarily
(d) a somatogravic : relying on instruments

4. You are captain of an aircraft which has a major problem and a decision must be made on how best to tackle it. To arrive at the best decision you should:

(a) express your own ideas instantly because you are the captain
(b) run a "tight ship" and discourage adverse comment
(c) solicit ideas from other crew members encouraging doubts and objections
(d) make a decision and keep it to yourself

(Courtesy, Air Services Training)

HUMAN FACTORS IN LEARNING AND INSTRUCTION

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This paper examines the provision of Human Factors education in two aviation settings: a University baccalaureate program involving ab initio commercial pilot trainees, and an airline three-day workshop for line instructors. Finally, a new focus, the different ways pilots approach learning, is discussed. Preliminary results are provided of a study involving eight international airlines and a sample of 230 pilots, revealing differences in learning strategies. The next phase of the study will examine ways in which these strategies can be optimally linked with various topics, exercises, checks and examinations in pilot training.

The provision of human factors as a key area of study was part of the rationale for Australia's first University aviation degree, which commenced enrolments at the University of Newcastle in 1978. Conventionally, university studies are either discipline-based, liberal (with a wide choice of subjects from a number of faculties or schools), or in varying combinations of the two. Because of the simultaneous demands on undergraduate students from flight training, pilot licence examinations, and the usual academic pressures of assessment exercises, assignments and examinations, the aviation program at the University of Newcastle has been revised and refined since 1978 to become a single-purpose, specialist course with no options in the beginning years. In brief, the course consists of four sections: <u>aeronautical engineering</u> (including engines and systems, avionics, fatigue, design, and aerodynamics); <u>aviation science</u> (including meteorology, forecasting, navigation and flight planning); <u>aviation management</u> (including aviation law and computer applications), and <u>human factors</u>. It is the last which will be detailed to show a sequence in content suitable for ab initio pilots. The depth, however, will need to be varied according to the entering abilities of the students or trainees, and the time which can be allocated in the training syllabus.

<u>TABLE 1 :THE UNIVERSITY OF NEWCASTLE HUMAN FACTORS COURSES (BACHELOR OF SCIENCE, AVIATION).</u>

Year 1:	Introductory Human Factors-4hrs/wk- (information processing, vision and balance; spatial disorientation; perception; memory; decision making; motor control).
	Aviation Psychology and Medicine-3hrs/wk- (atmosphere, respiration, acceleration, vision, hearing, air sickness,drugs, health, first aid, fitness, fatigue, attention, workload, stress, personality, communication).
Year 2:	Human Factors-4hrs/wk (ergonomics, displays, aircraft control, automation, simulation, training, stress/arousal, flight phobia, fatigue)

Human Performance in Multi-Crew Operations-3hrs/wk- (personality, communications, group processes, leadership, cabin safety)

Year 3: Aviation Instruction - Ground-4hrs/wk- (psychology of learning, instructional methods, evaluating instruction and learning, lesson planning, preparing and using aids, aviation instruction)

Advanced Aviation Instruction-4hrs/wk- (instructional design, problem-based learning, computers in instruction, simulation, training environments, student stress and training, aircrew performance assessment)

Flight Deck Performance-3hrs/wk- (systems theory, pilot selection and testing, human factors research methods, accident investigation)
Aviation Instruction Practicum-4hrs/wk-(practice instruction)

Directed Study (4hrs/wk) (project)

Year 4: Honours Research Thesis (20hrs/wk for year)

Aviation Research and Methodology (6hrs/wk)

In analysing the success of Human Factors education at the ab initio level, there are some important findings. For the inexpert and unexperienced pilot, there tends to be a ready acceptance of the importance of human factors as an integral aspect of pilot training. Provided the examples and applications are drawn from operational situations, from the outset there is high face validity in the equal status given each of the course components. Just as engineering contributes to aircraft systems, ergonomics and psychology contribute to their efficient operation. There is an acceptance of a body of knowledge to be transmitted, and because of this receptivity by the students, teaching methods usually are the lecture, assignment, reading, or group projects such as accident/incident analysis and discussion.

Experienced pilots, however, are a different matter. They may have flown for some time in the absence of serious consideration of stress management, decision models, resource utilization or situational awareness. They have performed well to date. Why another new course for them to attend?

For them, it is <u>change</u>, not mere education, which is the goal. Airline training in human factors thus is based on a different instructional design to that used with ab initio pilots. There is little point in lecturing to an uncommitted audience and expect that change will result. The emphasis has to switch from <u>content</u> to <u>process</u>: from what to how (and why). The medium of interaction is no longer expert to class: it is peer to peer in a group situation structured by a peer facilitator.

The instruction itself has a different basis,too. For students who have come directly from a high school education, pedagogical methods are possible. For adult learners, androgogy is the appropriate base (Knowles, 1980). It takes account of the differing motivation, experience, approach to learning and maturity of the airline pilot. Pupils become peers, and lectures become discussions and group exercises which enable the participants to draw their own conclusions rather than being presented with them. Instructional efficiency, in terms of time, is sacrificed for effectiveness. Better to take a little longer and convince someone by means of role play that group decision-making is almost invariably more effective than an individual's. The message becomes more indelible: change is more probable.

Maximum participation and activity is sought so that the group as a whole benefits from the sum of the experience and expertise that resides within it. Group dynamics, such as cohesiveness, leadership, climate, norms and communication have to be given time to take effect. Time for pilots' workshops, however, is a scarce and costly resource, so all phases of learning have to be exploited. Pre-reading, a course outline, statement of objectives, questions and exercises act as advance organisers in the presage phase. Receiving this material about two weeks in advance (not too soon, so that it will be shelved and forgotten; not too late so that it is given a hurried perusal on the way to the workshop), participants are aware of expectations of them, and can prepare in advance for the contributions they are expected to make during the workshop.

The next learning phase is that of the actual process of the workshop. The design will be such to ensure that there is a sequence of structured activities through which the facilitators will lead the group. Like a catalyst, the facilitators are vital for the change process, but their actual presence will not be evident in the personal consequences for each participant. The choice and role of the facilitator is thus vital for the success of human factors training. Apart from the obvious human qualities, they need to have high personal credibility with their peers.

Facilitators have the role of ensuring that each participant is involved as much as possible, while balancing inputs to restrain the verbose and encourage the recalcitrant... and all the time maintaining relevance in the contributions. For self-evaluation during sessions of the workshop, facilitators can periodically ask themselves: "What do I expect each of the participants to be DOING right now?" Because the workshop is activity-based, people should be active, not passive, learners. This will also remove the need for editorialising or risky "expert" comment from facilitators.

The workshop design will include (apart from the pre-reading manual mentioned above), a course manual to provide later reading and reference for participants/ facilitators, and a guide for facilitators. For example, the Cathay Pacific Airways Instructor Workshop Guide for Facilitators uses a standard format listing the points where audio-visual aids can be introduced and how to introduce them; a guide to timing; a script (not intended to be read, but to provide guidance in the choice of questions, introductions, summaries, and responses); hints on non-verbal communication which can be used; appropriate points for coffee breaks or discussion; room layout; use of equipment; back-up activities if the group works quickly when and how to use the prepared participant contributions; and an evaluation sheet for use in both formative and summative evaluation. This is advisory, not prescriptive as the course rationale is that instructors are effective because of personal ability, personality and experience (the art of instruction) combined with a knowledge of the underlying theory (the craft of instruction) (Telfer and Biggs, 1988). There is a degree of autonomy for facilitators to use their personal style in presenting and structuring the workshop experiences. (See Telfer and Bent, 1992, for details of the course, its objectives and results of initial evaluations).

That workshop also makes use of follow-up (the product phase) in the form of a pocket-sized checklist given to all participants. It thus utilises the before (presage), during (process) and after (product) phases of instruction for maximum effect and the greatest probability of inducing change in participants (Biggs and Telfer, 1987). A spiral curriculum extends over three days in which subjects are treated initially, then revisited for consolidation and elaboration.

The emphasis on process rather than content reflects another form of indirect instruction (characteristic of androgogical principles). The workshop itself exemplifies the methods and philosophies it espouses. Thus, the schedule varies in session length over the duration of any one day. Longer sessions are in the morning, when the more difficult topics are encountered. Thought-provoking or discussion-inducing topics precede coffee or lunch breaks so that reflection or clarification can occur in time-out. Variability, the design of contrasting activities to maintain interest and prevent boredom, precludes similar media or methods being used in successive sessions. The medium becomes the message.

Aviation instruction is distinctive in several ways: its structure, mission, stakes, focus, budget, flexibility and immediate transfer of training. At the individual learning level, there are differences related to the nature of the material to be learned, the nature of the examinations (typically multiple choice questions), and the application of the knowledge, skills and values to operations (Telfer, 1993). There are, therefore, special constraints in the design of human factors workshops for the aviation industry. These constraints take the form of tensions between traditional instructional design and that which aviation requires. The first tension is between effectiveness and efficiency. Effectiveness is always the intention: but efficiency will intrude. Time off- line for pilots and facilitators; opportunities for prior and later contact; the need for professionally produced videotapes; multiple revisions and reprints of manuals as the course is refined; allocation of a specialist training room and resource centre; ancillary staffing: all are highly desirable but subject to budgetary restraint.

Similarly, there is a tension between education (knowing why) and training (knowing how). The latter is by far the easier to attain, and companies may settle for second-best in the hope of faster change. Faster, perhaps, but far less sustainable.

The third tension is between theory and practice. While the aviation industry should be able to expect the same guidance from research in instructional methods as it obtains from ergonomics or engineering in aircraft design, instructional theory appears to suffer in comparison.

Part of this is due to ignorance of what there is to offer in the 1990's, and part of it is misguided application by supposed experts who uncritically import the results of studies which cannot be validly applied to aviation. The behaviour of a Grade 4 social studies class in Minneapolis has little to do with two Qantas trainees in a simulator at South Australia. Guiding theory is available: but it has to be selected judiciously with a clear priority to validity in application.

The design and implementation of a human factors workshop in airlines is inevitably a compromise between what is actually needed to effect the change management seeks, and the amount of resources it is prepared to provide. Some conclusions, however, are unequivocal. Workshops for experienced pilots have to be designed on androgogical principles requiring group-based, active learning which is based on participation rather than passive recipience of lectures. Support of the process of change has to extend before, during and after the workshop. Follow-up, in the form of a periodic refresher, newsletter and posters, is vital for change to occur. In brief, there needs to be an awareness of how pilots learn.

Over the last decade researchers have identified three predominant approaches to learning: Deep, Surface, and Achieving (e.g. Entwistle & Waterson, 1988; Watkins & Hattie, 1990; Biggs 1987a, 1987b). The deep approach to learning is intrinsically motivated, with a desire to be competent in the area of study. To achieve deep understanding, learners read widely and integrate their new knowledge with their existing knowledge base. The surface-oriented learner, however, is motivated by anxiety and the desire to do the minimal amount to pass the subject. Surface oriented strategies include rote learning and reproduction of material provided in course notes or manuals. The third approach, achieving, is concerned with ego enhancement and organising the time, source and place of learning.

The relationships between approaches to learning and performance in aviation have now been examined in several different populations as part of the ongoing Approaches to Pilot Learning Project at the University of Newcastle (reported in Moore, Scott and Telfer, in press). The first study examined approaches to learning (and their relationships with learning outcomes) in a sample of commercial pilot trainees. The second gained data from a sample of experienced pilots who were undertaking retraining, and the third study involved interviews with a small sample of experienced airline transport pilots. The concluding study examined ways in which approaches to learning in experienced pilots might be more appropriately assessed, leading to the development of the Pilot Learning Process Questionnaire.

The Ab Initio Study used 62 trainee commercial pilots for its sample (and is fully described in Moore and Telfer, 1990). Data were gathered on approaches to learning and on individual performance in each of the nine ground school topics (such as Aerodynamics, Navigation, or Flight Planning) and the time it took them to fly solo.
For the ground school results, the most prominent finding was the consistently significant negative relationship between ground school scores and the surface approach measure. Ab initio pilots who reported adopting a surface approach to learning scored lower on all measures of ground school learning than those who adopted a less surface oriented approach. Trainees adopting a deep

approach to learning went solo earlier. Briefly, then, the findings from the ab initio study demonstrate the generally negative effect of a surface approach to learning, and a tendency for positive effects of a deep approach.

The Pilot Under Initial Training (PUIT) Study was based on responses from a sample of thirty experienced pilots being given initial training by an international carrier.In addition to ground school results, a rating was gained for the PUITs' performance in their final simulator check ride. Correlations showed very little relationship between approaches to learning and performance in ground school or in the simulator. The only significant relationship was between scores on the Type test and Deep scores. PUITs reporting a meaning-oriented, wide-reading approach to learning scored higher on this test. In contrast to the ab initio results, surface scores were not negatively related to performance, and deep was not related positively to the measure of knowledge application, flying the simulator.

The findings from this second study raised some questions about the reliability and validity of a school/university questionnaire for examining pilots who had substantial experience in the industry. Several of the PUITs had indicated in their responses that items seemed irrelevant to the retraining or endorsement context in which they were learning. Additionally, reliability co-efficients were quite low. A third study was therefore undertaken, interviewing pilots about their own approaches to learning (Moore and Telfer, 1992).

The Interview Study was based on a small sample (n=11) of captains or first officers flying with domestic or international carriers. This study demonstrated that experienced pilots use a range of strategies and motives for the specific learning they need to do in aviation. Clearly, some of these approaches are "deep" in orientation (e.g. desire to understand, reading widely, self-testing levels of learning, using own summaries), others are "surface" (e.g.learning emergency drills), and others "achieving" in orientation (e.g. prioritising, using timetables for study, having material in compact form for studying). With these data and the results of the two previous studies, a fourth study was undertaken to develop an instrument for assessing experienced pilots' approaches to learning in aviation (Telfer, 1991).

The Questionnaire Development Study aimed to develop a reliable and valid questionnaire that could be used to assess experienced pilots' approaches to learning. The questionnaire was designed to distinguish Surface Approaches (motives and strategies), Deep Approaches (motives and strategies), and Achieving Approaches (motives and strategies). A sixty-two item, 6 point Likert scale, instrument was developed and distributed to eight international and national carriers.

Two hundred and thirty experienced pilots returned the questionnaire. Factor analytic and reliability analyses were undertaken to determine the structure of scales and the items to retain. The result was a three-scale, thirty item instrument: the Pilot Learning Process Questionnaire (PLPQ).

The next focus of investigation is the relationship between pilots' approaches and their performance in ground school topics, simulators and check rides to ascertain if particular approaches by pilots are more beneficial for specific areas of learning. Diagnostic and remediation strategies can then be introduced to increase pilot learning. Further, the application of the PLPQ to pilot selection testing will be investigated to examine the benefits to the individual and to the employer of identifying pilots' characteristic approaches to learning.

REFERENCES

Biggs, J.B. (1987-a) Student Approaches to Learning and Studying. Hawthorn, Victoria: Australian Council for Educational Research.

Biggs, J.B. (1987-b) The Study Processes Questionnaire (SPQ): Users' Manual. Hawthorn, Victoria: Australian Council for Educational Research.

Biggs, J.B. and Telfer, R.A. (1987) The Process of Learning, Sydney, Prentice Hall.

Entwistle, N.J., and Waterson, S. (1988) Approaches to studying and levels of processing in university students. British Journal of Educational Psychology, 58, 258-265.

Knowles, M. (1980) Modern Practice of Adult Education - From Pedagogy to Androgogy. New York, Cambridge.

Moore, P.J. and Telfer, R.A. (1990) "Approaches to Learning: Relationships with Pilot Performance", The Journal of Aviation/Aerospace Education and Research. Vol 1, No. 1. Spring.44-58.

Moore, P.J. and Telfer, R.A. (1992) Approaches to Learning in a Vocational Context. Paper presented to the Australian/New Zealand Association for Research in Education Conference, Deakin University, Geelong.

Moore, P., Scott, R., and Telfer, R. (in press) "Implications of Pilots' Approaches to Learning." Paper submitted for presentation to the 7th International Sytmposiuum on Aviation Psychology, Columbus, Ohio.

Telfer, Ross and Bent, John (1992) "Producing a Workshop for Training Airline Instructors," The Journal of Aviation/Aerospace Education and Research. Vol. 2, No. 3, Spring.

31-38.

Telfer, R.A. and Biggs, J.B. (1988) The Psychology of Flight Training, Ames, Iowa State University Press.

Telfer, R.A. (1993) "What makes Aviation Instruction Different?", Chapter 13 in Aviation Instruction and Training edited by R.A. Telfer, Ashgate, Aldershot.

Telfer, R.A. (1991) "How airline pilots learn." Paper presented at the Human Factors in South Pacific Aviation Symposium, New Zealand Psychological Society's Annual Conference, Palmerston North, August.

Watkins D. & Hattie, J. (1990) Individual and contextual differences in the approaches to learning of Australian secondary school students. Educational Psychologist, 10, 333-342.

HUMAN PERFORMANCE LIMITATIONS REQUIREMENTS THE UNITED KINGDOM EXPERIENCE

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The United Kingdom Civil Aviation Authority may have had an advantage over some other regulatory authorities as the importance of Human Factors in aviation was recognised as far back as the 1950s. At this time a Senior Medical Officer (Flight Safety & Research) was appointed to look into the Human Factor problems of high flying, fast jet transport aircraft. He was supported by a Human Factors Steering Group, membership of which was drawn from all sectors of the aviation industry.

In the mid-1970s this group noted the increasing significance of human error in accidents and recommended that human factors be included in the syllabus for a professional pilot's licence. This suggestion received further support when a King Air super 200 crashed near Nantes in France.

The aircraft was on a training detail during which the instructor carried out a "practice decompression" at 31,000 feet by using the dump switch. Following maintenance the oxygen system had not been reconnected and the crew rapidly became unconscious. The aircraft crashed nearly six hours later at the end of its endurance having drifted over the channel into French airspace.

A syllabus was prepared and discussions with the training schools and professional organisations arranged. Although there was general acceptance of the idea and agreement was reached to include limited time on this subject in flying training programmes there was resistance to the Authority making it compulsory.

We were therefore in a good position to meet the requirement in the 8th edition of ICAO Annex 1 that Human Performance and Limitations be introduced in all professional flight crew examinations.

A new syllabus was drawn up following internal discussions and advice from the RAF Institute of Aviation Medicine and the Applied Psychology Unit at Cranfield Institute of Aviation Technology. Because of the imminence of the European Joint Aviation Authorities the syllabus was also reviewed with our European partners. The final syllabus is very similar in content to that subsequently recommended by ICAO.

By 1990 we were in a position to put out Aeronautical Information Circulars advising that from April 1991 applicants for a professional pilot's licence would be required to sit an examination in Human Performance and Limitations. This requirement would also apply to pilots upgrading their licence from CPL to ATPL and to anybody who renewed their licence after having let it lapse. Applicants for Flight Engineers and Flight Navigators licences and PPLs wishing to include an instrument rating on their licence, would also have to sit this exam with effect from October 1991. In all cases there was to be an introductory six month period during which anybody who failed the exam would be granted a licence, although expected to return and re-sit this exam. Current licence holders would not be required to sit the examination retrospectively.

The interval between the circulation of the AIC and the introduction of the exams was used to consult with training schools, airlines, various aviation organisations such as the British Air Line Pilots Association and Guild of Air Pilots And Navigators and representatives from the private pilot fraternity, balloonists etc. through a series of seminars. These gave the aviation industry a further chance to express its views and the Authority an opportunity to explain the exam requirements and justify the syllabus. In understanding the latter it needs to be borne in mind that this may well be the only occasion on which the candidate will have to demonstrate a knowledge of human factors. It was also necessary to set up suitable courses for instructors, which currently take place at Cranfield Institute of Aviation Technology. A further consideration was to ensure that suitable reading material was available for applicants not attending a set course. In practice, notification of the impending exam prompted the appearance of several new books on this subject suitable for air crew applicants.

Exams are part of the educational system in the UK. What is important is not passing the exam but that the applicant should have been given an initial insight into human factors which hopefully he will explore and exploit as his career develops. This is certainly embedded in our approach to airline training since all holders of an Air Operators Certificate are required to include a Cockpit Resource Management course in the training programme.

One of the aims of this paper is to outline and justify the syllabus. We have divided this into four main topic areas:-

1. Basic aviation physiology and health maintenance.
2. Basic aviation psychology.
3. Stress fatigue and their management
4. The social psychology and ergonomics of the flight deck.

BASIC AVIATION PHYSIOLOGY AND HEALTH MAINTENANCE

Basic aviation physiology and the effects of flight.
Anatomy and physiology of the eye, ear, vestibular, circulatory and respiratory systems.
Composition of the atmosphere, gas laws and the nature of the human requirement for oxygen.
Effects of reduced ambient pressure and sudden decompression; times of useful consciousness.
Recognising and coping with hypoxia and hyperventilation.
Entrapped gases and barotrauma.
Diving and flying.
Effects of acceleration (+/-G) on circulatory system, vision and consciousness.
Mechanism, effects and management of motion sickness.

A knowledge of the anatomy and physiology of the eye, ear, vestibular, circulatory and respiratory systems and of the composition of the atmosphere and gas laws is necessary to understand the rest of the topics covered.

The relevance of most of the other topics listed hopefully needs little explanation. Had the instructor in the King Air previously mentioned been fully aware of the dangers of a decompression at 31,000 feet hopefully he would have been content to simulate the emergency or at least carry it out at a lower height. The problems of excess gas in the gut after a fatty meal or flying with a cold are embarrassing and painful experiences that most air crew will have suffered.

I would like to add a note of caution. A colleague who flies a large jet was detailed to carry out a type rating on a young first officer. On the day concerned he was suffering from a cold. Not wishing to let the first officer down, and mindful that on previous occasions when he had flown with a cold he had experienced little discomfort, he reported for duty. As they climbed away from the airfield he looked at the instruments only to find they were spinning round. When he concentrated on individual numbers on the dials they spun round in their own right. Fortunately the first officer was very competent and brought the aircraft safely back. The captain concerned had suffered an upset of his vestibular system as a consequence of his cold, leading to this illusion. Familiarity should not be allowed to develop into complacency!

Motion sickness deserves a special mention since a number of pilots experience this in their early training. A knowledge of how it is produced and what can be done to alleviate it may help these people enabling them to continue their chosen career.

Hyperventilation, or over-breathing, is more common than is often realised. It is potentiated by stress, motion sickness, excessive heat and breathing through a mask, all of which conditions may occur in flight.

Moderate hyperventilation is distressing and causes distraction. If allowed to continue collapse can occur, with obvious safety implications.

Underwater diving appears to be popular with air crew. All divers should be aware that if you dive to a depth of more than 30-feet a timed ascent to the surface is necessary to avoid the "bends". What fliers sometimes forget is that flying after a dive has the same effect as diving to a greater depth, in that it increases the total pressure change experienced.

Flying and health.
Noise-and-age-induced hearing loss.
Visual defects and their correction.
Arterial disease and coronary risk factors, ECG, blood pressure, stroke.
Diet, exercise, obesity.
Psychiatric diseases, drug dependence and alcoholism.
Tropical diseases and their prophylaxis, hepatitis and sexually transmitted diseases.
Common ailments and fitness to fly; gastro-enteritis, colds, use of common drugs and their side effects.
Toxic hazards.
Causes and management of in-flight incapacitation.

Not everybody would agree that health is a subject for examination, but in my opinion there are a number of reasons for including it.

By the time a pilot has finished his training a great deal of money has been invested in him. Anything that can be done to encourage him to preserve his state of health and hence his career, is worthwhile. A knowledge of diet, the effects of obesity and the benefit of reasonable amounts of exercise on physical and mental performance is relevant, as is information on the effects of alcoholism and drug dependence.

Fitness to fly is something every pilot should address. The commonest causes of incapacitation are not serious illness, such as coronary thrombosis, but gastro-intestinal upsets and upper respiratory infections. Most airlines now include incapacitation training in their courses.

Recently the captain of a Boeing 747-200 on a long-haul flight became ill. Command was taken by the co-pilot and the captain left the flight deck. The co-pilot decided to return to base, although he was now more than two hours out from base. During the return the captain re-appeared on the flight deck stating that he now felt better and could continue. The co-pilot decided this was not the case and returned to base where his decision was upheld. Some knowledge of the likely course of conditions that might be met on the flight deck may aid pilots who find themselves in this difficult position is likely.

Blood donations, pregnancy and medications, both prescribed and "over the counter" all have special significance in aviation. Air crew should ensure that any doctor to whom they go for treatment is aware of their profession. They should also remind him that they frequently travel abroad, if appropriate. There have been a number of occasions where, during an epidemic, a pilot has been diagnosed as having 'flu whereas the true diagnosis has been malaria. Regretably, one case I know of has resulted in the death of the person concerned.

Many pilots worry about their medicals, particularly a deterioration in their sight and hearing. In most cases this is associated with advancing years rather than disease. If the pilot understands this he is far more likely to accept the need for reading glasses rather than squinting and holding the test card as far away as his authorised medical examiner will allow.

BASIC PSYCHOLOGY

Basic plan of human information processing, including the concepts of sensation, attention, memory, central decision-making and the creation of mental models.

Limitations of central decision channel and mental workload.
Function of attention in selecting information sources, attention-getting stimuli.
Types of memory; peripheral or sensory memory, long term (semantic and episodic) memory, short term or working memorary, motor memory (skills).
Memory limitations and failures.
Perception, the integration of sensory information to form a mental model.
Effects of experience and expectation on perception.
Erroneous mental models; visual, vestibular and other illusions.
Recognising and managing spatial disorientation.
Use of visual cues in landing.
Eye movements, visual search techniques, mid-air collisions.
Skill, rule and knowledge based behaviour
The nature of skill acquisition, the exercise of skill, conscious and automatic behaviour, errors of skill.
Rule based behaviour, procedures, simulator training, failures of rule-based behaviour.
Knowledge based behaviour, problem solving and decision making, inference formation, failures in knowledge based behaviour.
Maintaining accurate mental models, situational awareness, confirmation bias.

Flying an aircraft is a complex task involving the assimilation of clues from outside and within the aircraft, processing this information to gain situational awareness and then making decisions and acting upon them. This process involves rule and knowledge based behaviour, conscious and automatic responses and the exercise of mental and manual skills. Such complex processing is open to error. The cause of the error may be very simple, such as a failure of short-term memory. We can normally retain about seven unrelated items in our working or short-term memory. If not actually rehearsed within 10-20 seconds this type of information will be lost. This obviously has significance when dealing with complicated instructions. Error may also occur due to erroneous mental models associated with such things as visual and vestibular illusions. It can also result from pre-conceived expectation or past experience.

The pilot of a fighter experienced severe vibration caused by failure of the tail fin of the aircraft, ejecting at the last moment and narrowly escaping death. Some months later he again experienced severe vibration and immediately ejected. The aircraft flew on for some considerable time, the vibration having been due to clear turbulence.

The number of topics involved in this particular part of the syllabus precludes going through them individually. A suitable simile to cover the syllabus would be that even as some knowledge of how the parts of a car work helps in learning to drive, so a knowledge of how our brain works helps in using it to the best advantage.

STRESS AND STRESS MANAGEMENT

Models and effects of stress
Definitions, concepts and models of stress.
Arousal, concepts of over-and under-arousal
Environmental stresses and their effects; heat, noise, vibration, low humidity.
Domestic stress, home relationships, bereavement, financial and time commitments.
Work stress, relationships with colleagues and management.
Effects of stress on attention, motivation and performance.
Life stress and health, other clinical effects of stress.
Defence mechanisms, identifying stress and stress management.
Stress comes in many forms stemming from the environment, work and the domestic scene. In the aviation environment noise, vibration and low humidity play a particular role but many of the stressors are part of our normal existence. Domestic stress and its problems are well known to most people. Both may affect a person's ability to perform on the flight deck.

The pilot of an air taxi hit a large concrete obstacle, smashing the extended undercarriage, whilst making an approach to a small airfield. The obstacle was clearly visible and no satisfactory cause for the accident was established other than "pilot error". A personal conversation with the pilot some time later established that his wife had walked out on him on the morning of the accident. He readily admitted that this situation had totally pre-occupied his mind and that his flight had contained a series of minor errors prior to the incident described.

Stress may also arise from the crew relationships and flight-deck workload. Some degree of stress is desirable in the promotion of arousal and performance, but too great a stress decreases performance and may even cause the person to freeze, a very undesirable situation in an emergency. Performance also falls off with too little stress which may have significance on the automated flight deck. It must be borne in mind that what is stressful to one person may not be stressful to another. A knowledge of stress and its effects, and recognition of the symptoms, are important factors in coping with it. Those that are prone to stress can be counselled and taught methods of managing it.

Sleep and Fatigue
Biological clocks and circadian rhythms, sleep/wakefulness and termperature rhythms, "zeitgebers".
Sleep stages, sleep at abnormal times of day, required quantity of sleep.
Work-induced fatigue.
Shift work.

All of us have a circadian rhythm which governs our bodily functions and ability to perform thereby preparing the body for periods of sleep and wakefulness. Performance peaks between 1200 and 2100 hours and is lowest between 0300 and 0600 hours. It also falls off with time on task. A pilot is therefore more likely to make mistakes after a long flight ending in the early hours of the morning, and this situation is best avoided. It is also important to preserve an adequate pattern of sleep if normal performance is to be achieved.

Airlines usually have "round the clock" operations which may be further complicated by flights which cross multiple time zones with consequent upset to the operating pilots' normal circadian rhythm. This may make the objectives outlined above difficult to achieve. Some protection is offered by flight time regulations but even the best of these does not cope with every situation. Pilots therefore need to develop their own sleep strategies. This can only be done if they understand how their body functions and how to manage sleep, including the benefits of napping and the use and abuse of drugs.

SOCIAL PSYCHOLOGY AND ERGONOMICS OF THE FLIGHT DECK

Individual differences, social psychology and flight deck management.
Individual differences, definitions of intelligence and personality.
Assessing personality
Main dimensions of personality; extroversion and anxiety. Other important traits; warmth and Sociability.
Impulsivity, tough-mindedness, dominance, stability and boldness.
Goal-directed, person-directed types of behaviour.
Individual personality related problems of flying, especially risk-taking.
Personality interaction on the flight deck and the interaction of personality with status or seniority, role (eg, handling/non-handling) and perceived ability of crew members.
Concepts of conformity, compliance and risk shift. Implication of these concepts for the flight deck with regard to effects of crew size (especially 2 v 3 crew).
Communication; verbal and non-verbal communication, one and two way communication, different communication styles.

Methods of maximising crew effectiveness and improving flight deck, or cockpit resource, management.
Interacting with cabin crew, air traffic services, maintenance personnel and passengers.
Personality and individual traits will affect a person's approach to flight safety. We have all met the "hearty, kick-the-tyres, lets go" type as well as the "doubting Thomas" who does all his checks three times

and still isn't sure things are satisfactory. Both are undesirable traits carried to extremes. A knowledge of their personal traits will not change an indivdiual but it may highlight possible shortcomings, letting the person make suitable allowances for them.

Flying invariably calls for contact with other people, be it as part of a crew, with ATC, or with ground handlers. Knowing how to handle difficult personalites, how others can influence your decisions and how to communicate is therefore important. Much of this forms the basis for Flight Deck Resource Management courses.

One personal experience concerns a two-crew freighter destined for Milan. The co-pilot had only joined the company recently but had many hours on type, more than the captain who was a rather domineering gentleman. Although there were thunderstorms about the captain elected to position for the approach by means of an ADF beacon. The first officer felt this was unwise but rather than comment he preferred to let the captain "stew in his own juice". The result was that pieces of the freighter covered nearly half a square mile on a hill outside Milan. Luckily the crew were not seriously hurt.

The design of flight decks, documentation and procedures
Basic principles of control, display and workspace design.
Eye datum, anthropometry, and workspace constraints. External vision requirements, reach, comfort and posture.
Display size, legibility, scale design, colour and illumination. Common errors in display interpretation.
Control size, loading, locating, location and compatibility of controls with displays.
The presentation of warning information and misinterpreation of warnings.
The design and appropriate use of checklists and manuals.
Effects of automation and the "glass cockpit". Integration of information from many data sources on one display and automatic selection of displayed information. Mode and status representation.
Machine intelligence and relationship between aircraft decisions and pilot decisions.
The avoidance of complacency and boredom and maintaining situational awareness. Maintaining basic flying skills.

Modern aircraft may have very complex flight decks with the extensive use of automation. Although much thought and Human Factors effort goes into most designs it is inevitable that compromises are made. A knowledge of the basic principles used in the design, common errors in interpretation of displays and the effects of automation can help to avoid pitfalls. This also applies to a knowledge of the correct approach to check lists and manuals.

Judgement
The inclusion of this topic in the sullabus needs no justification. It is interesting to note that various countries have promoted "judgement training" with good effect on accident/incident rates.

I am reminded of the pilot who flew three caribou hunters up to the mountains. As they departed he advised them that the limitations of the aircraft would mean they could only carry one caribou on the return flight. A week later they greeted him with two caribou assuring him last year's pilot had carried two on the same plane. He was eventually persuaded to accept both animals and took off, crashing shortly afterwards. After recovery from shock one hunter asked where they were. "About half a mile away from where we crashed last year" advised one of his companions.

To date approximately 10,000 UK professional and private pilots have taken the exam. The initial pass rate was around 30% but this has now risen to between 70-80%. It is obviously too early to judge whether it is having an effect on flight safety. What is encouraging is that Human Factors has become a common topic of conversation in crew rooms and there is a waiting list of people wishing to borrow some of the recommended reference books from the CAA's library.

Human Factors Knowledge Requirements for Flight Crews

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HUMAN FACTORS EDUCATION

Education precedes training. It would be difficult to train a pilot how to correct for the effects of wind strength and direction upon flight path over the ground if the pilot did not know what a vector was. Similarly, an introductory physics student who asked "Where does the light go when it goes out?" is indicating a fundamental misunderstanding of elementary physical principles. But because many aspects of human factors seem intuitive to those who are not yet educated, the parallel between the question about where light goes and the question "What is pilot mental workload?" is not obvious (Kantowitz, 1987). While aviation personnel can be readily trained to obtain some measure of pilot mental workload, perhaps by using a subjective rating scale, the proper interpretation and use of this measure requires a human factors education.

The distinction between education and training has been well stated in ICAO Circular 216 (ICAO, 1989):

> Education encompasses a broad-based set of knowledge, values, attitudes and skills required as a background upon which more specific job abilities can be acquired later. Training is a process aimed at developing specific skills, knowledge or attitudes for a job or a task. Proper and effective training cannot take place unless the foundations for the development of those skills, knowledge or attitudes have been laid by previous education [p. 15].

This paper discusses human factors education that will provide a broad base for acquiring later job skills. It suggests key areas that flight crews need to understand and compares such suggestions to existing curricula in aviation human factors.

Key Topics in Human Factors

Human factors covers a very broad area of knowledge. For example, my own human factors textbook (Kantowitz & Sorkin, 1983) contains 700 pages divided among twenty chapters (Table 1). Furthermore, the second edition now being written contains several topics that were either entirely omitted or only briefly mentioned in the first edition. Human factors is a field that is evolving rapidly and any text more than a decade old cannot do justice to its current state.

1.	Systems and People	11.	Data Entry
2.	Error and Reliability	12.	Feedback and Control
3.	Hearing and Signal Detection Theory	13.	Human Factors in Computer Programming
4.	Vision	14.	Decision Making
5.	Psychomotor Skill	15.	Workspace Design
6.	Human Information Processing	16.	Noise
7.	Visual Displays	17.	Microenvironments
8.	Auditory and Tactile Displays	18.	Macroenvironments
9.	Speech Communication	19.	Environmental Stressors
10.	Controls and Tools	20.	Legal Aspects of Human Factors

Table 1. Key Topics from Kantowitz and Sorkin (1983)

At first, one might hope that by narrowing topics to only those that apply to aviation human factors much material could be eliminated. However, a more recent edited text devoted solely to aviation human factors (Wiener & Nagel, 1988) contains 684 pages in nineteen chapters (Table 2); not much saved here.

1.	Introductory Overview	11.	Pilot Control
2.	The System Perspective	12.	Aviation Displays
3.	System Safety	13.	Cockpit Automation
4.	The Human Senses in Flight	14.	Software Interfaces for Aviation Systems
5.	Information Processing	15.	Cockpit-Crew Systems Design and Integration
6.	Human Workload in Aviation	16.	Airline Pilots' Perspective
7.	Group Interaction and Flight Crew Performance	17.	General Aviation
8.	Flight Training and Simulation	18.	Helicopter Human Factors
9.	Human Error in Aviation Operations	19.	Air Traffic Control
10.	Aircrew Fatigue and Circadian Rhythmicity		

Table 2. Key Topics from Wiener and Nagel (1988)

Human factors textbooks, including my own, tend to place heavy emphasis upon facts and known empirical findings. Often, principles of human factors are taught inductively by giving concrete examples of good and poor designs. Thus, as shown in Table 1, a considerable body of fairly detailed information can easily overwhelm the reader. For example, a table in my own text lists aural alerts in different airplanes. While pilots might find this information compelling, the average reader drowns in such detail, and this table will not appear in the second edition. However, this kind of detailed information fills most human factors textbooks.

Such details have the advantage of convincing the reader that human factors is more than common sense. The human factors profession has always needed to stress horrible examples to emphasize the importance of human factors, which tends to get noticed only when done incorrectly or not at all. While any aviation human factors education should cover human factors mishaps, if only to get the crew's attention, it is difficult for students to retain lists of details and concrete examples. Thus, some integrating mechanism is also required for sound human factors education.

Beyond SHEL

The SHEL model --software, hardware, environment, liveware-- provides a conceptual framework for human factors that was used to generate a model syllabus (ICAO, 1991). Half of the course time is devoted to the Human Element (Liveware) and the remainder of pairwise interfaces between the SHEL elements, e.g., Liveware-Hardware, Liveware-Software, Liveware-Liveware, and Liveware-Environment. Hence the SHEL model provides the necessary integrating mechanism for sound human factors education.

While the proposed ICAO curriculum does a good job of covering traditional human factors, it needs to be extended to reflect current advances and recent trends. Such trends center upon the increased use of cognitive models of human behavior to predict and explain operator performance and error. Traditional view of human factors are based upon empirical "knobs and dials" studies. Modern human factors emphasizes the need to predict flight crew behavior based upon theories of human performance. Especially in highly-automated flight decks, extrapolation from older empirical findings will not be sufficient. Theory is necessary to guide human factors measurement, interpretation, and design (Kantowitz, 1992). I believe the following discussion illustrates how theory can be introduced to pilots without sacrificing practical utility or creating abstract academic exercises. Indeed, theory, when properly explained, becomes a powerful practical tool.

MENTAL MODELS

In this section I first introduce a practical problem that has considerable safety implications for flight crews, the issue of altitude deviations. The behavior of crews is then related to their mental model of flight-deck automation. Finally, a theoretical explanation of stimulus-response compatibility is invoked to help explain why inappropriate mental models are used by pilots when automation has been implemented in violation of good human factors practice.

Figure 1 shows that altitude deviations in the MD-80 were a serious problem from 1985-1987 (ASRS, 1990). An Aviation Safety Reporting System synopsis based upon reported incidents suggested that many of these deviations were related to the automation introduced in the MD-80. Pilots flying manually tend to slow their rate of ascent when within one or two thousand feet of the desired altitude. But in the MD-80 automation maintains a high rate of climb, in some instances 4000 feet per minute. Thus, pilots tended to worry that this high rate implied that the automation would exceed the target altitude. Therefore they manipulated the trim pitch wheel to slow the rate of ascent. However, such pilot action also disarms the altitude capture function which the pilots did not realize due to the stress of the moment and the poor annunciation provided by illumination of an LED. The airplane, at a decreased rate of climb, then continued through the assigned altitude. Ironically, by taking action the pilot created the deviation he or she was trying to avoid. Neither the automation nor the pilot was controlling the aircraft.

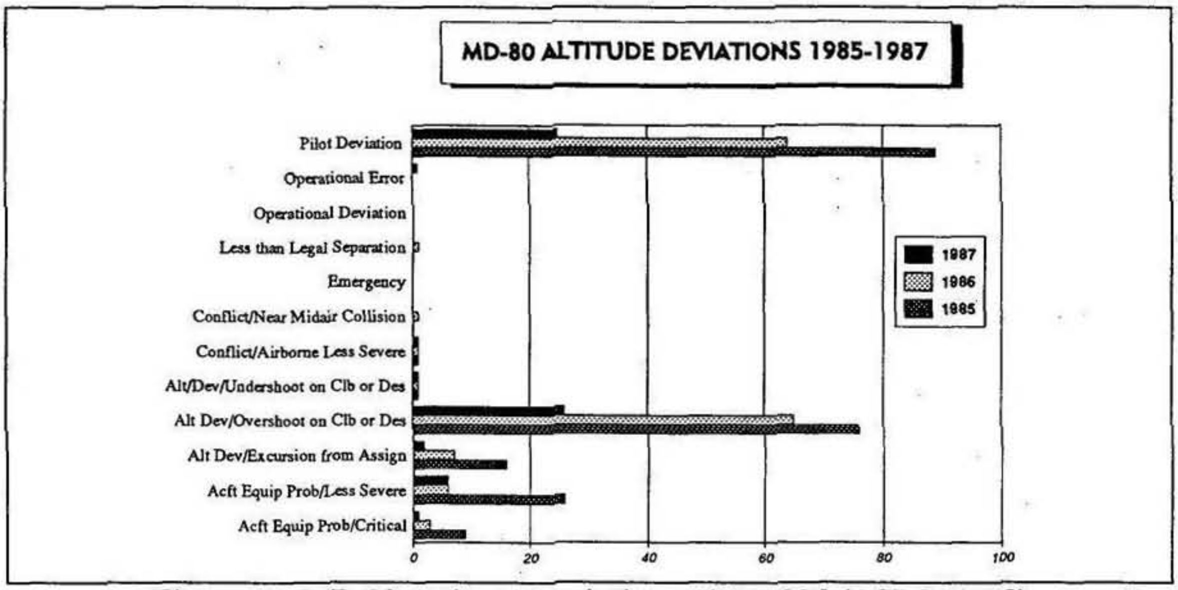

Figure 1. MD-80 Altitude Deviations 1985-1987 (ASRS, 1990)

The mental model of these MD-80 pilots was that automation functioned in the same way as another human pilot. When the behavior of the automation failed to match the expectations generated by this mental model, pilots made a dynamic allocation of function decision to correct the automation. Eventually, pilots learned through experience how the altitude capture function really worked and modified their mental model. Altitude deviations in the MD-80 then decreased.

From a human factors perspective, this problem is one of stimulus-response compatibility. Figure 2 shows a recent model of frames, rules, and response tendencies (Kantowitz, Triggs, & Barnes, 1990). Without going into technical details, it is sufficient to define only a frame as a well-developed knowledge structure derived from pilot training and experience. Frames tell us what rules to invoke in different situations. For example, what direction should a switch be thrown to turn on a light? In the United States, the switch should be thrown up. In England, the switch should be thrown down. In many flight decks, a "sweep-on" rule is used to determine how overhead switches should be thrown. Knowledge of one's environment activates the appropriate frame.

Plans and actions that run counter to established frames, i.e., conditions of low stimulus-response compatibility, are potential flight-deck problems. Thus, a pilot's mental frame that invokes a rule that automation functions just like another pilot is likely to cause trouble. The optimal human factors solution is for the original design to be consistent with stimulus-response compatibility principles. However, airlines and pilots have to use the equipment at hand and sometimes this means that training must be used to overcome design deficiencies. A pilot who has been educated about frames and mental models is better prepared to benefit from such training.

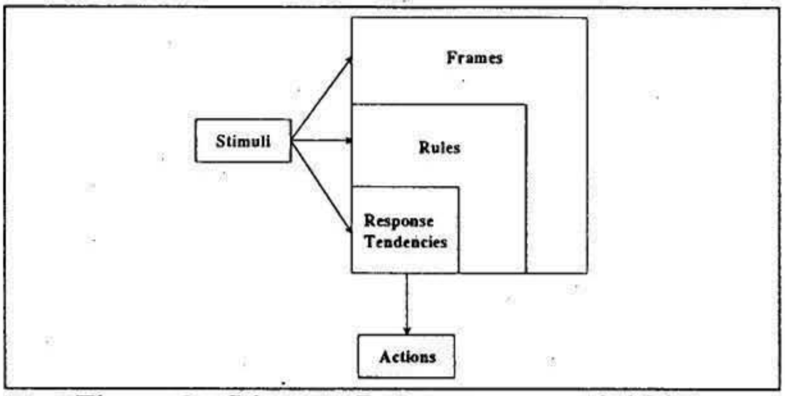

Figure 2. Stimulus-Response compatibilities.

FLIGHT CREW EDUCATION

I believe that there are three key issues that are important for the human factors education of flight crews:

Honor thy user. This is the first principle of human factors. It means that all designs should take the user's limitations and strengths into account. Unfortunately, not all flight decks are designed to meet this vital goal. A crew that is educated in human factors will be able to evaluate to what extent the first principle has been achieved. This will help them to fill any gap between their own capabilities and the demands of their airplane.

The crew is part of a system. As the SHEL model indicates, humans, equipment, procedures, and environments form a system. Any part of a system will influence the other parts. Since all the parts are important, crews must understand that undue attention to any one part may compromise their ability to detect error and to implement needed corrections in other parts of the system.

Knowledge of aviation. Here flight crews have an advantage because their professional training and experience gives them a deeper understanding of aviation than the typical human factors expert. General human factors principles and theories are of little use to flight crews unless they are applied in a concrete way to aviation problems.

The training of human factors professionals is quite arduous, crossing many disciplines (Howell, Colle, Kantowitz, & Wiener, 1987). Fortunately, operational personnel do not need to become human factors experts. Instead, they require an appreciation of how human factors professionals think and approach problems. This can be accomplished through a series of human factors case studies that not only illustrate how ergonomists work but also drive home the point that human factors is quite relevant to aviation. This casebook would be based upon human factors theory and key concepts that are supported and illustrated by appropriate aviation examples. I would make extensive use of incident reports (ASRS, CHIRPS, etc.) in creating a workbook of aviation case studies. I believe such an approach would be especially valuable for helping pilots avoid errors with advanced flight-deck automation (Kantowitz, 1992). New methods have been created to analyze incident reports objectively using multivariate statistical techniques to relate incident components to taxonomies of flight-related topics as well as a model of human information processing (Kantowitz & Bittner, 1992). This would allow appropriate incidents to be selected. A workbook based upon these selected incidents would help flight crews gain a relevant human factors education.

References

ASRS. (1990). MD-80 altitude deviation synopsis, aviation safety reportting system, NASA-AMES/FLS:262-4. Mountain View, CA.

Howell, W. C.; Colle, H. A.; Kantowitz, B. H.; & Wiener, E. L. (1987). Guidelines for education and training in engineering psychology. *American Psychologist*, 602-604.

ICAO. (1989). Fundamental human factors concepts. Human Factors Digest No. 1. Circular 216-AN/13. Montreal, Canada: International Civil Aviation Organization.

ICAO. (1991). Training of operational personnel in human factors. Human Factors Digest No. 3. Circular 227-AN/136. Montreal, Canada: International Civil Aviation Organization.

Kantowitz, B. H. (1987). Mental workload. In P. A. Hancock (Ed.), Human Factors Psychology. Amsterdam, The Netherlands: North-Holland.

Kantowitz, B. H. (1992). Cockpit automation and pilot workload. *International Conference on Environmental Systems*, Society of Automotive Engineers, Paper 921132.

Kantowitz, B. H.; & Bittner, A. C. Jr. (1992). Using the aviation safety reporting system database as a human factors research tool. *Proceedings of the 15th Annual Aerospace & Defense Conference*, Institute of Industrial Engineers, 31-39.

Kantowitz, B. H.; & Sorkin, R. D. (1983). *Human Factors: Understanding People-System Relationships*. New York: John Wiley & Sons.

Kantowitz, B. H.; Triggs, T. J.; Barnes, V. (1990). Stimulus-response compatibility and human factors. In R. W. Proctor & T. Reeves (Eds.), *Stimulus-Response Compatibility*. Amsterday, The Netherlands: North-Holland.

Wiener, E. L.; & Nagel, D. C. (1988). *Human Factors in Aviation*. San Diego: Academic Press.

IMPLEMENTATION OF HUMAN FACTORS KNOWLEDGE REQUIREMENTS IN THE CANADIAN FLIGHT TRAINING SYSTEM

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It is an honour to be able to share our human factors endeavours with you. And in keeping with the objectives of the symposium,

I trust that relating our experience to you will open the door to further discussion and development.

Several Branches in Transport Canada are involved with human factors. Our Branch--Aviation Licensing--is concerned with pilots who are undergoing training for flight crew licences. Other Branches direct their efforts at licensed pilots.

Aviation Training is a Division within the Aviation Licensing Branch. It is divided into two Sections: Flight Training and Aviation Education. Flight Training deals with skills and Aviation Education with knowledge requirements. As I represent the Aviation Education Section, I will address our efforts at developing human factors knowledge. From this perspective, I will relate how Transport Canada has proceeded with the introduction of ICAO human factors knowledge requirements in the Canadian Flight Training System.

My discussion will centre around the following:

1. how we utilize ICAO Digest No. 3 in the development of of our examinations and publications,

2. adaptation of our existing pilot decision-making and aeromedical materials to the basic ICAO outline,

3. efforts to pass on requirements and reference material to pilot candidates, and

4. research endeavours to improve and validate the program.

ICAO--Basis of the Program

The basis of our human factors program is the philosophy and training curriculum outlined in ICAO Circular *Human Factors Digest No. 3*. We altered the ICAO outline slightly and numbered the headings and sub-headings to fit into a master coding index utilized in our examination computer system. This satisfies a requirement to code examination questions and to identify areas that are being tested.

The study and reference guides for the various flight crew licences were then revised to include the ICAO human factors topics appropriate for that particular licence. This was done by checking off items from the master list and including them in the study and reference guide. Many human factors topics, such as aeromedical facts, have historically been included in Canadian flight crew examinations and in corresponding study and reference guides. These were formerly listed under the Flight Operations section heading, but we have now reorganized the headings.

Our new study and reference guides designate Human Factors as a separate section heading along with other major headings such as Air law, Meteorology and Navigation. This produces a distinctive visual advantage that raises the profile of human factors and allows for the inclusion of a greater number of sub-sections and topics under the heading. I think that this is a significant starting point.

Pilot Decision-making

Transport Canada's early commitment to pilot decision-making has been over-taken by developments in human factors. Briefly this is what has happened. A joint study in the early 1980's by the Federal Aviation Administration, Transport Canada and the General Aviation Manufactures Association resulted in a prototype judgement training publication. Other countries and agencies added their support to the project and a series of Aeronautical Decision Making manuals were published by the American Owners and Pilots Association (AOPA), Air Safety Foundation. When the AOPA manuals became available, Canadian instructors were encouraged to use them on a trial basis--but their use was not mandatory.

In early 1991, Transport Canada produced a combined student and instructor manual entitled *Pilot Decision-Making Manual for Private Pilot Training*. The major focus in this manual is the decision-making process and the factors that influence decision-making. In contrast, the AOPA manuals contain a greater emphasis on attitudes.

The intention was to make the new manual simple, concise and oriented towards a broader human factors perspective. The manual also suggests strategies for teaching pilot decision-making in ground school and in the cockpit. This 14-page reference contains six chapters:

The Decision-Making Process

Factors that Influence Pilot Decision-Making
Situational Awareness
Stress
Managing Risk
Hazardous Attitudes

Following ICAO recommendations and practices, Canada has made human factors including pilot decision-making a mandatory requirement for all flight crew licences. The enabling document is the Personnel Licensing Handbook Volume 1.

Aeromedical Facts

In order to supplement the reference material available for pilots undergoing basic training, the Department of Health and Welfare, a government agency associated with Transport Canada, has produced a manual entitled *The Pilot's Guide to Medical Human Factors*. The topics contained in this manual along with the *Pilot Decision-Making Manual for Private Pilot Training* cover the topics included in the private and commercial study and reference guide. The pilot decision-making manual is directed towards psychological aspects, while physical and physiological aspects are grouped together in the medical manual.

As a point of interest, in 1981 the Department of Health and Welfare produced an advanced book entitled *Cause Factor: Human--A treatise on Rotary Wing Human Factors*. This book was ahead of its time containing human factors information that is current today.

Given a strong aeromedical base, we wanted to expand the broader aspects of human factors into the Canadian flight training system. We had to keep in mind that a number of topics would be new to some while recognizing that many flying training colleges and larger flying schools have been offering excellent instruction in human factors for many years.

Another area of consideration is the time required for human factors training. The minimum ground school required for private and commercial licence in Canada is 40 hours. Although 40 hours would be a reasonable minimum for a human factors course, it may not be practical for a small flight school to provide 40 hours of human factors instruction. Consequently, the new human factors manuals were designed to be a realistic starting point that could be easily enlarged.

In future, we intend to put a greater emphasis on aviation psychology, for example information processing.

Implementation

In addition to study and reference guides, publications and written examinations, human factors knowledge has been promoted in several other areas.

In 1989, a flight training enhancement project was initiated to develop six additional training publications to assist flight instructors. These include instrument flight training, private pilot training syllabus, night flying, multi-engine training, ground school, and instructor training. All of the publications will include human factors.

Human factors are also being promoted at flight instructor refresher courses and flight test examiner workshops held across Canada each year. Targeting instructors is important because they are probably the most effective means of distributing human factors knowledge.

Research and the Transportation Development Centre

The Transportation Development Centre is Transport Canada's centralized research and development organization. It serves as a centre of expertise on transportation technology and innovation.

In January 1991, our Branch asked the Transportation Development Centre to undertake a research study to develop and evaluate a total human factors program including knowledge and skill requirements. The request was based on the questions:

- What human factors knowledge requirements are appropriate for pilots at various experience levels?

- What human factors skills are appropriate for pilots at various experience levels?

- How are human factors knowledge and skills best learned, and what teaching methods and activities are most effective?

- What resources are required to support the instructional activities?

- What are the most appropriate testing processes for written and practical examination, and are there areas that should not be evaluated?

This project is indicative of what we would like to accomplish, and this research is especially important to validate our initiatives. The project was delayed for a time due to financial restraints but it is now underway.

To keep abreast of developments in other countries, representatives from our Branch have attended human factors courses at the Cranfield College of Aeronautics in Great Britain and the Aeromedical Training Institute in the United States. We have also discussed human factors development with the British Aviation Authority (CAA) and the United States Federal Aviation Authority (FAA).

The Future

Our plans for the future basically consist of continuing in the same direction, but with an emphasis on the psychological side of human factors.

We are optimistic that the Transportation Development Centre will guide us in the development of a total program. We are especially looking for self directed resources aimed at assisting flying instructors to teach human factors and tools to evaluate both human factors skills and knowledge.

We will continue to maintain joint human factors committees within our Branch and other Branches in Transport Canada to liaise with each other and external groups.

Perhaps most importantly, we have recommended to our management that our Directorate establish various levels of personnel expertise in human factors. If we have the training and expertise in place, the application of Human Factors will follow.

Summary

I have given you a brief description of how the Aviation Education Section of Transport Canada has proceeded with the introduction of human factors knowledge requirements. There is much more happening in human factors in other groups and directorates in Transport Canada, but I have been speaking for my Section.

I have discussed (1) how we have used ICAO Digest No. 3, (2) how we have adapted aeromedical and pilot decision-making materials to the ICAO outline, (3) efforts to pass on information to pilot candidates, and (4) research activities.

I have presented this to you knowing that we have just commenced our human factors journey and knowing that there is a great deal more to do. I hope that sharing this beginning with you will open the door to much more discussion of the subject with each other.

HUMAN FACTORS IN GENERAL AVIATION

Ronald D. Campbell (IAOPA)

Introduction

For the purpose of this paper, the term General Aviation also includes Aerial work operations as the statistics quoted apply to the period before ICAO separated these two activities.

Most (if not all) books published on human factors are written around multi pilot operations in large aircraft, thus a large part of such books are of little interest to General Aviation pilots who, in the main are engaged in single pilot activities. This means that most of the human factors material which is available for reading concentrates on human inter-relationship on the flight deck, much of which is irrelevant to General Aviation pilots.

This results in a situation where although the subject of human factors in aviation has at last been given much greater exposure, it has been mainly directed at the Commercial Air Transport sector, which is the smallest segment and also the one in which the least number of accidents occur. Nevertheless, this is understandable in view of the fact that just one accident involving a multi pilot aircraft can affect the safety of a large number of passengers. If we are to improve safety across the total spectrum of aviation operations, more emphasis must be given to the sectors which conduct the largest number of aviation movements, and in this respect it should be noted that General Aviation conducts over 8 times the number of aircraft movements than the Commercial Air Transport sector.

However, human factors involve pilots and therefore what is probably more relevant to this symposium is the fact that some 80% of all pilots operate within the General Aviation sector. It is also pertinent to point out that a number of single pilot air taxi operations occur within the Commercial Air Transport sector. From this we see that in terms of pure numbers, our current human factors education is predominately aimed at the lowest number of active pilots, and the following general figures illustrate this fact.

Aviation facts - World Wide

Due to small annual variations, the following figures are approximate.

Pilots - 1 million

20% of all pilots are employed in the Commercial Air Transport sector

11% of all aircraft operate within the Commercial Air transport sector

80% of all pilots operate within the General Aviation sector

89% of all aircraft operate within the General Aviation sector.

Total Aircraft 330,000

Aircraft employed in Commercial Air Transport operations - 40,000

Aircraft employed in General Aviation operations - 290,000

Total aircraft movements (departures)

Commercial Air Transport - 18 million

General Aviation - 99 million

Although the latest ICAO figure for annual flying hours being completed by Commercial Air Transport (CAT) and General Aviation (GA) show that GA conducted just over twice the flying hours done by CAT, this does not show a true comparison when it comes to measuring safety factors. This is due to the fact that the 'risk factor' varies with the type of operation being conducted, and the specific phases of flight in which past accidents have occurred.

Pilot experience versus the environment

If we are to succeed in improving GA safety through the human factors approach, we clearly need to establish the operational environment which GA pilots have to cope with, as distinct from their contemporaries in CAT operations. In accepting this philosophy, the following factors would have to be considered in structuring human performance education for private pilots, while bearing in mind that a number of these factors would also apply to pilots engaged in Aerial Work activities.

EXPERIENCE & ENVIRONMENTAL FACTORS FOR CONSIDERATION

90% of pilots used in CAT have an instrument rating
10% of private pilots have an instrument rating

75% of the hours flown in CAT are carried out with two pilots on board
95% of the hours flown by private pilots are conducted with only one pilot on board

90% of aircraft used in the CAT sector have two or more engines
90% of aircraft flown by private pilots have only one engine - a significant fact when one engine fails

Pilots involved in CAT fly on average 300 to 500 hours per year
Private pilots fly on average, say 10 to 30 hours per year

Pilots involved in CAT have on average 5 times more training in terms of hours and experience than private pilots

85% of flights undertaken in CAT take place in the confines of protected airspace
90% of the flights undertaken by private pilots take place in uncontrolled airspace

CAT flights are conducted mainly from large well equipped aerodromes
Private pilots operate from small aerodromes and landing strips, the latter leaving little margin for pilot error

60% of all accidents occur during the take-off and initial climb, and the approach and landing phase of the flight:
The average length of a CAT flight is 2 hours
The average length of flights conducted in GA is 30 minutes
Thus GA flights are exposed to the highest risk area 4 times more often than those in CAT.

Additionally, the annual total flying carried out in GA include 1 million hours with student pilots at the controls.

From the preceding facts it can be seen that type specific information is needed when developing programmes aimed at improving pilot behaviour during single pilot operations. Currently during training, all pilots are indoctrinated into the facts concerning aircraft performance. However, it is just as important for all pilots to have an understanding of human performance and how fatigue, stress, anxiety, lack of arousal and imperfect communication between others and oneself can inhibit the ability to make sound judgements and decisions.

The ability to safely operate an aircraft stems from the development of physical skills and cognitive judgement. The definition of the latter can be loosely stated as:

'getting it altogether through perception, reasoning, or intuition and arriving at a correct decision and then implementing it at the right time'.

However, in this respect the main problem which faces the pilot is the fact that, whereas physical skills can be developed through good tuition and practice, cognitive judgement is much more difficult to acquire. This is because the cognitive process has no colour, shape, size or feel, thus it can only be developed through the acquisition of knowledge and implemented by the use of intellect in conjunction with experience (or experiences).

If we study the recorded details of past incidents and accidents, it is not difficult to see that in most cases it was not so much a lack of physical skill which gave rise to the occurrence, but rather the lack of a good decision implemented at the right time. Therefore, it is this aspect to which our training initiatives on human factors must be directed.

The limitations of flight checks

In this respect, that oft quoted panacea for safety - the 'flight check' is not enough, because all pilots know that on these occasions, their pay cheques or their privileges are on the line, and being cognisant of this fact, will operate by the book. What concerns us today are the flights conducted after the examiners or check pilots have completed their assessment and gone on their way. It is then that human behaviour reverts and so easily becomes prone to errors of judgement, brought about by the insidious presence of complacency and other common behavioural attitudes, which of course are not easily recognisable in oneself.

Human factors education

Following the publication by ICAO of the 8th edition of Annex 1, considerable interest has been aroused and much work is being done to bring the subject of human attitudes and flightcrew co-ordination to the fore during training and at regular intervals thereafter. However, in relation to single pilot operations and the individual type of activity ranging from recreational flights to aerial work, it is far less practical to construct programmes for reinforcing knowledge of human performance aspects after completion of basic pilot training.

Human factors and the flight instructor

Flight instructors are the people most involved with pilots education, and this is particularly so in the case of private pilots, a group who hold over half the world's pilot licences. Therefore it is vitally important that flight instructors have an 'in depth' understanding of human factors, if they are to inculcate awareness of human behaviour into student pilots during their initial training and while they are under supervisory control.

Notwithstanding the fact that flight instructors aim to impart good judgement, it is generally done in an irregular fashion, mostly based upon specific situations as they arise. This is largely because there has been no structured guidance material or specific written goals within the various pilot syllabuses. Traditional training programmes in the past have tended to focus on physical pilot skills rather than on cognitive judgement.

The statement in the foregoing paragraph can be reinforced by the fact that while there is a surfeit of books covering the development of flying skills and technical knowledge, it is only in recent years that books have appeared which relate to the involvement of human factors in aviation. This has been an encouraging move, however while it would be wrong not to acknowledge the expertise of the authors of such publications and the excellent work they have done, it must also be appreciated that these books have to be easily understood by people who wish to obtain a pilot's licence and be competent in that role, rather than becoming experts in psychology or physiology. To sum up this last statement, we need more written material which states the facts simply, and to which the reader can relate in the environment of the cockpit rather than a deep and extensive psychological treatise on human behaviour.

Conclusions

Bearing in mind the important part which flight instructors play in establishing levels of safety to both students and qualified pilots , the way forward would be to incorporate specific human factors training programmes in all initial flight instructor training courses. In addition re-current training in this subject via seminars should be a mandatory requirement for re-validating flight instructor ratings.

Seminars, specifically designed to cover human factors with an emphasis on the development of good judgement and decision making should become a standard method of communication between civil aviation administrations, flight safety officers and General Aviation pilots.

More readable, motivating written material, aimed at the total pilot population, should be made available and in a form which encourages student and qualified pilots to give greater thought to human behavioural patterns in relation to reducing risks and developing better judgement and decision making.

NEW AVIATION PROFESSIONALISM: KNOWLEDGE SYSTEMS THAT INTEGRATE HUMAN FACTOR COMPETENCIES IN JOB PERFORMANCE

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Abstract

One of the much used words in aviation is that of "professionalism". Every pilot wants the privileges (especially money), respect, and responsibilities that come from being a captain employed by a major airline. To achieve this end, pilots accept that the means to such an end involve high technical standards of performance, integrity and an acceptance of the "rules of progression" from trainee pilot, second officer, first officer and finally captain. Similar aspirations may be found with air traffic controllers, maintenance engineers and other occupational groups within the industry. Acceptance of these "means to an end" are what job incumbents mean when they describe their work status as "being professional". However, is this label legitimate. This paper will examine strategies which will need to be implemented if airline flight crews, air traffic controllers and maintenance engineers are to develop from craft based operators, to members who can be accorded the status and responsibility practiced by most of the recognised professions. Aviation's need for an internationally recognised tertiary-delivered, content of knowledge, long accepted by other professional groups, is discussed. Included in such knowledge systems will be the need for integrating human factor dimensions, with those that recognise the cultural context in which aviation personnel operate. The new professionalism in aviation will result in expanding the competencies of its members in technical, management and human factor applications.

The Nature of Professions

One of the much used words in aviation is that of "professionalism". Every pilot wants the privileges (especially money), respect, and responsibilities that come from being a captain employed by a major airline. To achieve this end, pilots accept that the means to this end involve the attainment of high technical standards of performance, integrity and an acceptance of industry folk laws including seniority systems for career progression from trainee pilot, second officer, first officer and finally captain. Acceptance of these "means to the end" are what pilots mean when they describe their work status as "being professional". However, is this a label which accurately reflects current status, or is it a hope for some future social attainment?

What is a Profession?

The word "profession" conjures up many images: high public esteem, respectability, independence, prestige, and in many cases, wealth. Traditional professions, medicine, law, engineering - are almost universally accorded high prestige status when compared with other occupational groups - construction workers, sales representatives or clerical workers. And in most societies, education for a career in one of the major professions is regarded as a gateway to financial and social security. The best students from secondary education fiercely compete for available places in the professional faculties of a nation's best universities. To succeed, students must devote long years to education and training, achieve a high level of self-discipline and be prepared to expend considerable sums of money (either from their own or family's financial resources, or through those resources provided by the state).

If it is this kind of status which pilots either believe they are a part of, or seek to become a part of, what are its characteristics. What is it that professions have which set them apart from other occupational groups, and for which individuals or families will sacrifice so much in order to be admitted? This author believes there are at least 3 characteristics which are important is separating "professions" from other working groups:

1. Ways of acting or operating which relate to "discipline-based" procedures rather than "craft-based" practices.
2. A defined body of knowledge (or knowledge system) which is generally agreed to be requisite for the group to operate in a professional manner, and which is organized in such a way that the knowledge system becomes "owned" by its users (the professional incumbents).
3. Accepted codes of individual and group conduct and procedures for punishing infractions against such codes.

Characteristics of a Profession

1. "Discipline" versus "Craft-Based" Practices

Characteristics of Craft-Based Practices.

It is the shift from craft-based practices to discipline based methodologies that usually signal the emergence of a "professional discipline". The business of transferring knowledge from a master craftsperson to novice in a crafts-based occupational context, is invariably based around the following activities and structures:

1. The novice is required to observe the processes and products of the "master" Initially, the learner is not allowed to do anything, but "watch" and "learn".
2. After a period of time, the master, "seeing" that the novice is *ready* to progress to the next stage, will invite the student to execute some of the basic skills that he or she has observed. These skills will be very simple and general.
3. A good deal of *time* will be allocated so that the student can practice and practice again these defined skills until a high level of mastery has been achieved. Often, this "time to mastery" will be quantified and documented in some industrial ward or competency type statement.
4. More skills will be added to the novice's repertoire of skills. Some of them will be more complex extensions of those previously learnt. Again, the mastery of these more complex behaviours will be defined in terms of allotments of *time* the master believes is required for the skills to be learned, as well as to experience the ways in which the skills might be used.
5. Should the master describe the way in which knowledge is to be transferred, these descriptions would more often than not emphasise concepts of linear gradation, that is, teaching from concrete objects to abstract concepts, and progressing from simple knowledge and skills to complex expert performances.

Useful though these approaches to training might seem they contain a number of obvious disadvantages:

1. The novice's performance is very dependent upon the quality of the master, since this person is the "fountain of knowledge". If the master's ability to transfer his or her knowledge is poor, the novice's chances of acquiring those requisite knowledges and skills is also likely to be poor.
2. The knowledge that the master has acquired, and now demonstrates as his or her expertise, is different from the knowledge required in achieving that expertise. It is difficult for many masters to make this distinction. They wish to impart the knowledge they currently use, not the knowledge and skills which were needed to be acquired before their competency could be expressed.
3. Undertaking practice in the *real world* of the master may be expensive, and dangerous if mishandled. It may well be better to provide instructional simulations of the real world so that the novice can practice the requisite knowledge and skills in safe and inexpensive ways.
4. It is often difficult, if not impossible to get into the "mind of the master". High levels of understanding generally require access to the broader disciplines from which the specific applications are derived.

Most examples of *ab initio* pilot training follow the craft-based model of competency development. Experience is defined by regulatory authorities in terms of logged hours. Criteria for the award of private or professional licences are based upon prescribed flight hours. Little attention is paid to *how* those hours might have been achieved, nor the types of environmental or human factor conditions which might be required to optimise "mastery performance". The broader disciplines for problem solving and decision making are absent.

Examples of Occupational Groups which have progressed from craft-based to discipline based learning.

General Practitioners - The forefathers of todays general practitioners were individuals who diagnosed a patients problems, created the remedies and prescribed the treatment regime. If the patient lived, their fame and reputation grew (so too, presumably did their fees). If the patient died, forces from the other side of consciousness, and beyond the reasonable control of the practitioner, were found to explain the unfortunate failure. It was someone or something else's fault. It is perhaps interesting to note that many of the occupations which were the forerunners of todays prestigious professions still exist. Surgeons who still are required to exhibit a high degree of manual dexterity only separated from a manual workers union, the English Barbers Guild, in the seventeenth-century.

Elementary School Teachers - Elementary teachers might argue that they have only comparatively recently joined the ranks of true professionals. Teacher training has long been a craft-based practice. Entry into the so called profession required that a teacher trainee be assigned to a "master teacher" and admonished to observed the ways and means by which he or she handed down knowledge and skill to those intrusted to their care. Such "masters" might well have declared (and often did) that "You don't need a university education to teach kids - all you need is a strong arm and a powerful voice to force the right ideas into their little heads."

In many countries, pre-service training for elementary (and secondary) teachers now require at least three years of tertiary based intensive theoretical and practical education. The content of such study includes an extensive examination and application of scientific disciplines such as psychology, sociology, the sciences, educational practices, and classroom management.

2. A Body of Aviation Knowledge

Discipline-Based Knowledge

The theory of professionalism has much to do with how knowledge (and/or skill) is used by its owners (the knowledge incumbents) to pursue their activities. Most often the professions are centred on typical 'problem-solving' systems of knowledge and or skill. The problems are posed or solved in a conceptual framework. These concepts and their relation one to another tend to be used by convention in one way and not another, and those who have the appropriate education or training know how to use it. Two points of view have arisen on the importance of knowledge systems. The first asserts that what is important is the prestige and power that the knowledge provides the owners, whether or not that knowledge has any real value in solving problems (Collins, 1979). The second views knowledge acquisition as much more instrumental to professionals (it is knowledge that is required in job performance) in actual problem solving, and in enhancing their standing in society. It is this second perspective that has importance in aviation. Pilots are charged with the requirement to conduct their activities in a professionally safe and effective manner. The knowledge to do so must be instrumentally valid and more inclusive than just the technical requirements of flight performance or systems management. It must include the operational competencies for safe and effective performance, and also the cultural, managerial and human factor abilities that high capitol, high technology, and high socially significant systems demand.

The knowledge system which supports pilot performance has evolved dramatically in only a few short decades. For centuries the human race's fascination for flight was expressed in many artistic and ingenious attempts to emulate the bird. Not until sufficient knowledge had been assembled in related dimensions such as aerodynamics and the requisites of power-to-weight ratios were Orville and Wilbur Wright able to make their first epic flight in 1903. As an aside, there is still some support for the view that the world's first powered flight took place not at Kitty Hawk, but on a desolate farm in the South Island of New Zealand at Waitohi by a recluse inventor, Richard Pearse. If such a flight did take place on the date claimed by many, March 31, 1903, the event would have predated the much publicised Wright Brothers epic by 9 months. Whatever the case, the fact that he was one of the earliest pioneers to access this same knowledge system, though separated by thousands of miles from other pioneers of the knowledge, is not in dispute.

In the pioneer days, selection criteria for persons who might become owners of the knowledge (pilots) tended to emphasise ingenuity, tenacity, versatility and adaptability. Like the forefathers of todays medical practitioners, early pilots were required to invent the resources which could be used in applying the then known knowledge. For example, as Elwyn Edwards has described "Flying was uncomfortable, difficult and hazardous. Experience indicated, however, that certain basic aids were essential in order to achieve an acceptable level of control. Early amongst these was the famous piece of string tied either to the trailing edge of an elevator or to a lateral frame member so that the pilot could avoid skid or slip during a turn by keeping the fluttering sting parallel to the fore-and-aft axis of the aircraft. Without this aid, turns could easily lead to a spin from which there might be no recovery (p.6-7)."

One of the earliest attempts to construct a pilot training curriculum was that developed by the British pioneer aviator, Robert Smith-Barrie. In 1913 he produced the first *Flying Training* manual. His reasons for doing so were quite clear. Contemporary approaches to disseminating flight knowledge to trainee pilots was haphazard, capricious and sometime quite untrue. The best instructors were promoted from training to administration or other activities, and took with them their knowledge and experience. New instructors were reliant on the knowledge that had been passed to them from their instructors, right or wrong. An analysis of his manual is interesting. It comprised three major content areas: practical flying (about 85 percent of instruction); engines (controls and maintenance - 10 percent); and map and compass reading (5 percent). What might have been termed "airmanship" was more closely identified with "officer qualities", skills in horse riding and mess etiquette. These attributes pilots were expected to have developed prior to undertaking flight training.

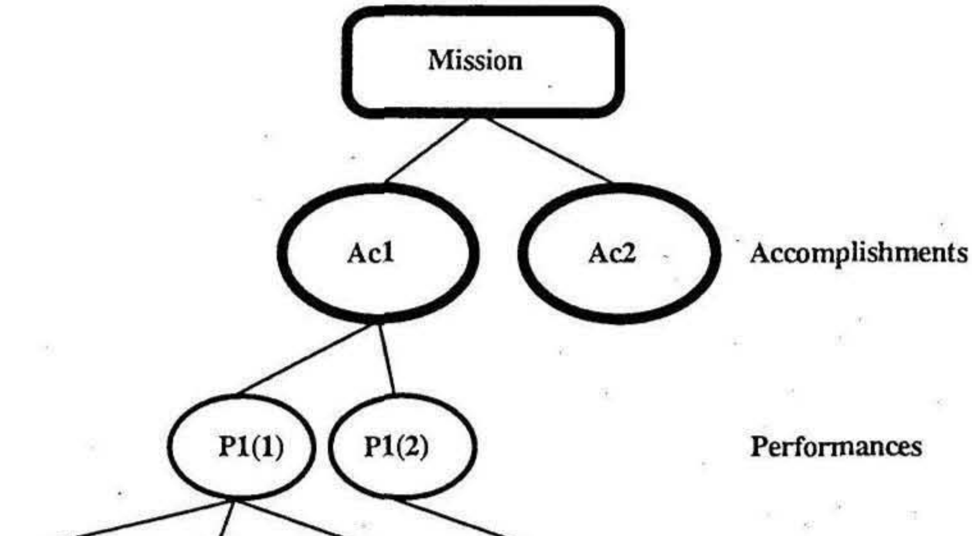
A Model for Identifying Requisite Pilot Knowledge

Analyses of requisite pilot performance have traditionally been derived from observations of flying skills ("stick and rudder") and the individual's knowledge of flight rules and procedures. When these dimensions have been translated into predictive indices, no more than about 25 percent of the variance of performance at advanced stages of competency have been accounted for (Roscoe and North, 1980). However, as these researchers note, despite the prediction problem, flight crew are able to identify "abilities" such as *estimating* probable outcomes for different courses of action, or *attending* to *resolving* an emergency without losing control of the on going routine procedures. The trick in developing a map of pilot competency is to be able to relate these types of requisite abilities to contextual applications. For instance, consider the abilities involved in executing a landing. At least two are critical: *assessing* the relative position of the aircraft in relation to the ground; and *perceiving* the changes in the shape of the runway in relation to reducing height. A description of this interactive process of *ability* and *context* might be provided in an instruction to a trainee pilot such as:

> *"You will recognise the flare height when the runway appears to expand rapidly outwards. Use this view as the cue for assessing the moment at which you need to flare."*

In this example, the identification of each "ability" assumes a larger, more integrative knowledge base from which it has been derived. In a knowledge structures hierarchy model of pilot competency, this assumption is structured in a top down, three-level hierarchy of increasingly specific capacities to process knowledge. This method developed by Hunt (1986), provides a procedure for mapping abilities in a manner in which interactive specifications of human competency can be prescribed.

Figure 1 **Knowledge Structures Hierarchy**



At the Apex of the hierarchy is the Mission or overriding goal. This is the purpose to which all the accumulating activities are directed. These statements claim their validity from the degree to which all participants within the mission's purview can agree to its value and usefulness in providing direction and purpose. In civil aviation an acceptable mission might be *"the process of managing and operating the transportation of people and goods by air, both nationally and internationally, in a manner which maximises safety, efficiency and effectiveness."* Such a statement provides goal directed purpose for identifiable sectors within the industry; aviation regulators; air traffic controllers, airline operators; aircraft manufacturers; travel and tourist operators; airport managers and administrators; flight crews; cabin crews; aircraft maintenance engineers; and passenger service personnel. Each of these groups must in turn translate the macro based statement into sector mission statements giving specific focus and direction. For airline flight crews, a sector mission might be *"to operate and maintain scheduled aircraft services which maximise safety and enhances the efficiency and effectiveness of the airline's services."* In this statement implicit reference is being made to a number of pre-requisite capabilities. Such a sector mission could not be achieved without the prior attainment of the organisation's ability to be "accomplished" or highly competent in the complex behaviours which underlie flight standards and flight operations management, command, and the management of other technical sub systems.

The level beneath the mission provides individual elaborations of the goal's directives. These elaborations or *accomplishments* are the broad functional capabilities which contribute to personal expertise. Each accomplishment is the synthesis of two or more generic knowledge bases which are stored in and retrieved from long-term memory. For example, the flight crew accomplishment of *command*, defines a capacity to exercise formal, legal power and authority over aircraft crew and passengers and to establish and maintain effective and efficient crew performance.

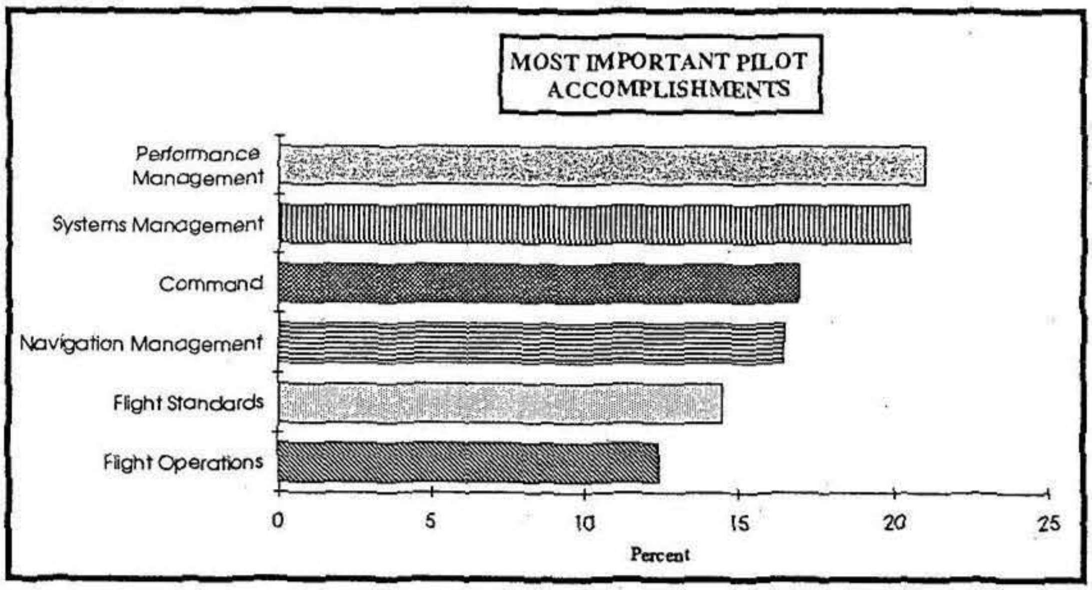
Each accomplishment is in turn defined by two or more *performances*. A performance is a statement of procedural knowledge ("intellectual skill," "knowing how") that is required in executing an accomplishment. This entity is an application of the concept developed by Newall and Simon (1972) who propounded the notion of a cognitive entity as a *production*, which entered into more complex *production systems*. Such an entity comprised a rule of procedural knowledge composed of a *condition* and *action* Gagné & Glaser, 1987). In this knowledge structures hierarchy model, performances provide the intellectual skill definitions related to individual accomplishments. One performance (for example *making in-flight adjustments*), may with other performances, provide the particular characteristic of a given accomplishment (say, *aircraft performance management*). That performance, in a different constellation of performances, will provide the construct for another accomplishment (for example, *navigation management*). Competency analyses of flight crew behaviour (Crook & Hunt, 1988) have identified that the *command* accomplishment can be defined by six performances, each one providing a subordinate contribution to its dependent accomplishment. These performances have been identified as *captain supervising, pilot managing, managing critical incidents*, and *managing crew interactions*.

The base of the hierarchy is provided by the *specific abilities* which define each of their superordinate performances. Specific abilities may have both cognitive and affective applications. For example, from the accomplishment of *command* and its performance, *crew interacting*, cognitive abilities are included in *assessing, decision-making* and *monitoring*, and affective abilities in *leading* and *listening*.

A Map of Pilot Competency

In a study of pilot competency (Hunt, 1990) a sample of 120 airline pilots were surveyed for their perception of the desirable ability attributes for pilot performance. From a mission statement which found more than 75 percent of the sample agreeing to a goal which explicated *"the process of managing and operating the transportation of people and goods by air, both nationally and internationally, in a manner which maximises safety, efficiency and effectiveness."* a canonical discriminant analysis generated six statistically significant accomplishments. Further analyses revealed that these accomplishments could be categorised into two groups (figure 1). The first related to the pilot's operational management of the aircraft and its systems. These accomplishments together are described as "piloting accomplishments." The second cluster prescribe the pilot's relationship to the types of operational requirements (air transport, aerial work, etc.,) and flight standards (regulatory and organizational requirements) which impact upon flight crew procedures. These are described as the pilot's "environmental accomplishments."

Figure 2.



In the piloting accomplishments both aircraft performance management (APM) and aircraft systems management (ASM) have a similar magnitude in perceived importance. APM is defined as the accomplished ability to safely and productively control the flight profile of the aircraft under Visual and Instrument Flight Rules (VFR and IFR) from "take off" to "landing." It embraces all the capacities a flight crew must engage in order to operate and control an aircraft through the performance modes of take off, climb, cruise, manoeuvre, descent and land. In contrast, ASM is defined as the accomplished ability to safely and productively manage the aircraft's technical systems in all environmental and performance conditions including the flight crew ability to recognise abnormal aircraft system performance, identify malfunctions and arrive at solutions to remediate the conditions.

The third piloting accomplishment is navigation management. This accomplishment is defined as the dynamic process of systematically determining the position of an aircraft in flight in legally defined operating conditions and taking it safely and productively in those conditions from a given position to the desired destination.

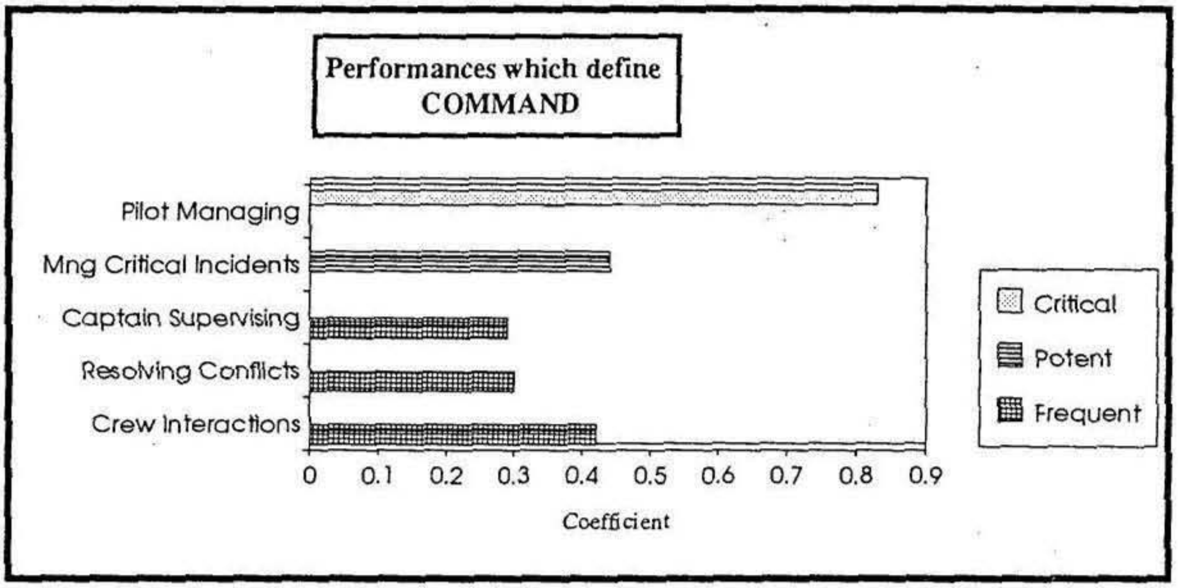
The final piloting accomplishment is command. While there are legal role connotations embedded within this accomplishment for analytical purposes this critical piloting outcome is defined as being the capacity to manage interpersonal relationships with inter system relationships (aircraft crews, passengers, and air traffic, with aircraft systems and performance requirements) in order to achieve the operational goal of a flight. It may include the exercise of formal, legal power and authority over other crew members and passengers, but also includes the responsibilities of a First Officer (whether that officer be in a "Pilot Flying" or "Pilot Not Flying" status. It is within this accomplishment, but not exclusively related to it, that much of the focus of "crew resource management" (CRM) (Helmreich, & Wilhelm, 1991) takes place.

An Example: *Flight Crew Performance Management*

Effective flight crew performance has been defined by Chidester and Foushee (1989) as a joint product of the piloting skills, attitudes and personality characteristics of team members. As Jensen and Biegalski (1989) and others have suggested it is to the first component of this definition that much of the effort in training has been historically expended. Only in more recent times, and especially since the airliner collision at Teneriffe in 1977, have attitudinal and personality characteristics received much attention for training purposes. The focus of this attention has been to enhance the problem-solving and decision-making strategies of crews in normal and abnormal operating situations. However, as the studies reviewed by Chidester and Foushee reveal, short training interventions to achieve personality changes which might induce more consultative, open and collective problem-solving leadership offer little promise. Further more, although the evidence is less conclusive, attitude modification training programmes for the same purpose tend not to be effective when delivered over short periods of time. On the other hand, as Rumelhart (1981) has argued, effective problem-solving and decision-making strategies can be established if the information structures which underlie them are built into clearly organised knowledge structures and *schemata*. Such schemata represent procedural knowledge (accomplishments, performances and abilities) and the interrelationships between objects, events, and sequences of events. Once an appropriate schema is retrieved to working memory, knowledge processes are available to problem solve a situation. However, the variable for ultimate effectiveness is the prior organization and perception of relevance that the schemata may provide Flight crew performance management (FCPM) then is seen as a process for developing schemata to enhance problem-solving and decision making strategies on the flight deck.

An example of FCPM schemata can be seen from figure 2. The key piloting accomplishment *command* is defined by five contributing performances: *crew* *interactions, resolving conflicts, captain supervising, managing critical incidents and pilot managing*

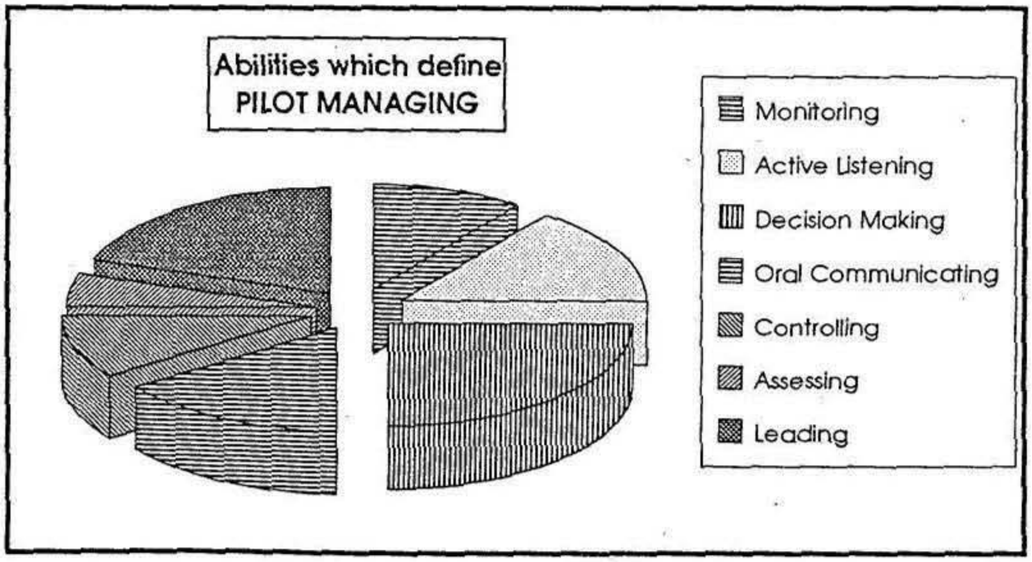
Figure 2



Wilks Lambda .7327   Chi-Squared 121.91   DF 52 Significance 0.00p<.01

Each of these performances are in turn defined by process abilities which combine in a cognitive and affective manner many of the attributes which have been the subject of CRM type courses (figure 3). As the data demonstrates, the effective execution of a pilot managing performance in both Pilot Flying and Pilot Not Flying modes is predicated on the previously stored abilities for *decision-making, oral communicating, controlling, assessing, leading, monitoring* and *active listening*.

Figure 3.



For training purposes, each of the capacities when defined as performances or process abilities can be analysed in terms of the impact they make in defining their superordinate performance or accomplishment. Added to this as figure 2 illustrates, is an instructional weighting continuum which identifies each capacity as being "common," "potent," or "critical." A *critical* performance or process ability is one in which the size of the correlation within the discriminant function is high (approximately at least +.30), while at the same time accounting for a high proportion of the reported observations. The size of the correlation is based upon each capacities pooled within-groups correlation between discriminating variables and canonical discriminant functions. A *potent* performance or process ability is one in which the size of the correlation within the discriminant function is high, but the frequency of reported observations is less than 35 percent of the total observation. At the level of least impact are those performances and abilities which are *common*. These entities have a low discriminant coefficient and are reported on by less than 35 percent of the observations. Common entities tend to equate with the "core" components of a training syllabus, while potent and critical entities suggest crucial capacities for learning and competency acquisition. In the discriminant analysis of the process abilities underlying *pilot managing* both *decision-making* and *controlling* resulted in critical weightings, while *active listening, monitoring, assessing* and *oral communicating* were found to be common.

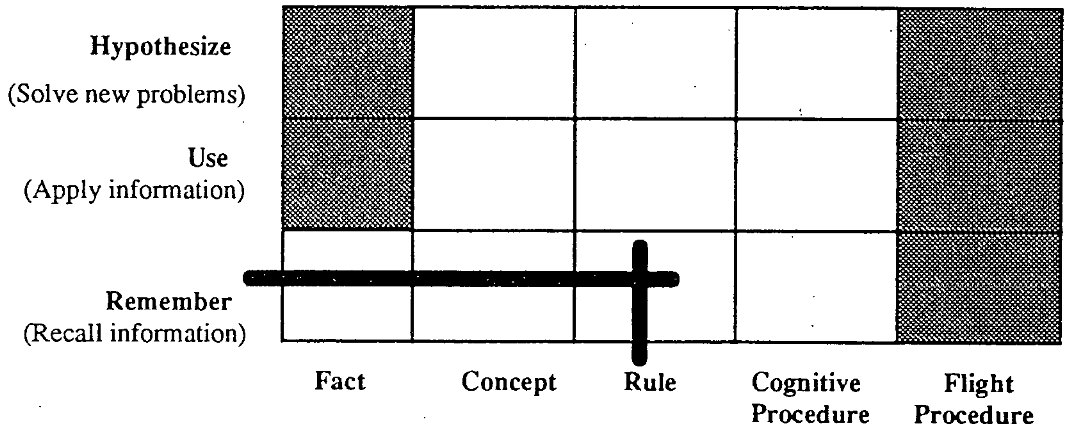
Validating Knowledge Structures

Gagné and Glaser (1987) have assumed that different learning outcomes require different conditions for competency acquisitions. Similarly, if the content of learning (especially declarative (knowing that) and procedural knowledge) can be specified in terms of facts, concepts, rules and procedures, so can the thinking processes which are required to transform the information into expressed outcomes. One approach to this two-dimensional matrix has been described by Merrill and others (Merrill, 1983) as a performance-content matrix. A modification to this matrix has been made by the author and applied to the identification of the levels of learning outcome processes to content knowledge structures. For example (figure 4), examine the learning process and content knowledge requirements for solving this question:

Frequent inspections should be made of aircraft exhaust manifold-type heating systems to minimise the possibility of

- *(a) exhaust gasses leaking into the cockpit.*
- *(b) a power loss due to back pressure in the exhaust system.*
- *(c) a cold running engine due to heat withdrawn by the heater.*

Figure 4 **Knowledge-Process Outcome Matrix**



The answer to the question lies in the student being able to access rule knowledge and process this information at the "remember a rule" level of learning outcome. Recognition of these content-process intercepts can be used to validate the applications of knowledge structures in the context in which the capacities will be used. For instructional design purposes, these content-process interactions are identified through the construction of competency specifications (figure 5). Such specifications not only detail the contextual application of the knowledge under consideration, but also the means for determining a criterion-based measure of the competency's validity.

The ramification of these results for training and regulatory purposes are significant. They provide licensing authorities, trainers and flight crew examiners with an objective means of defining, prioritising, instructing and evaluating flight crew competencies. Given such maps of pilot ability and the contexts in which they apply, it is possible to construct competency specifications identifying the interaction of abilities with any number of their contextual applications. For example, in a competency specification which focuses on the accomplishment *command management*, and *pilot managing* as a critical performance, a crew resource training application for this competency might be:

> *"Given busy radio/telephone traffic, including the issuance of amended decent profiles, the First Officer is required to brief the air crew on arrival and approach procedures in accordance with the airlines standard operating procedures. The Captain will assess the appropriateness of the plan and the alternatives which have been suggested to cope with a shortened visual approach or emergency. The Captain will decide on which strategy is best."*

Figure 5

Competency Specification

Accomplishment	Command	
Performance	Pilot Managing	
Abilities	Oral Communicating: Assessing:	Active listening Decision Making

Task Context

Given busy radio/telephone traffic, including the issuance of ammended decent profiles, the FO is required to brief air crew on arrival and approach procedures in accordance with airline's SOP's. The Captain assesses appropriateness of plan and alternatives which have been suggested to cope with shortened visual approach or emergency. The Captain will decide on which strategy is best.

In this example, the performance of pilot managing is being examined through the interactive application of the abilities of such as *speaking* (oral communicating), *active listening* (being able to critically listen for relevant information) *assessing* (determining relevant environmental and interpersonal conditions), and *decision-making* (choosing the best of competing alternatives). Cognitive and affective skills are embedded in the overall mastery of the accomplishment.

3. Professional Responsibility

A third characteristic of a profession is the way in which it organizes and moderates its activities, particularly in relation to its clients. Carr-Saunders and Williams (1964) and others have gone so far to declare that no profession is a "true" profession until it throws up an "autonomous corporate association with the function of guaranteeing the competence, honour and security of its members." However, this principle of autonomy is atypical of the vast majority of professions. In England, probably only barristers could be regarded as "true" professionals. The more usual form of relationship is through some form of collegial control modified by state or external regulatory controls. In aviation, the potential for this characteristic to be met may be found through the interactive relationship of regulatory licences, airline corporate governance, and pilot associations. A pilot's legal status is defined in national civil aviation legislation and the privileges under which employment is executed, through the various licences and ratings which the legislation so recognises. However, the conditions of service which may apply to any given pilot (excluding those conditions which may be deemed to impinge upon safety - for example, flight hours and rest periods) are more a function and responsibility of the particular airline or employer.

One of the major anomalies of the pilot fraternity is the system of company seniority. The airline pilot is firmly attached to his or her company, since seniority is not transferable. In large airlines, promotion from second officer to first, and especially from first to captain, is slow. Stone and Babcock (1988) have suggested that in large airlines it may take a pilot 15 to 20 years before being made a captain. Airlines, largely supported by regulatory authorities condone the seniority system. It is the traditional system, and a system which requires few assumptions to be made about competency. Increased competency is simply the sum of experience, which is the sum of time spent in continued flight operations. However, the Airline Deregulation Act of 1978 may be part of the processes of changing these conventions. In this environment pilots are increasingly seen to be more critical to the airline's success. In a less regulated environment, completing a mission, at minimum cost while achieving maximum revenues is having the effect of making the pilot a more critical factor in the operation, beyond the accepted safety dimensions. Pilots see their role as being more susceptible to "pushing" - being forced by direct or indirect means to compromise safe practices in order to complete flights. Regulators increasingly recognising these pressures are supportive of changes to pilot education and training. Programmes like the FAA's *Advanced Qualification Program* are examples of ways by which new approaches to pilot competency may be researched, implemented and evaluated. The net result of these trends, and a more scientific understanding of pilot competency, may move pilots away from inflexible seniority based systems of promotion to professionally prescribed systems of competency-based performance.

Pre-Service Education and Training

Finally, all major professions require a pre-service educational programme in which candidates undertake significant periods of formal education study prior to entering the practice of their chosen profession. These programmes are located in the professional schools of multi faculty universities - schools of medicine, law, architecture, dentistry, and now aviation. In retrospect, it is perhaps surprising that aviation has been so slow in recognising the need for more formal educational approaches for entry into the industry. The statistics clearly demonstrate that while flying may be much safer than driving a motor car, it is not as safe as it could be.

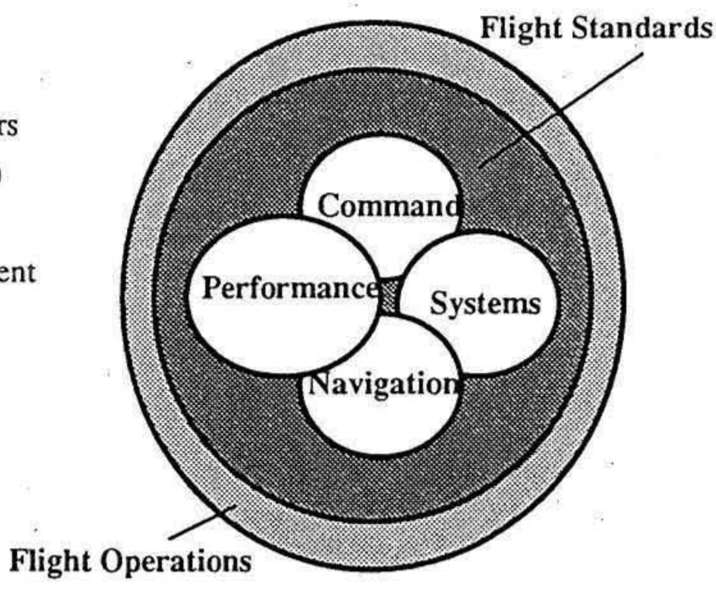
In the first half of 1989 more than 600 people died in 26 aircraft accidents. This compares with an annual average, calculated since 1959, of 567 persons (IATA, 1986). The prognosis for eliminating human error in aviation accidents is not very good. The consistency and stability of these figures across time, political and cultural boundaries is remarkable. Hawkins (1987) reporting on a German study by Meier Muller in 1940 concluded that in that year 70 percent of all aircraft accidents could be attributed to some form of human factor deficiency. In a more detailed analysis of only judgemental and decision-making factors, Jensen and Benel (1977) identified these two components of human factors to account for 52 percent of all general aviation fatalities in the United States from 1970 to 1974. To sum up, approximately 70 percent of all fatalities are due to pilot or air traffic induced error. Of the remaining 30 percent, probably about 12 percent can be attributed to weather related factors, 9 percent to acts of terrorism of one kind or another, 6 percent to maintenance defects and only about 3 percent to structural failures.

Pilot training must change. University based approaches may provide a means to that end, but only if they develop integrated programmes - that is, academic curricula which integrate flight skills with technical, scientific and human factor disciplines. There are a number of major international universities which provide aviation education, The Ohio State University; the University of Illinois; and the University of Newcastle (New South Wales, Australia) and Massey University to name some. However, Massey University is one of a very few which achieve an integrated programme. The Bachelor of Aviation is an undergraduate degree which includes 2 year full-time *Flight Crew Development* for students wishing to integrate pilot training (commercial and air transport licences and ratings) within an academic programme.

Figure 6

Integrated Bachelor of Aviation degree
(Massey University)

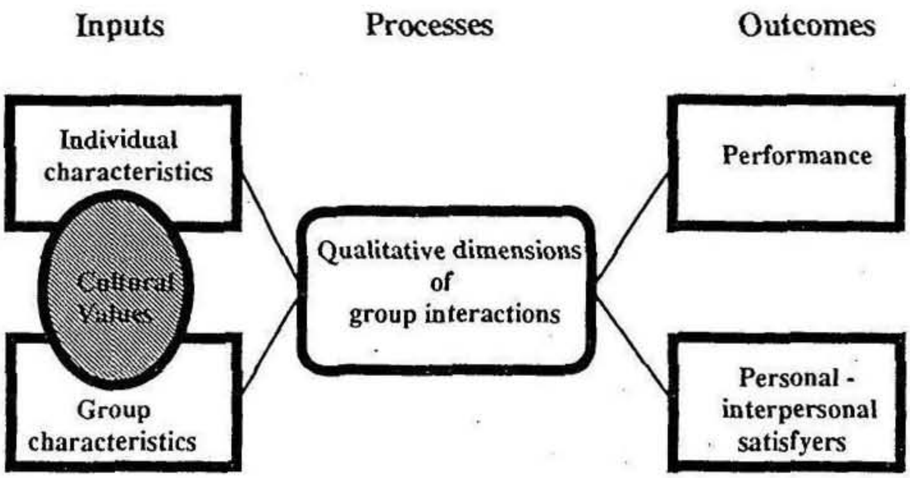
Aviation Human Factors
Aviation Studies (core)
Aviation Systems
Flight Crew Development
Flight Instruction



Cultural Contexts

Cultural Characteristics Flight deck performance is all about the interactive effects of three different variables - (1) the personal and group characteristics which each member of a crew bring into the cockpit; (2) the ways in which communication and work practices are processed, and (3) the quality of the group's overall performance in achieving its task in relation to the safety, efficiency and effectiveness of the flight and the manner in which the members of the group feel about themselves and each other (figure 7).

Figure 7 Interactive variables in group performance



Within this model is the recognition that the members of a crew come to work with a set of ideas about themselves (knowledge, skills and attitudes - achievements and failures) which make up each individuals "self concept". Some of these characteristics rub off from one to another. A depressingly maniacal person is likely to turn the flight deck group into a cautious, humourless and even fearful group of people. Interwoven into both the personal and group characteristics are the cultural values which moderates the manner in which each individual interacts with each other. This overlay effects the way in which the group interacts in terms of communication modes, interpersonal relationships, power and authority. These in turn will influence the outcomes of the operation, particularly to the degree that the crew will feel the performance together was a satisfying and rewarding experience. As the satisfiers become less obvious, and degenerate into annoyers so the performance effectiveness of the flight may become more jeopardised.

Unfortunately, very little evidence has been established for the generalisability of these models of social interaction (Amir & Sharon, 1987). Their conclusions questioned the justification of applying theories and explanations of human behaviour conducted within a particular cultural setting (eg., European, or North American airline operations) to other settings (eg., African or Asian airline operations), unless such theories and explanations have been replicated in the target setting. Rarely, has this been done in aviation.

One model which has attempted to examine the manner with which both input and process variables can be effected by culture has been the focus of systematic study by Professor Geert Hofstede (1983). In his study of work-related values across different cultural groups he determined that individuals tended to share a range of characteristics which tended to aggregate to a national *persona*. These characteristics in turn could be scaled and differentiated across four basic dimensions: (1) power-distance; (2) uncertainty-avoidance; (3) individualism; and (4) masculinity. Captain Neil Johnston (in press) has provided an important glimpse as to how the interactive dimensions of this model might apply cross culturally to flight deck performance. But no data has yet been generated demonstrating the culturally specific diversity of these dimensions in flight deck performance. Much more effort will need to be made on studying the cultural transferabilities of human factor components from one cultural setting to another if models included within accepted European and North American practices such as crew resource management are to be translated from dogma to human effectiveness.

Conclusion

This paper commenced by raising the issue as to whether practices in aviation, particularly those personified in flight crew performance, could meet criteria that would be acceptable in according its incumbents with the status of "a profession". The question was asked whether such a condition was extant, or a still to be achieved goal? The proposition put was that professionalism embodied at least three key attributes, two of which related to the inculcation of a specialised body of higher order knowledge. Justification for this attribute was based not only upon within group notions of exclusivity, but more rationally, upon empirical evidence in which observed expertise was seen as a domain specific phenomena (Glaser and Chi, 1988). The competencies which contribute to the professional accomplishments of a pilot constitute one such domain. Evidence to date would suggest that, especially in terms of pre-service preparation, aviation has a considerable way to go before it can rightfully claim equity with the more traditional professions such as medicine or law. However, the growing effort of a handful of universities around the world which provide for the integration of technical theory, academic knowledge and manipulative practice in dedicated qualification programmes provide the promise of a *new*, and perhaps *real* professionalism in aviation. In this promise lies the future for professional flight crew development.

References

Amir, Y., and Sharon, I. (1987). Are social psychological laws corss-culturally valid? *Journal of Cross Cultural Psychology, 18, 4,* pp. 383-470.

Besco, R.O. (1989). Analyzing knowledge deficiencies in pilot performance. In R.S. Jensen (Ed.) *Proceedings of the Fifth International Symposium on Aviation Psychology, Vol 1.* The Ohio State University, 61-86.

Billings, C.E. (1991). Toward a human-centered aircraft automation philosophy. *The International Journal of Aviation Psychology,* 1, 4, 261-270.

Carr-Saunders, A.M., and Wilson, P.A. (1964). *The professions.* London: Cass.

Collins, R. (1979). The credential society: an historical sociology of education and stratification. New York: Academic Press.

Costley, J., & Johnson, D., & Lawson, D. (upublished paper). A comparison of cockpit communication B737-B757.

Chase, W.G., & Simon, H.A. (1973). Perception in chess. *Cognitive Psychology,* 4, 55-81.

Chidester, T.R. and Foushee, H.C. (1989). Leader personality and crew effectiveness: a full-mission simulation experiment. In R.S. Jensen (Ed.) *Proceedings of the Fifth International Symposium on Aviation Psychology, Vol 2.* The Ohio State University, 676-681.

Crook, C., & Hunt, G.J.F. (1988). Competent flight crew licensing II: the terms of reference for the Hurda Programme. Palmerston North: Instructional Systems Programme, Massey Univesity.

Chi, M.T.H., Glaser, R., & Rees, E. (1982). Expertise in problem solving. In R. Sternberg (Ed.), Advances in the psychology of human intelligence (Vol. 1, pp. 17-76). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cotley, J., Johnson, D. & Lawson, D (unpublished) A comparison of cockpit communication B737-B757. St Ives, Cambridgeshire: Interactive Trainers Limited.

Edwards, E. (1988). Introductory overview. In E. L Wiener & D.C. Nagel (Eds.), *Human factors in aviation* (pp. 3-25). San Diego: Academic Press.

Foushee, H.C., & Helmreich, R.L. (1988) In E. L Wiener & D.C. Nagel (Eds.), *Human factors in aviation* (pp. 189-227). San Diego: Academic Press.

Gagné, R.M. (1970). *The Conditions of Learning* (2nd Ed.). New York: Holt, Rinehart and Winston.

Gagné, R.M. & Glaser, R. (1987). Foundations in learning research. In R.M. Gagné (Ed.), Instructional technology: foundations (pp .49-83). Hillsdale, NJ: Lawrence Erlbaum Associations.

Glaser, R., & Chi, M.T.H. (1988). Overview. In M.T.H. Chi, R. Glaser, & M.J. Farr (Eds.), The *nature of expertise.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Helmreich, R.L., & Wilhelm, J.A. (1991). Outcomes of crew resource management. *The International Journal of Aviation Psychology,* 1 ,4, 287-300

Horne, R.E. (1973). *Introduction to Information Mapping*. Lexington, Massachussetts: Information Resources, Inc.

Hunt, G.J.F. (1986). Needs assessment in adult education: tactical and strategic considerations. *Instructional Science*, 15, 287-296.

Hunt, G.J.F. (1990). An abilities based approach to pilot competency and decision making. In *ICAO Human Factors Digest* No. 4 (pp. A302-A309). Montreal, Canada: ICAO.

Jensen, R.S.,& Biegalski, C.S. (1989). Cockpit resource management. In R.S. Jensen (Ed.), *Aviation Psychology*. Aldershot, Hants.: Gower Technical Press.

Johnston, N. (in press). CRM - cross-cultural perspectives. In E. Weiner, B. Kanki, and R. Helmreich (Eds.). *Cockpit Resource Management*. San Diego: Academic Press.

Kantowitz B.H., & Casper, P.A. (1988) Human workload in aviation. In E. L Wiener & D.C. Nagel (Eds.), *Human factors in aviation* (pp. 157-187). San Diego: Academic Press.

Merrill, M.D. (1983). Component display theory. In C.M. Reigeluth (Ed.), *Instructional design theories and models: an overview of their current status*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Newell, A., & Simon, H.A. (1972). *Human problem solving*. Englewood cliffs, NJ: Prentice-hall.

Posner, M.I. (1988). Introduction: what it is to be an expert? In M.T.H. Chi, R Glaser & M J Farr (Eds.), *The nature of expertise*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Roscoe, S.N. and North, A.A. (1980). Prediction of pilot performance. In S.N. Roscoe (Ed.) *Aviation Psychology*. Ames, Iowa: The Iowa University Press.

Rumelhart, D.E. (1981). *Understanding understanding*. La Jolla, CA: University of California, San Diego, Centre for Human Information Processing.

Stone, R.B. and Babcock, G.L. (1988). Airline pilots' perspective. In E. L Wiener & D.C. Nagel (Eds.), *Human factors in aviation* (pp. 529-560). San Diego: Academic Press.

Wiener, E., & Curry, R.E. (1980). Flight-deck automation: promises and problems. *Ergonomics*, 23, 995-1011.

Williams, R.G. (1977). A behavioural typology of educational objectives for the cognitive domain. *Educational Technology*, 17, 39-46.

Some Aspects on Our Human Factors Concept

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Human Factors

For three days we are going to talk about Human Factors. It is therefore extremely important that we have a united view about the translation of these words. In discussions with others and in articles I have found that this expression has quite a different meaning for different people.

Every one of us, of course, has a very clear idea of the meaning of the words. But, if we analyse each individual, we will soon find that these very clear opinions diverge a lot. Different nationalities and different cultures as well as differences in age, occupation and academic background, have a great influence on our feelings towards these words. Some have an old meaning of Human Factors in their mind.
In the ICAO circular, Human Factors Digest No.1, there is a warning on page 3 against this misconception about Human Factors and the belief that it is somehow a branch of medicine. Human Factors is, for many of us, the same as Human Error. The view of Human Factors as being a contributing factor to accidents in our life, is a negative one. Human Factors cause accidents. This is very bad and, as accidents should be avoided, consequently Human Factors should be eliminated.
Others have a much more positive view of this expression. Human Factors are those factors which make us human. Some even regard our Human Factors as Divine Factors. I would like to say that it is thanks to Human Factors, that the airline business is the safest transportation system of all.
Thanks to Human Factors, in the whole airline system, IATA members flew more than 1,25 billion passengers safely from gate to gate last year.

We often hear that 75% of all accidents are caused by Human Factors. But we can also say that, during the last twenty years, thanks to Human Factors, other reasons for accidents have been dramatically reduced and are now as low as 25%.
Which expression do you like most?
Let us compare with the word FEVER.
For most of us fever is something very negative.
It keeps us in bed and makes us unable to work.
For others, fever is a positive reaction which helps our infected body to recover.

Also in the ICAO Human Factors study group, I have clearly noticed that the group members look at "Human Factors" from different angles.

Both the positive view and the negative view can be clearly both seen and heard. And of course it is important that some kind of identification of the expression is made, in order to unite and help instructors and students in our industry.

An Agreed View of the Meaning

In the ICAO digest No.1 we can, in the very first sentence, read "Human Factors as a term has to be clearly defined"
But no clear, short and holistic definition, suitable for practical IATA work, can be found in the text. There are definitions and they are different from each other. Scientists from different faculties will have and must have different definitions, because they do research and they look at Human Factors from quite different angles.

If we just take one of those and apply it to our airline sphere, we will have difficulties in being united. Our faculty is flying. What we need is a kind of definition which suits our work. Something we can accept and use in our airline business.
There already exists a wide spread explanation of the word Psychology so why not start with that?
It says, Psychology is: The scientific study of Behaviour and Mental Processes.

In order to cover Human Factors completely we have to add the function of our body and its limits. That is Physiology. May I therefore propose the following, which contains both the positive and the negative aspects and can easily be accepted by Airline Personnel. For us Human Factors means

Physiology Behaviour and Mental Processes.

And when I say Mental Processes, I include EMOTIONS.
EMOTIONS is a factor, which is extremely important to throw light upon, if we want to improve flight safety by using knowledge of Human Factors as a tool in our industry.
In combination with the SHEL concept and its components, Software, Hardware, Environment and Liveware, it covers what Human Factors should mean to those of us engaged in the flying business.
Yes, within IATA, we need a more united and holistic view of the meaning of Human Factors in the future. A holistic view will act as a conditioned stimulus for the whole system and our behaviour will change towards more flight safety related actions and thinking.

The Use of Human Factors

I usually say that the Human model we now are operating is about 50,000 years old. Our brain and our nervous system then got its present design with its enormous capacity.To know more about Human Factors is firstly to know and appreciate the performance of our system. The performance and capacity which has made it possible to create our world and our very safe air transport system.

The expression "Human Performance and Limitations" is used by ICAO. And a very important part of Human Factors training is to know about the Limitations.
Limitations there are and Limitations we have. With knowledge of the Limitations we can improve safety.
Without that knowledge, those Limitations will cause a lot of accidents.

If we look positively at Human Factors, we can use it to improve communication and reduce the risk of misunderstanding.
We can handle stress and improve our performance.
We can increase productivity. The social part of our life can get better and we become more confident.
Negative attitudes can be reduced and this gives us more job satisfaction.
If we have a positive attitude towards Human Factors and if we learn more about it, this list can be made endless. On the other hand, if we look negatively at this concept, the list will be very short and the result will be disastrous.

Human Factors courses are therefore necessary for all airline personnel.
For Pilots, Cabin Attendants, Technicians, Instructors, for Front Line Personnel, and last but not least all the managers from Flight Operations.
Flight Operations, being responsible for flight safety, easily get the wrong impression that they are experts on Flight Safety and sometimes believe that their Flight Operations Manual can take care of all problems regarding Human Factors.
As a final resort they decide to spend some money and send their pilots on a three day course to get rid of the last trace of dangerous Human Factors.

I am now painting a very dark picture, but unfortunately this picture exists. I can also paint brighter and more colourful pictures of Managers and Flight Operations, who really want to learn.
They do not consider the Human Factors concept as a concept, which can be learned once and for all. They consider the Human Factors concept to be a process, which runs through the Airline and which will continue forever, where one learned psychological item will lead to another interesting question and so on.

I can see airlines and I can see aircraft manufacturers of different kinds.
One tries to **use** Human Factors and the other tries to **eliminate** Human Factors.
I can also see the result and I can assure you that the organisation, which tries to eliminate Human Factors will definitely lose in the long run.
If instead we try to use it, we will learn how to avoid getting into the danger zone.

So, energy has to be spent on Human Factors courses, where we can learn how to utilise Human Performance and know the limitations and make flying even safer. The interest for Human Factors has grown dramatically during the last ten years and that is indeed very good. But there is always a risk that also positive thinking and positive actions might create a situation with unexpected backlash effects.

Human Factors Research

A lot of research has started (at universities around the world) on Human Factors and flying. Thanks to this we have learned a lot. But this research is mostly focused on the negative side of Human Factors. When it reaches the public, via press radio and TV, they easily get and transmit the wrong impression that flying is heading towards reduced safety instead of towards increased safety, as it is in reality. There is a risk that this research is digging deeper and deeper into pilots' mistakes only. And that will cause a dilemma for our industry and its reputation as being an extraordinarily safe transportation system.
As counterbalance I would like to have research also on how Human Factors eliminate errors and mistakes. That kind of research would make the picture of what we are doing in our industry more complete. It would make a positive impact on the public and create confidence in our business.

It is not difficult to find errors made in connection with flying.
I have been flying for 50% of aviation history and during that time I have made around 13.000 safe take offs and landings. But Ladies and Gentlemen, I can assure you that on a lot of those 13.000 flights, I have made errors caused by Human Factors. But also, thanks to Human Factors, those errors were corrected and compensated for and the result was a safe flight.

Incidents

The second risk of a backlash, which I will mention, is that our great interest in Human Factors now, which is very positive, has caused a situation, where we observe and analyse incidents, which did not bother us some years ago. This new interest is very good, but it creates an uncomfortable situation for the spectators. Because both airline personnel and passengers, who very often regard an incident as an accident, get the impression that there is an increased rate of accidents caused by Human Factors. We know that we are improving flight safety that way, as we have always done, but the spectators believe that dangerous events happen more often now than earlier, when, in reality, the opposite is true.

These Human Factors incidents must be looked at from another, more positive, point of view. Namely, Human Factors prevent incidents from becoming accidents. An incident positively indicates that our Human Factors safety net is operating as expected. That message must be given to the public and Airline personnel.
We must remember that incidents happen daily in every man's life.
They might happen when we drive a car, when we cross a street or do the cooking. The person who takes them too seriously and regards them as accidents, will most probably meet an early death due to psychological stress and not due to the incidents.

Examination

The third backlash risk we might face and which we must work upon to reduce, is the introduction of the Human Factors concept to pilots within our organisation.

Many countries have ratified, or will soon ratify, the ICAO annex 1 suggestion to have Human Performance and Limitations on the training programme for all levels of pilot licensing. That is extremely good.
The training subject "Human Factors" will then have the same status as Aerodynamics, Meteorology and others had earlier.
For years those subjects have been the subject of written examination. And usually those tests have been in the form of Multiple Choice.
As Human Factors now has the same status, it is very easy to fall into the same habit regarding tests and the result is that we start to test Human Factors knowledge by giving Multiple Choice questions.
I think it is OK, but not necessary, to have such a test on the Private Pilot Licence level, where most of the questions are about physiology and simple questions on psychology. But on higher levels, for commercial pilots, there should not be any written test. **Leadership, Attitudes, Conflict Management** and **Communication** are subjects too important to simplify as just right and wrong.

The tuition and its result will get much better without a written test. Those pilots, who are going to use their knowledge within commercial flying, are wise, judicious and interested. My experience is that they are very interested in this rather new subject. And this interest would most probably decline if they knew that the seminar would end in a written test.
Their way of listening would change. **That is a Human Factor!**
They would listen less to the message and try instead to concentrate on what kind of questions will come up later. Valuable discussions would probably vanish, as they take time and the students want continuous information from start to finish.
Authorities, schools and instructors also display a rather poor Human Factors knowledge, if they believe that simple, unambiguous answers can be given on this variable and complicated subject.

Well then, how can we be sure that the pilots know, what they should know about Human Factors. The answer is: "We can never be sure".
At least not after a test.
Then the students are happy and will probably not think about it any more.
But without a test we might start a process which will continue long after the course has ended.
In Sweden the CAA is now running a system on trial, which I fully agree with. They give tests on the licence A level. On the commercial pilot licence level they do not give tests but have system checks on those, who conduct the teaching. To be approved by CAA as an instructor, one has to have a lot of knowledge and experience both of psychology and commercial flying.

In chapter 2 of Annex 1 (Personnel Licensing) nothing is said about a written test. It says:
The applicant shall have demonstrated a level of knowledge appropriated to his duty.
That can be done in a dialogue between the instructor and the student during the Human Factors seminar. So, is a test really necessary?

Let me conclude.

We should not spoil the great and growing interest for Human Factors among pilots by giving them tests on a subject which has more nuances than just black and white.

We must think, very carefully, about how this Human Factors concept will influence the image of safety. I would like to say that the IATA members and the ICAO people must control and act in a way, so this positive stake will not turn out to produce a boomerang effect. A positive approach to Human Factors will create an optimistic picture, which is what we need.

We must have a united and holistic meaning of the expression Human Factors, which suits those who work within the airline business.
Let me suggest **Physiology Behaviour and Mental Processes.**

We must use the Human Factors concept positively and give our customers the correct feelings and the conviction that they can have confidence in our industry now and in the future.

Appendix.

Complacency

I will take this opportunity to propose a definition of another word which is very often used in our IATA vocabulary and that is Complacency.
It is a word, we very often use in connection with accidents and incidents. In a research some years ago professor Ragnar Hagdahl at Stockholm University and I asked pilots and others to answer an investigation questionnaire, in order to give us an indication, what the word Complacency really meant to them. The form was delivered to around 1400 persons and we got hundreds of different answers. This indicated that the meaning of this word is quite different for different individuals and also differed between nations and different languages.
Of course important words used in important communication should be defined. And in our report on this research we suggest that Complacency *on flight deck* is defined as a state where
The pilot unconsciously does not use the knowledge and information available.
That means that the pilot, under certain conditions, unconsciously does not fully utilise his own or his colleagues' cognitive skill and knowledge.

TRAINING HUMANS FOR AN AUTOMATED ATC ENVIRONMENT

Bert Ruitenberg
Executive Vice-President Professional
IFATCA

Good morning, ladies and gentlemen. My name is Bert Ruitenberg, I live in The Netherlands where I work as an Air Traffic Controller at Schiphol, the airport of Amsterdam.

Today I have the privilege to address you in my function as the Executive Vice-President Professional of IFATCA, the International Federation of Air Traffic Controllers' Associations. I am aware that the previous sentence may have baffled you slightly, but I will explain more of the organization of IFATCA in a few minutes, so stay tuned and it will all become clear.

Before giving a short overview of the contents of my presentation I would like to use this opportunity to thank ICAO, first of all for inviting IFATCA to present a paper at this Global Symposium on Human Factors in Aviation, and secondly for arranging the timetable of the presentations in such a way to allow this speaker to be here and still be able to arrive in Christchurch, New Zealand, in time for IFATCA's Annual Conference and the associated pre-conference Boardmeeting on Friday.

The first part of my presentation will be a short introduction to IFATCA, followed by a look at the relation between the Federation and ICAO's Human Factors Programme. Next, we will arrive at the main body of the presentation: ATC-training, Automated working-environments and Human Factors. I hope to point out some interesting differences compared to pilot-training, and will use some examples to indicate the role of Human Factors in ATC-training. Finally, of course, there are a number of conclusions that will be subtly brought to your attention.

Now that you know what is in store for you, we might as well get it over with, so we will launch directly into the short introduction to IFATCA I promised you.

The International Federation of Air Traffic Controllers' Associations was founded 32 years ago by Air Traffic Controllers from 12 European countries and has since grown to a body with over 80 Member Associations worldwide.
Among its objectives are: "the promotion of safety, efficiency and regularity in International Air Navigation", and: "to render assistance and advice in the development of safe and orderly systems of Air Traffic Control".
IFATCA is an independent, non-government, non-political, professional organization that has gained universal recognition from other aviation-related organizations as being "the voice of the Air Traffic Controller". This recognition is given shape by the many invitations IFATCA receives to participate in meetings, panels, working-groups etcetera where the opinion or input from operational Air Traffic Controllers is sought.
The IFATCA-representatives at those meetings etc. can rely on an extensive set of Federation Policies covering most of the topics that will be up for discussion, be it in the Technical field (e.g. on ATC-procedures, TCAS or ADS) or the Professional field (e.g. on working-conditions, medical or legal topics).
To conclude this brief introduction to IFATCA, you are probably wondering where I fit in the organization, so I will tell you. As the Executive Vice-President Professional I am the Executive Board-member responsible for the Professional matters of IFATCA. In the Board are also an EVP Technical, EVP Finance and EVPs for each of our four Regions, together with an Executive Secretary and an Editor. To keep us all in check we have a very competent President and Chief Executive Officer, aided by a Deputy President. If all this sounds impressive - good! (It was designed to do just that).

With this knowledge about IFATCA and its methods, it will be no surprise that there exists a healthy relation between IFATCA and ICAO, a relationship that may well be illustrated by our involvement in ICAO's Human Factors Programme. This incidentally brings us to the second part of my presentation.
Although we didn't attend the Leningrad Symposium and also weren't present at the first Regional Seminar (Cameroon), IFATCA was aware of the importance of the Programme and so was only too pleased to accept ICAO's invitation to present a paper at the second Regional Seminar (Bangkok). From that time on, similar presentations were made at Seminars in Mexico City and Cairo, and IFATCA was also involved in the drafting of the ICAO Digest on Human Factors in ATC.
Inspired by the ICAO Programme, IFATCA has furthermore begun an internal campaign to increase awareness of the importance of Human Factors in Aviation in general, and in ATC in particular. To that end, I have the honour to present a seminar-type paper on HF in ATC to the delegates at our Annual Conference next week.
It is felt there is a need for such a campaign, for in traditional ATC-training very little attention is given to subjects other than those dealing directly with ATC-procedures, separation-criteria or aviation-background (like meteorology and aerodynamics). To be fair to ICAO, I hasten to say that recently the licensing-criteria for Air Traffic Controllers have been reviewed, and that one of the changes is the inclusion of a requirement "to have knowledge of the human performance and limitations relevant to Air Traffic Control", so it looks like things will get better in the future.

If you remember the beginning of my presentation, you will have noted that I smoothly took you from the second part into what I called the main body of it, for we are now already looking at ATC-training. But before exploring this further, I have a little anecdote about training in the Royal Dutch Air Force that I want to share with you.

In recent years the Dutch Airforce operated two different fighter-aircraft: the NF5 and the F16. As the NF5 was growing outdated, the Airforce was in a process of slowly phasing them out while looking for a replacement when all of a sudden the Gulf-war erupted. NATO put heavy pressure on the Dutch and it was decided that the Tornado would be the successor of the NF5.
The Tornado's characteristics are such that it would make up for all shortcomings of the NF5: it's bigger, has a better performance and endurance, larger payload, etcetera. The only small disadvantage is that because of all this the aircraft is more difficult to operate, which led the Airforce to decide to use two pi^_lots on it. The task for each pilot was tentatively worked out on paper, but could be adjusted operationally if found necessary. This couldn't be practised in a simulator, as there was none available yet. Again, under NATO-pressure, it was decided to go operational with the Tornados immediately, even before official test-flights could be made by Dutch Airforce pilots. Such test-flights weren't possible anyway since various vital systems from the NF5s had to be built-in in the Tornados, while the number of operational fighters had to remain constant. (The Airforce had ordered new systems and instruments, but delivery wouldn't be before the end of the year so they had to be installed afterwards).
The Airforce however was confident that everything would go well, starting with the first missions in the Tornados. After all, the pilots were able to operate their NF5s too, weren't they?

In case you still have doubts: this story is NOT true. That is to say, it is not about the Airforce, aircraft or pilots. The scary part is, it is about Civil Aviation, the transition from an old to a new Control Tower, and Air Traffic Controllers!

This is what really happened "somewhere in Europe". As a result of airport-expansion, there was a need for a higher Control Tower, with a larger cab (or workfloor). This made up for all shortcomings of the old Tower, but had one disadvantage: because of the diameter of the cab and the height of the Tower, it proved to be impossible to see the part of the airfield below the opposite end of any control-position. So,

management decided that there were going to be two Groundcontrollers (i.e. the Controllers responsible for taxiing aircraft) working simultaneously, as opposed to the existing practice of having just one Groundcontroller.
A few internal co-ordination-procedures were devised (on paper), but it was expected that these would be modified while working the new system. As there was no Tower-simulator available, there was no way of checking things in advance. Furthermore, it was impossible to use the new Tower to test the procedures before going operational, since vital equipment from the old Tower had to be transferred to the new one at Transition Day. New equipment was ordered, but delivery was delayed so it would have to be installed later. Management however was confident that the Controllers would be able to cope. After all, they were able to work from the old Tower too, weren't they?

Do you see the analogy with the Airforce-story? The big difference is that in the Airforce-story everyone would agree that this is not the way to do it, whereas in the real ATC-story it took the ATC-association a lot of effort to convince management that maybe some things could be done differently - and even then the transition took place without any simulation at all, for simple lack of a simulator. This is in fact a common occurrence with ATC throughout the world.

Let's have a closer look at ATC-training in general. As with pilot-training there is normally an extensive programme to bring ab initio-trainees up to licensing-standards, although even here already it is probably correct to say that in pilot-training more use is made of simulators. Please don't think that Air Traffic Controllers are against the use of simulators for training! The reason they're not used is far more basic: it involves money, as usual.
When a manufacturer of simulators builds a simulator for, say, a Boeing 737 he has a wide range of potential customers. Every B737-operator in the world can use that simulator to meet his demands, give or take a few minor modifications. But try selling a simulator for Heathrow Tower to an ATC-school in Japan!
ATC-simulators are by nature very site-specific, and there^_fore expensive to buy. Furthermore, they usually require a lot of manpower to operate them (fake-pilots/blipdrivers), including up^_dating of the training-exercises, which adds to the operating-costs. For those reasons there are still many ATC-agencies that do not have the simulation-capabilities they require.

So what training is done in ATC after qualifying for the licence? In the more advanced countries with simulators, some refresher-training is conducted, and regular proficiency-checks take place. But this is the exception rather than rule, when looking at it on a global scale. Usually the post-licence training consists of no more than seeing changes in procedures (including major changes) on paper, after which experience on how to use these new procedures is gained while working - in an operational environment with real aircraft!
And when new equipment is installed, the Air Traffic Con^_trollers usually receive an introduction on how to operate the hardware (i.e. what the buttons are for), but not how to use it. That again is left for the individuals to discover while working, using live traffic as part of the learning process.
In that process, interesting discoveries are sometimes made! For example, in a new system that was about to be implemented somewhere in Europe, one of the more spectacular items that were automated is the traditional Flight Progress Strip - the rectangular piece of paper used by Controllers to keep track of the whereabouts of an aircraft. Normally, annotations concerning estimates, heights and speeds are made in pencil or pen on the strip, but in the new system every input goes per keyboard and electronic strips appear on monitors.
Controllers do not have to sort the strips anymore - the computer does it all, based on the estimates. The interesting discovery however was, that people using keyboards do tend to hit a wrong key every now and then. Well, maybe this was known already, but the discovery that if an estimate-time is wrong by one hour or more, the computer will sort the strip straight to a part of its memory where it cannot be retrieved until that time comes up, surely was a new one!

This was just one example, and more could be quoted here. The bottomline is: if the design of ATC-systems is left solely to technicians, and the Controllers receive little training before using the system operationally, the Latent Failure-phase of the Reason-model is entered without a second thought. And guess who are in the last line-of-defence?

Is automation as beneficial as many engineers and managers seem to believe, anyway? It is tempting for them to think that by introducing a high level of automation in Air Traffic Control there will be a spectacular increase in capacity, in other words, that because of automation more aircraft can be handled by less controllers. I would like to label this "a popular misconception". I will even explain why.
No matter how state-of-the-art the automated systems that become available for ATC are, there is not going to be one that is absolutely fail-safe. So, when the system fails, it is the Air Traffic Controller on whom everybody relies to handle the problem. And since his automated system has failed, he will be required to use a back-up system, which will usually be automated to a lesser degree. This implies a higher workload for the Controller, so he shouldn't be overloaded with too high a number of aircraft to handle. In other words: even in an automated environment a Controller should never be responsible for more aircraft than he can safely handle without the automated equipment - which is equal to the number of aircraft he handled before automation was introduced. So far for the increase in capacity.
But surely the number of Controllers required can be decreased with automation, you say? I'm afraid the same argument as before applies: you need sufficient Controllers to take over when the system fails, so *you probably need the same number as before. Worse even: you might require more than before!*
Although I maintain that there is no such thing as an absolutely fail-safe automated ATC-system, I will concede that today's systems are pretty fail-safe. (Which in ATC is just not good enough!) Therefore, just like pilots, 999 out of 1000 times an Air Traffic Controller will work a shift without experiencing any problems with the automated system - or even at better odds. It is that ONE time occurring that makes people really appreciate having pilots on board, or Controllers on the ground. For that reason, pilots go through regular training-programmes where the special skills required to handle emergency-situations are practised and sharpened.
It should not be different for Air Traffic Controllers working in highly automated environments. If their old-fashioned or manual skills are relied on to keep disasters from happening when^_ever the system breaks down, you better make sure they haven't forgotten how to use them! So, when automation is introduced, this doesn't cancel the need for training the Controllers in the old methods - it enhances that need, while at the same time adding the need for training how to operate the new system. If all that is done conscientiously, it may well imply that because of the introduction of an automated ATC-system there are more Controllers required than before.
Having arrived at this point, it is interesting to note that in many areas of the world there is a serious shortage of Air Traffic Controllers, a shortage that many politicians and other people responsible for ATS expect to solve by automation. See why I called it "a popular misconception"?

By now you may get the impression that IFATCA (or Controllers) are completely against all forms of automation in ATC. If you do, you are wrong. IFATCA feels there are genuine needs for automation to assist Controllers, to improve performance and reduce workload, to increase efficiency, to remove non-essential tasks, and to enhance job-satisfaction and the safety-element of the Controller's task. But there is also a need for Air Traffic Controllers to be involved as an essential part of any future ATC-system. The man-machine interface needs to be examined closely so that the system fits the human, *rather than have the human fit the system.*

Therefore IFATCA has always urged that Controllers be involved from the designing-phase onward in the development of new equipment. The Human Factors aspects of automation must be fully considered when developing automated systems and should include the maintenance of essential manual skills and Controller awareness.

It is our belief that the Controller must remain the key-element of the ATC-system and must retain the overall control-function of the system. Safeguards must be established to ensure that the Controller remains an active, rather than a passive, user of an automated system.

The preceding statements are examples of IFATCA-policies that I referred to in my introduction to the Federation earlier. They are the result of many meetings in which Controllers from all over the world endeavour to formulate statements on subjects that concern them all.

Another such policy is that before a new system is implemented, Controllers should receive adequate training in operating the system. This should seem obvious but is not always done. IFATCA is also in favour of regular refresher-training and proficiency-checks, always with the aim to keep the professional standard of the Controllers as high as required.

Coming to the end of my presentation, in which you first were briefly introduced to how IFATCA works, and what the relation is between IFATCA and ICAO's Human Factors Programme, it is my hope that the main part about ATC-training, Automated working-environments and Human Factors has given you an insight in our Federation's concerns in this field. Don't get carried away by technological possibilities when considering automation in ATC. Remember that the Human Element - the Air Traffic Controller - remains the heart of the ATC-system, and that the system is there for the Controller, not the other way around.

Thank you for your attention.

Transavia's Integrated Approach to Human Factors Training

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The Background

The early 1980s saw a growing interest amongst airlines in Cockpit Resource Management training. The publicity and interest generated through various conferences and symposia led to more airlines perceiving a potential need in this area. In 1984 Transavia Airlines' Flight Training Department began an evaluation of flight crew performance to determine if current training programmes were meeting crew needs. After consultations with the instructor corps, Transavia introduced a LOFT programme into the 1985 Recurrent Training schedule. All the airline's instructors attended a briefing prior to the LOFT. At this briefing they were advised of the goals of the Recurrent Training:

1. To find out how crews dealt with communication, cockpit management and crew decision making.

2. To give simple feedback on crew non-technical performance.

Transavia realised that with no formal training in this area, instructors would be basing their feedback on accepted subjective norms of behaviour and conduct. The major purpose of the exercise was to derive feedback from the instructors on the overall level of non-technical skills of the crews. Three scenarios were used which, whilst not complex, nevertheless provided instructors with an opportunity to investigate the non-technical behaviour of the crews. All the crews flew the LOFT using the former American Airlines B737 simulator at London Gatwick. The performance evaluation of the LOFT included recording all the routine and emergency PA broadcasts from the flight deck.

After completing the LOFT programme, all the Instructors met to discuss the results. The LOFT identified a discrepancy between technical and non-technical skills among the crews. There was a subjective feeling that some pilots needed training in the area of non-technical skills. A number of pilots developed some natural skills in the appropriate areas despite having no formal training. Overall Transavia decided to develop a training programme to meet this need for enhanced non-technical skills among its flight crews.

Captain Han Luchsinger, the Chief Instructor at the time, started a discussion among the Flight Department personnel to establish the training objectives for a Crew Resource Management course. These early discussions included representatives of the Personnel Department and the Chief of the Cabin Crew Department.

The Design and Development

Working in cooperation with the Personnel and Cabin Crew Training Departments, the airline agreed a set of goals and training objectives. These discussions were valuable in determining from the outset how the airline would approach the matter of CRM training. CRM was seen as a comprehensive system for improving crew performance, not a quick overnight fix. It was accepted that CRM training should not be independent of other training but should be integrated into the aircrew system. CRM is an opportunity for people to examine their own behaviour and convince themselves of the need for change. It is not an opportunity for management to dictate or impose a specific set of rules about how the crews will work together. If it was to be successful it would require support and commitment from the management and participation from the crews. The agreed training objectives were subsequently incorporated into the course design with the overall goal of reinforcing the safe operation of Transavia's aircraft, whilst preserving independence of crew action with operational limits.

By September 1988, Captain Luchsinger had assumed leadership of the CRM Project Group and handed over his job as Chief Instructor to Captain Alf van den Bichelaer. Transavia's next step was to investigate what CRM training was currently available. Captain Alf van den Bichelaer attended the United Airline's CRM programme and Captains Han Luchsinger and Willem de Regt attended the KLM Crew Management Course. After evaluating these courses and other available information, Transavia decided that the KLM approach was more in line with their needs. Transavia liked what they saw in KLM Crew Management Course but the course did not fully meet their specific objectives. Transavia approached Interaction Trainers Limited for help in developing a CRM programme. ITL is the UK based training organisation which has conducted KLM's CMC training since 1979. Transavia chose ITL as their training consultants because of the Company's proven track record in worldwide airline CRM and Flight Instructor training. An initial meeting occurred at Schiphol Airport on 21 March 1989 between the Transavia CRM Project group and ITL. The meeting set the goal of running a 4-day proving course by the end of 1989.

The CMC (the accepted title) would be consistent, wherever possible, with existing management training in the airline. The target group was all pilots, starting with the middle group of junior Captains and senior First Officers and working outwards from there. The CMC would be followed up through Type Recurrent Training and Type Qualification training where appropriate. Flight Instructors would require some additional training beyond the initial CMC. Because of the high level of participation required, the aim would be to have 6 participants per course. The course would be residential and conducted away from Schiphol airport.

ITL devised a Project Plan and Costings for Transavia's consideration. The plan envisaged 5 phases to the project:

Phase 1 from July to August 1989	Programme Design
Phase 2 from September to October	Preparation of draft training materials. Editing and production of Master Documentation
Phase 3 during November 1989	Conduct of the proving course and revision meeting
Phase 4 during Nov and Dec 1989	Revision of training materials

Phase 5, January 1990 onwards — Conduct of the CMC programme and tutoring of Transavia CMC trainers

Captain Luchsinger attended a pre-design meeting at ITL's headquarters at St Ives, Cambridgeshire on 8 August 1989. There followed further design and development meetings and on 20 October the training materials were approved.

The proving course was conducted in The Netherlands between 7 - 10 November 1989. The course was held at Castle Staverden, a residential training centre operated by Nedlloyd, the shipping group. A mixed group of Captains and First Officers with a representative of the Personnel Department attended the course. Some minor revisions of the material were carried out and then the programme was implemented in January 1990.

The Crew Management Course Programme

The CMC programme operates during the quieter winter months thus avoiding the busy charter periods of the spring and summer. The training season has run every year since 1989 from November through to March.

Originally the intention had been that Interaction Trainers would design and develop the programme and conduct only the initial courses. Transavia pilots would shadow ITL and then co-tutor courses with ITL, eventually taking over the conduct of the entire programme. Early in the initial courses, Captain Luchsinger had formed the view that the specialist expertise of the ITL consultants was an essential part of the course. It was decided that the programme would continue with each course conducted by an ITL consultant with support from a Transavia pilot. Throughout the entire programme Han Luchsinger and Frans Trompert have shared the responsibility for supporting the CMC.

The 4-day CMC programme addresses the following areas:

Communication - the core subject

Leadership	Decision Making
Judgement	Information Management
Delegation	Teamwork

A mix of presentations, group discussions, group exercises and video accident reconstructions is used in the course. The emphasis is on participation by the pilots. In 4 days the course aims to increase knowledge in all the subject areas and improve communication skills. A computerised analysis takes place of all the group discussions and interactions during exercises and the individual and group data is fed back to the participants. The data provides feedback on their communication styles and any changes that take place during the course.

The methodology is based on original research in the United Kingdom by the Air Transport and Travel Industry Training Board and the Huthwaite Research Group. That research generated a technique of behaviour analysis which enables tutors to observe and record communication behaviour. The behaviour analysis used in the Transavia CMC is ITL's own development based on this original research. These verbal behaviour observations can be fed back to the participants, which is helpful for changing behaviour and improving skill and performance. The participants can see how they stand in relation to others in the group. They can compare their behaviour with the models for effective performance presented in the course.

In the earliest NASA workshops on CRM, it was recognised how important effective communication is to the overall teamwork and management of a modern aircraft. The Transavia CMC course aims to target this area throughout all the subject sessions.

To date, 22 Crew Management Courses have been conducted by Transavia and ITL. All the Captains have attended the programme and almost all the current First Officers. The current situation has created an opportunity for a major review of the CRM programme with the goal of even greater integration of CRM into a total training philosophy to meet the needs of the next century. Since the programme's inception in 1990 a number of changes have been incorporated in response to participant feedback. Some subject areas have been streamlined to make them less intensive. The evening sessions have been reduced to combat fatigue and increase effectiveness. The CMC course was always seen as a dynamic event that should evolve as experience was gained by the airline and especially in response to feedback from the participants. Changes have been implemented in response to consist feedback themes, not as reaction to isolated events or perceptions.

Instructor Follow-On Training

One of the outcomes of the meeting of 21 March 1989 was acceptance of the need for additional training for instructors. Since CRM was to be integrated into Recurrent Training and Command Training, it was evident that instructors would need additional skills to be able to handle CRM debriefing sensitively and effectively. A two-day workshop was designed to meet this need. The first part of the first morning is spent identifying the learning styles of the instructors. The remainder of the day is spent refreshing the content of the CMC by showing video reconstructions of events. The videos were produced in a flight simulator using Transavia flight deck crew and flight attendants. The instructors are required to identify the CMC related topics depicted in the events and the impact they have on the crew. The participants are provided with small plastic aide-memoire cards for future use.

The second day deals with debriefing CRM in LOFT and Recurrent Training. The idea is to provide the instructors with a guideline for conducting a debrief or feedback session followed by practice of the technique. The group are shown video scenarios and then role play the debriefing. Two participants play the roles of the crew as depicted in the video and one acts as the instructor. The debriefing is recorded on video for subsequent review and discussion amongst the group.

The practice sessions involve the SPIN approach to debriefing:

S	=	Situation
P	=	Problem(s)
I	=	Implication(s)
N	=	Need(s)

Through use of questions, the instructor guides the crew through the debrief allowing them to identify where both positive and negative CRM is evident. The use of video feedback on their debriefing performance is a valuable tool for emphasising the shift in behaviour necessary to achieve success. The ITL tutor gives a demonstration of how to use the SPIN approach effectively. This approach is a non-threatening method for debriefing in what can be a sensitive and subjective area.

Because of the very practical nature of the training, participant numbers are usually limited to 4 per course.

The first Instructor Follow-On course was conducted on 12 November 1990. To date 11 Instructor Follow-On courses have been completed.

Annual Refresher Training

Annual refresher training for all crews is to be instituted in 1993. It is designed to refresh the content of the CMC and to strengthen the non-technical skills of all pilots. The duration will be one day; the course will use a mixture of video and presentation and be conducted in-house by the airline. ITL will assist with the design and development of the programme.

Recurrent Training

In the 1992 Recurrent Training programme the emphasis was on CMC aspects. LOFT scenarios were constructed, allowing crews the opportunity to use the knowledge and skills learnt from the CMC. The additional training provided for instructors enhanced the quality of debriefing on non-technical performance.

Command Training

During his career as a First Officer with Transavia, a pilot is encouraged to work positively toward developing a high level of professionalism and proficiency. The Crew Management Course forms part of that development process which will make the transition to command natural and smooth. The Command Course is designed to assist a First Officer in reaching the required standards expected of the Pilot-in-Command. CMC aspects are integrated into the initial Command Ground Course and into the subsequent simulator sessions.

The Future Approach in Transavia Airlines

With all the Captains and most of the First Officers having completed the CMC, Transavia and ITL have embarked on a project to provide an integrated approach to training for the year 2000. The programme follows the natural progression of a pilot from initial recruitment as a First Officer through his Command Training and subsequent development as a Line Training Captain then on as a Base / Simulator Instructor.The Training courses are stand-alone modules which integrate into a total training programme.

The Integrated Training programme comprises:

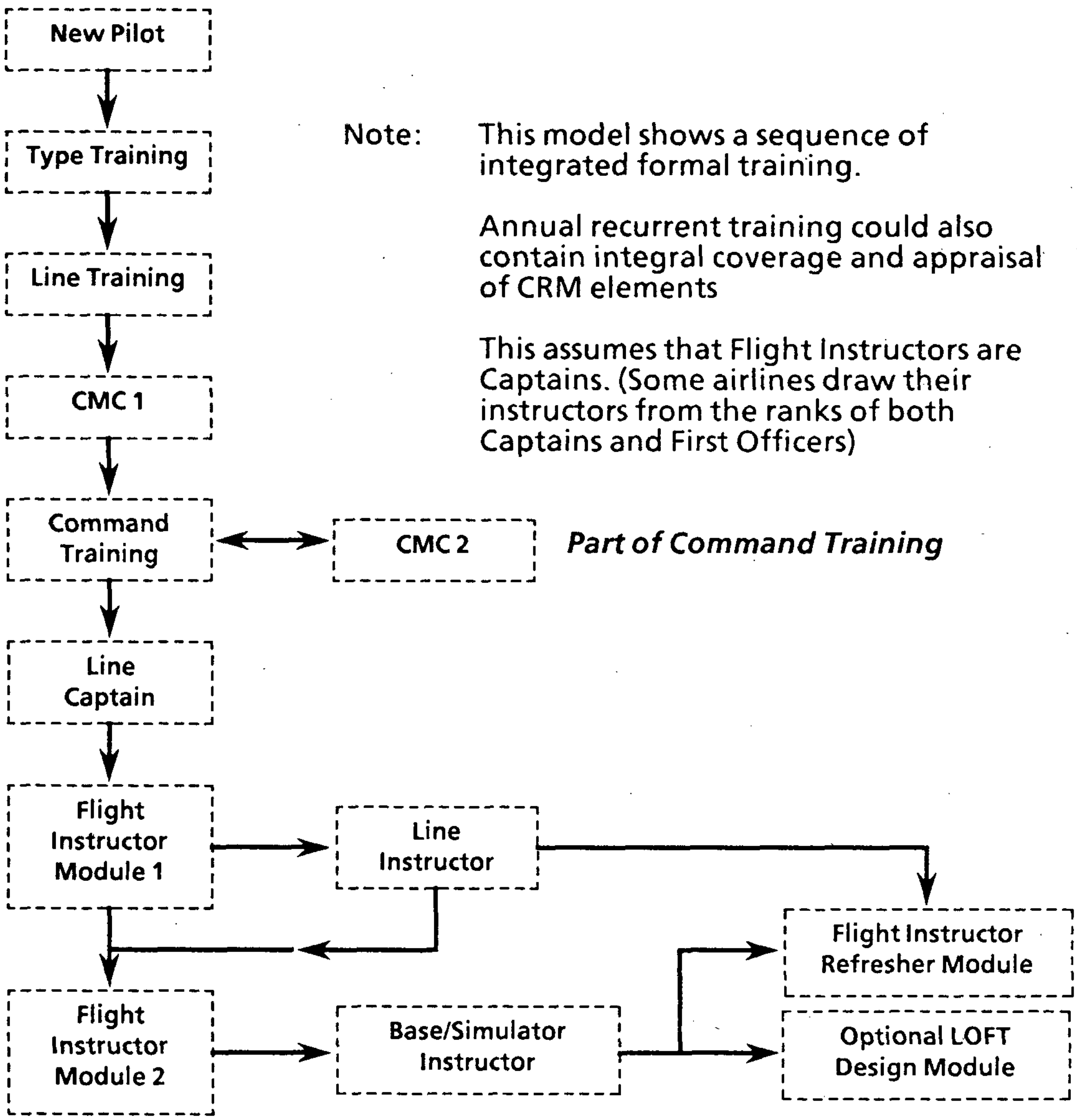
1. A CMC 1 course for First Officers with a proposed length of $2\frac{1}{2}$ - 3 days.

2. A CMC 2 course for Captains, as part of Command Training, with a proposed length of $2\frac{1}{2}$ - 3 days.

3. A Flight Instructor Skills course (FIS 1) for Line Captains designed to teach basic instructional skills - duration $2\frac{1}{2}$ - 3 days.

4. A second Flight Instructor Skills course (FIS 2) for Base / Simulator Instructors, designed to enhance the basic skills learned from FIS 1 - duration 2½ - 3 days.

Pilot Training Progression



Summary

Transavia's move towards a fully Integrated Technical, Non-Technical and Instructor Development Programme will provide a progressive training system, aimed at meeting the needs of a new First Officer, shaping and developing their skills throughout their career in the airline.

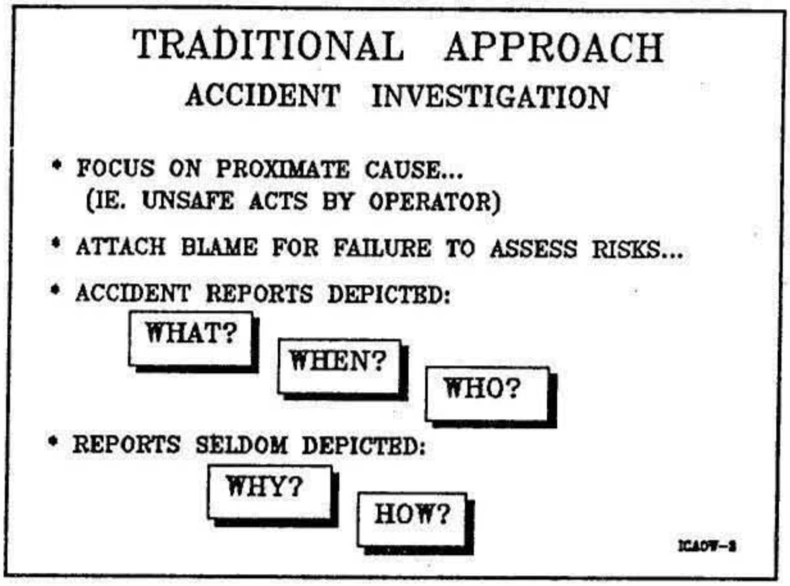
PRESENTATION TO ICAO FLIGHT SAFETY
AND HUMAN FACTORS SYMPOSIUM
WASHINGTON, D.C.

12 to 15 April 1993

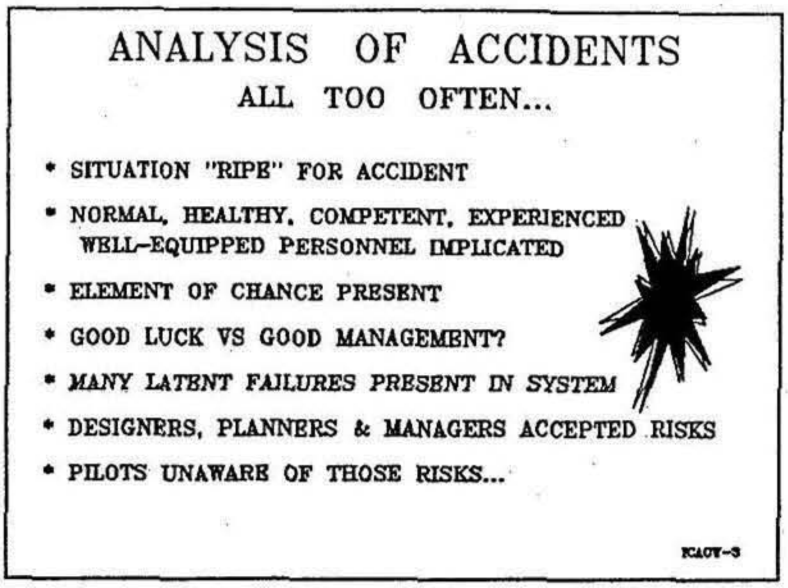
"TRAINING THE INVESTIGATOR"

Peter G. Harle (CANADA)

HISTORIC CONSIDERATIONS



In accident investigation, traditionally investigators have tended to focus on the proximate cause; specifically, they have identified the unsafe acts committed by the operator. Since the pilot is usually the first one at the scene of the accident, there has been a tendency to focus on "pilot error" - often attaching blame for the failure of the pilot to assess the inherent risks in his actions, such as continuing into instrument meteorological conditions under Visual Flight Rules (VFR), descending below published minima, deviating from established procedures, etc. Hence, their accident reports typically have depicted **what? when? and who?** with a factual travel log of the occurrence, micro-second by micro-second examining the crash dynamics. Investigators have focused on the personnel failures, often with much finger-pointing, such that the Honourable John Lauber of the National Transportation Safety Board of the U.S. speaks of the "**whodunit?**" approach to accident investigation. On a world-wide basis, accident reports have seldom depicted accurately **why? and how?** the occurrence came about. They have provided little assessment of the events preceding the accident with a full consideration of all the potential contributing factors.



When we analyze accidents, we find that all too often the situation was ripe before the accident; the experts were saying "it is just a matter of time". All too often, we find that normal, healthy, competent, experienced, well equipped personnel were implicated in the accident. They did not have any intention of committing suicide; on the contrary, they often had strong motivation towards mission accomplishment. Often, they had committed the same potentially unsafe act hundreds of times before, suggesting an element of chance. It would seem then that accident avoidance is often more a question of good luck than good management. Daily, we see incidents pointing to latent failures that are present within the aviation system. Designers, planners, and managers often knowingly (but sometimes unwittingly) accept the inherent risks of these failures in the system. Sometimes pilots are not even aware of those risks, such that some observers have called pilots the "unwitting inheritors of all the system's defects".

OUR CHALLENGE

WHY DO NORMAL,
HEALTHY,
QUALIFIED,
EXPERIENCED,
WELL-EQUIPPED
PERSONNEL COMMIT HUMAN ERRORS?

I.E.

WHAT IS THE CONTEXT FOR HUMAN ERROR?

ICAOT-4

So, when investigators ask "why do normal, healthy, qualified, experienced, well equipped, personnel commit unsafe acts?" they must strive to better understand the context in which these errors were committed.

A SYSTEMS APPROACH TO INVESTIGATIONS

SYSTEMS APPROACH

ACCIDENT INVESTIGATION

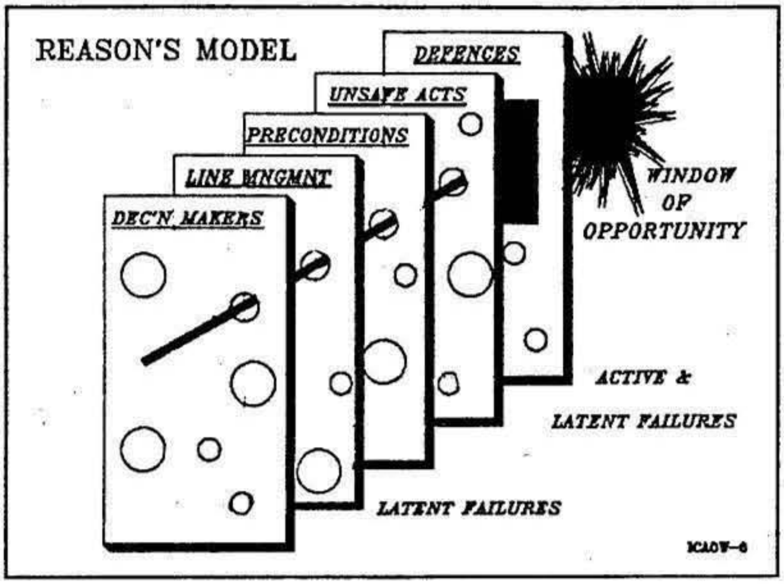
* CONSIDER TOTAL LATENT SITUATION WHEN UNSAFE ACT WAS COMMITTED:

SHEL

* DEMONSTRATE CONTEXT IN WHICH PEOPLE WERE IMPLICATED IN ACCIDENT CAUSATION.

ICAOT-5

This suggests a need for alternative approach to accident investigation, whereby we consider the total latent situation when the unsafe acts are committed. A systematic approach is required. One useful model is the SHEL Model offered by Elwyn Edwards, as modified by Frank Hawkins. This model focuses on human beings (Liveware). In addition to understanding the physical, physiological, and psychological factors affecting the pilot's performance, we must examine the interfaces between personnel, their equipment, their operating environment, and the effectiveness of all of the system support that is put in place for them. By examining all blocks and interfaces of the SHEL Model, we should be able to demonstrate the context in which normal people were implicated in accident causation.

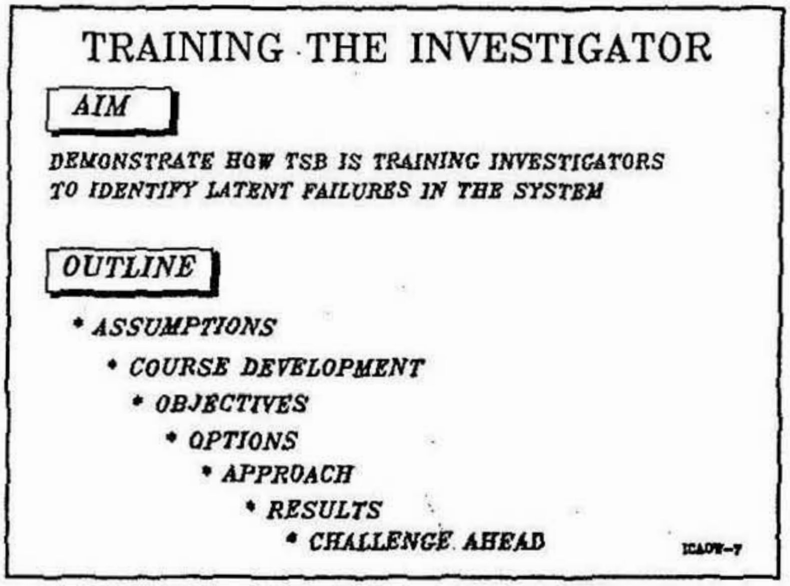


More recently, Dr. James Reason of the University of Manchester, has offered another systematic approach which considers the whole production system - in our case the entire aviation system. Here is a layered depiction of this systems approach. One layer depicts the unsafe acts undertaken by flight crews and other personnel. Fortunately, the aviation system has many structural defences built-in to mitigate the circumstances of such unsafe acts; for example, an incorrect read-back of an ATC clearance should be picked up by an alert controller. On the other hand, if a pilot disables a Ground Proximity Warning System (GPWS), the safety benefit of the GPWS is nullified. But Reason goes further than focusing on the immediate circumstances of the accident. He would have us examine all of the pre-conditions at the time of the occurrence, including such things as "psychological precursors". Such pre-conditions might include crew fatigue, stress, prior experience with false indications etc. which might explain why the pilot chose to disable the GPWS. He defines a fourth layer, to depict the effects of line management on the production system. This includes the role of first-line supervision, where crews are scheduled, aircraft dispatched, training conducted, etc. And finally, Reason includes a layer representing all senior decision-makers; those of the carrier, the manufacturer, the regulator, and the unions. Reason notes that these decision-makers frequently make "fallible" decisions.

Under a particular set of circumstances, a window of opportunity may be created for an occurrence. If the defences work, we might have a benign incident. If they fail, we may have a tragic accident.

As already mentioned, traditionally in investigations of aviation occurrences, we have focused on the unsafe acts and how the defences may have failed. But if we are to make any significant impact on accident prevention, we must better examine the latent failures in the system, as evidenced by the higher three layers of Reason's model; i.e. the pre-conditions, line management, and decision-makers.

AIM AND OUTLINE



My aim today is to demonstrate how the Transportation Safety Board of Canada (TSB) is training its investigators to identify the latent failures in the transportation system; in other words, to better understand the context in which humans erred - so that preventive measures can be taken.

First, I will briefly discuss some of our basic assumptions and the course development process we went through, outline our training objectives, review the options that we had available to us for training and the approach we finally settled upon; then I will give you a preliminary indication of our initial results, and conclude by discussing some of the remaining challenges ahead for us.

ASSUMPTIONS

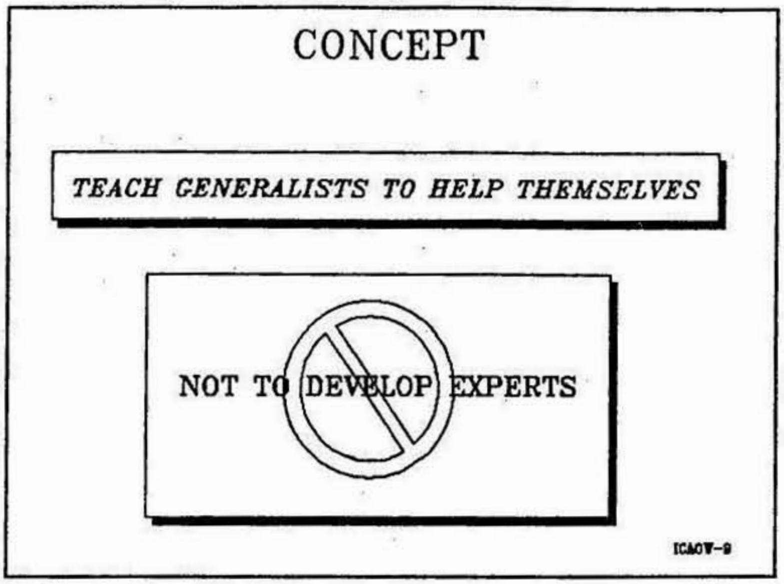
ASSUMPTIONS

- INVESTIGATORS DAILY EXPOSED TO HUMAN FACTORS
- *INVESTIGATORS HAVE WEALTH OF PRACTICAL EXPERIENCE*
- EXPERTS LACK BREADTH OF PRACTICAL EXPERIENCE
- *INSUFFICIENT EXPERTS FOR ROUTINE INVESTIGATIONS*
- GENERALISTS CAN COPE WITH ROUTINE HF ISSUES
- *IN-HOUSE SPECIALISTS AVAILABLE TO INVESTIGATORS*
- EXPERTS AVAILABLE ON DEMAND FOR NON-ROUTINE ISSUES

ICADW-B

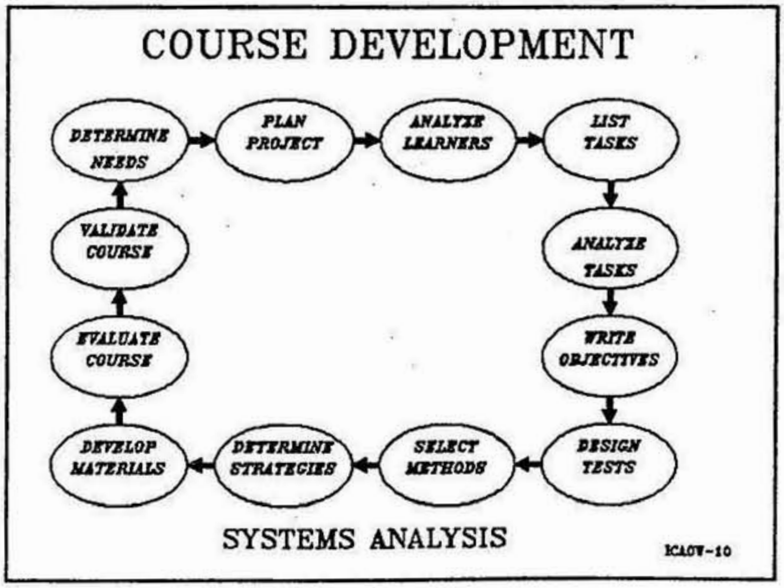
In undertaking such a training program, we made several assumptions, some of them explicitly and some of them implicitly. Because all of our investigators have extensive operational experience and are trained as generalists in the investigation of aviation occurrences, we believe that they have a significant personal knowledge of the more common human factors through their daily work exposure. Although this knowledge is seldom based on their academic credentials, the investigators' practical experience supports their broad appreciation of the more common phenomena. We find that the more highly qualified subject matter experts in human factors have a profound knowledge of specific phenomena, but often they lack the broad practical experience that our investigators possess. Moreover, given the incidence of human factors in virtually all investigations, there are insufficient resources available to provide specialist advice for each and every investigation. Therefore, just as our generalist investigators must address such diverse issues as meteorology, aerodynamics, and engineering, we believe that our investigators can cope with routine human factor issues. However, recognizing that they will frequently have insufficient formal training to address particular issues, we have a small staff of human performance specialists in-house available on a consultancy basis to assist our investigators. Furthermore, when investigating human performance at the extremes of any normal distribution of human behaviour, we can also obtain the consultant services of professional experts outside the organization.

CONCEPT



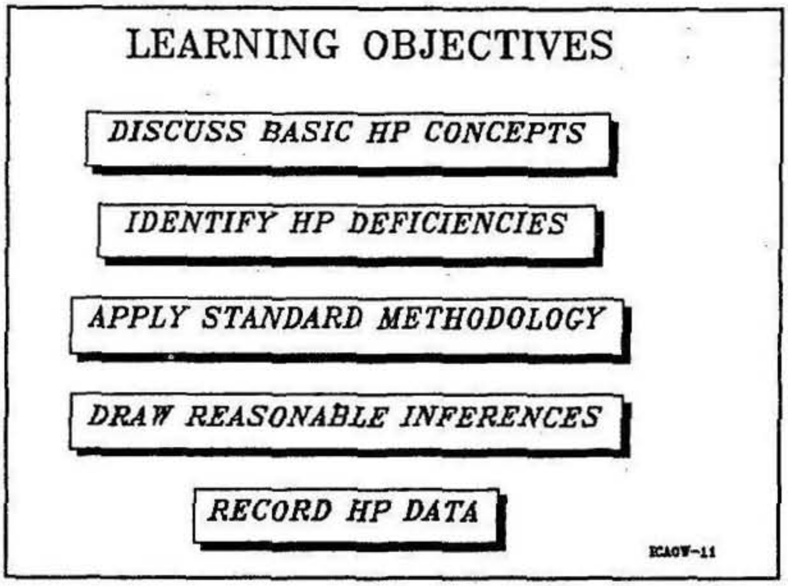
The concept that we followed in developing the training program was that we would help our generalist investigators discover how they can help themselves in investigating human performance issues. We have no intent to try and develop the individual investigators as pseudo-subject matter experts in human factors.

COURSE DEVELOPMENT PROCESS



Just as we advocate a systems approach to investigation, we tried to follow a systems approach in the development of our course. We began with a formal assessment of our investigators' and analysts' needs - across all modes of the TSB. We then spent a lot of time carefully analyzing the tasks they are required to perform in an investigation. We selected the training methods and strategies that would best facilitate our course members' acquisition of the knowledge, skills, and attitudes necessary to complete these tasks in the field; and finally, we must follow-up with an evaluation of the course itself and a validation of its effectiveness over time, refining the course as necessary to meet our investigators' needs.

LEARNING OBJECTIVES

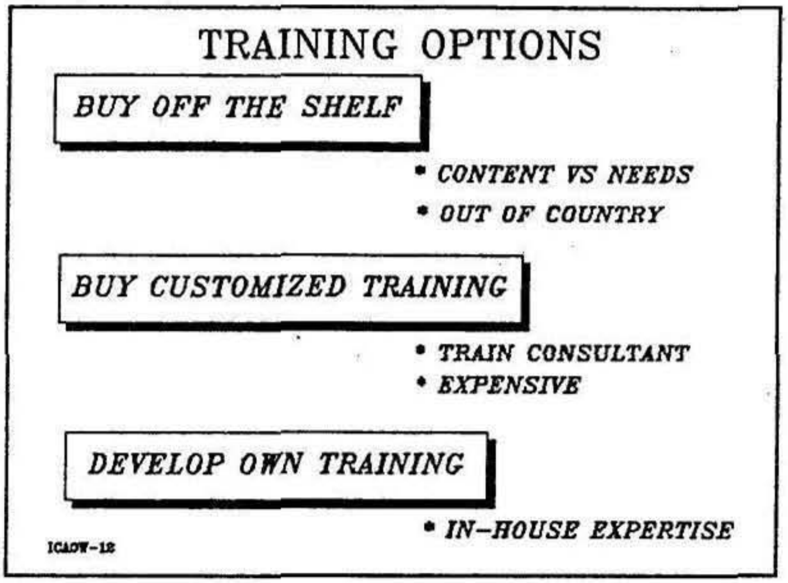


Having surveyed and analysed our individual investigators' needs, we established five broad learning objectives. We decided that, upon course completion, all investigators and safety analysts should be able to:

- Discuss the basic concepts of human performance that frequently impact on transportation safety;
- Identify human performance deficiencies which may degrade transportation safety;
- Apply a standard methodology for the conduct of the investigation and analysis of human performance issues;
- Draw reasonable inferences from their investigations and analysis for the findings, reflecting the appropriate level of certainty;
- Record human performance data for macro analytical purposes.

Of note, these objectives are written in performance-oriented terms. We want our investigators to be able to do specific things as a result of this training.

TRAINING OPTIONS



Having established our learning objectives, we considered several options for conducting the training.

Ideally, we would buy the training "off the shelf". Unfortunately, little comprehensive human factors training at the level of operational personnel is currently being offered in Canada. Further, of the human factors training programs available to us outside of Canada, none are tailored to meet the needs of the accident investigator. These courses tend to focus on the knowledge-related aspects or the basic concepts of human performance; but they do not address the skills needed of an investigator.

Consideration was given to having a consultant develop a customized training program for us. Unfortunately, such situations usually involve spending a great deal of money to train the consultants who will then charge you a big fee to deliver the service you trained them for.

Finally, we considered developing an in-house training program based on our own expertise. Although we have our own psychologists and many highly experienced investigators, we have less experience in designing and delivering effective training programs.

In the end, we compromised. With the professional services of a consultant we developed an in-house program. The consultant we retained has a good working knowledge of the aviation industry and has extensive experience in designing and delivering training programs - including the cockpit resource management training program used by Air Canada.

TSB APPROACH

TSB APPROACH

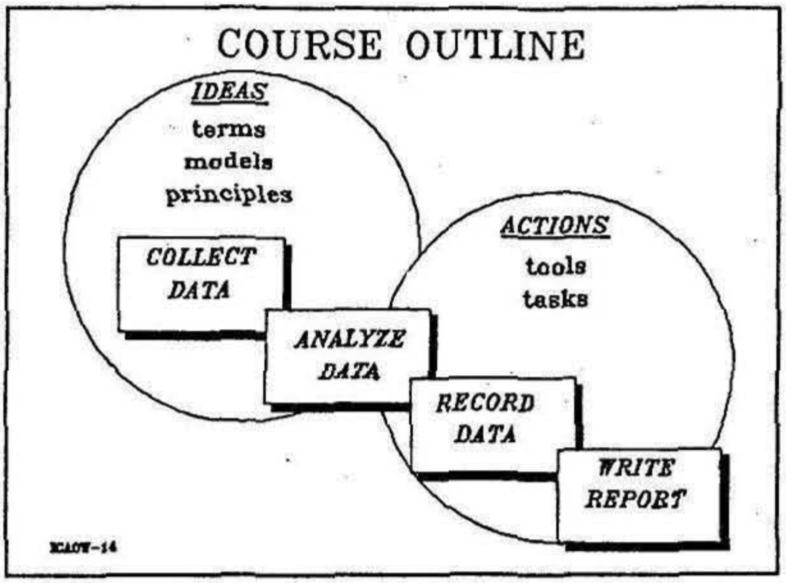
"HUMAN FACTORS IN INVESTIGATIONS"

- MULTI-MODAL PROGRAM WITH UNIMODAL CASE STUDIES
- ONE WEEK DURATION
- RESIDENTIAL
- PRE-COURSE PREPARATION
- IN-HOUSE TRAINERS AND FACILITATORS
- LEARNING VS TEACHING ENVIRONMENT

ICAOT-13

Because we have responsibility for investigating occurrences involving marine, rail, commodity pipeline and aviation occurrences, our training program is designed to be multi-modal - catering to the needs of all of our investigators. However, much of the syndicate or group work is based upon uni-modal case studies. For one week, the entire group lives and works together, exchanging views and sharing their experience. There is some pre-course preparation, reading some of the basic concepts that will be applied during the week. By and large, we use in-house trainers, assisted by experienced investigators serving as facilitators for the delivery of the program. Their job is more one of creating a learning environment than delivering lectures.

COURSE OUTLINE

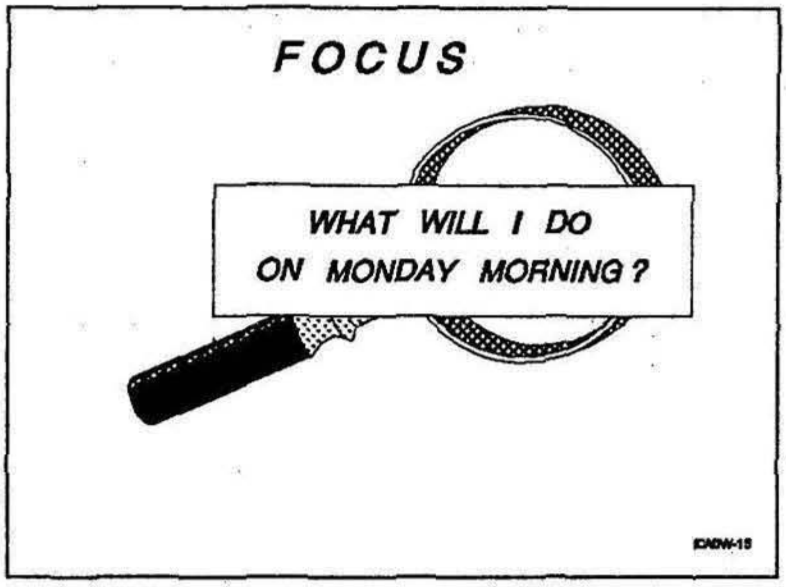


In its simplest terms, the course can be viewed as four blocks: collect data, analyze data, record data, and write accident report. Thus, we work through the sequence that an investigator actually performs his duties. For each of these blocks, various terms, models, and principles are discussed, and the tools and tasks necessary for completing the investigative actions are applied.

Basic models such as SHEL and REASON, and Rasmussen's Skills-, Rules- and Knowledge-based approach to considering human errors form the knowledge portion of the curriculum. The investigators then develop skill and practice in applying these concepts in real situations, mimicking field behaviour in group activities.

Of prime importance, they learn that Human Factors investigation is not something that you add-on to a normal investigation. Rather Human Factors considerations are an integral part of every phase of the investigation.

FOCUS

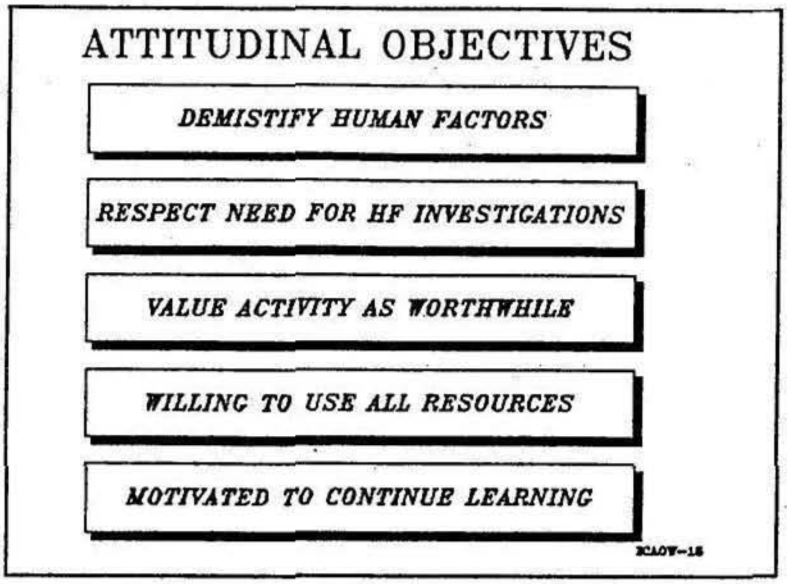


The focus of our training efforts has been on the question "what will I do on Monday morning"? The possession of theoretical knowledge by the investigators will be of little use if they lack the skill and confidence to apply these concepts in their daily work.

Typically, we find that one week courses try to cram a lot of information into intensive lectures. Thus, a key strategic issue for us was: how much learner involvement could we afford in a one week course? With the volume of material to be covered, intuitively little time could be spent in syndicate work. However, the more important question became how would we best be able to help our people perform back on the job? Since people tend to retain 10% of what they read and 20 % of what they hear vs. 90% of what they say and do, we opted for high learner/group involvement - even though it meant covering less content. Therefore, much of the course is spent in syndicates, working on practical case studies. To the extent practicable, we have tried to create situations where the course members can mimic the behaviour required in actual investigations in an adult learning environment. We promote continuous personal involvement in the learning process, and we try to create a climate where the course members enjoy the process, believing that people tend to remember best what they had most fun doing.

With this approach, we believe that our investigators will have the confidence to apply their knowledge and newly practised skills when they return to the field.

ATTITUDINAL OBJECTIVES

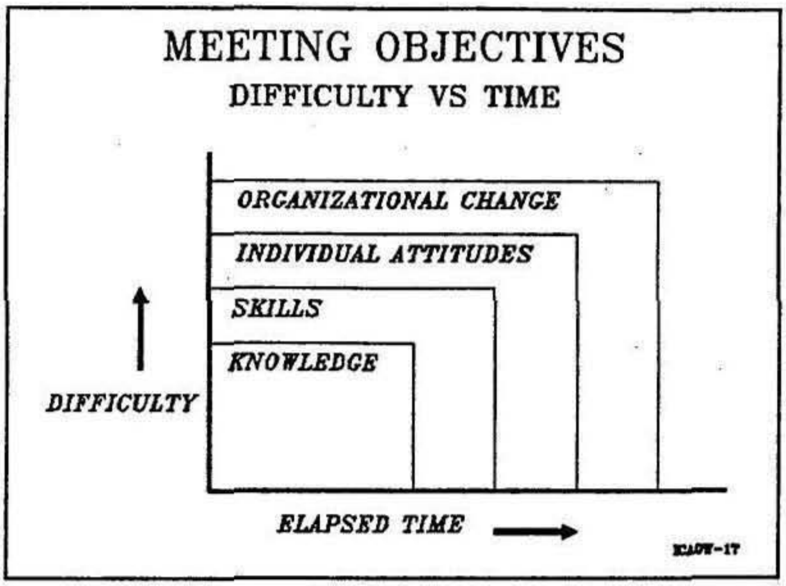


In putting the course together, it became apparent that in addition to the five formal learning objectives which had been established, we must recognize a secondary agenda of attitudinal objectives if the training is to be effective. For example, we realized that many of our investigators see human factors as some kind of mystique. Therefore, we have tried to demystify the subject of human factors - putting academic concepts into practical and workable terms, understandable to the field investigator.

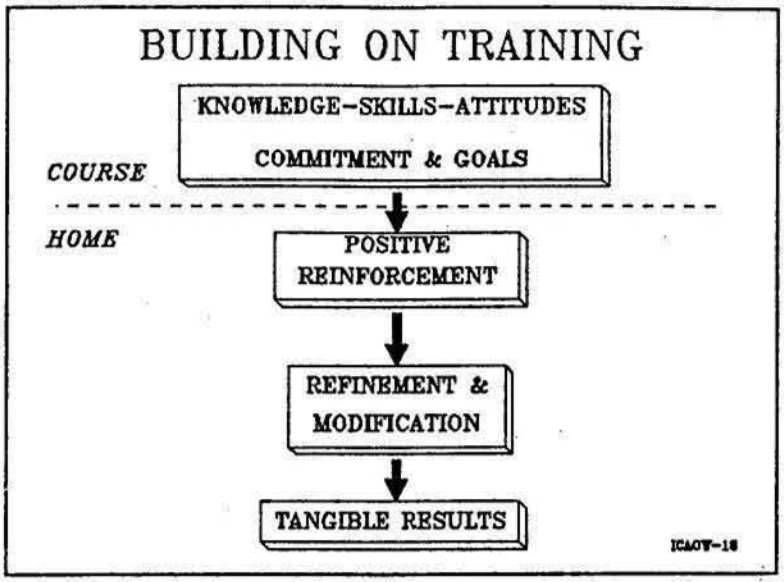
For a number of reasons, many of our investigators have developed a cynicism towards the practicality of human factors investigations. For those, we must help them develop a respect for the fundamental need for emphasising this aspect of their work, and to realize that efforts expended on these often non-material issues are worthwhile.

We discovered that many of our investigators are not aware of the organizational resources available to help them in their investigation of human factors. Without academic credentials, many felt they were not competent to address Human Factors issues. Thus, during the training program, we aim to develop their knowledge and willingness to use all the resources available to them; for example, the services of our medical staff for physiological issues, our behaviourial specialists, our engineering laboratory staff for computer-based anthropometric modelling, our library services for literature searches, etc. Furthermore, recognizing the limitations of a one-week course, we must strive to motivate our course members that the course is just the beginning; hopefully, we will have provided them with a framework and the motivation to facilitate continued learning through the balance of their careers for the investigation of human factors issues.

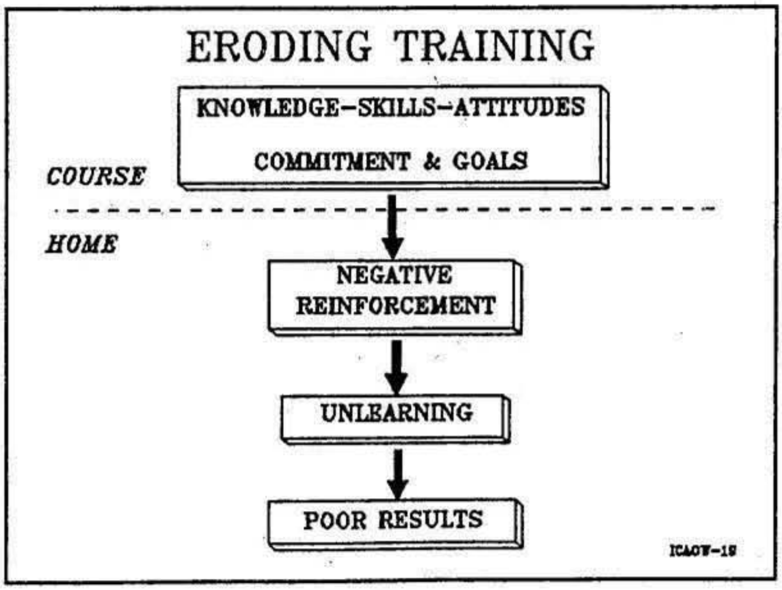
MEETING ORGANIZATIONAL OBJECTIVES



Our consultant brought to our attention the difficulties in successfully implementing a human factors training program such as we envisaged. As indicated earlier, it is not simply a matter of imparting knowledge; that is relatively simple in terms of the time required and the difficulty value. Developing skills to apply these concepts and principles in a practical and credible way is a much more difficult task taking greater time. But if our individual course members harbour negative or cynical attitudes towards human factors, we have an even greater challenge in terms of difficulty and the time required to effect the necessary attitudinal change. Finally, no matter how successful we are in developing our staff for the investigation and analysis of human factors issues, all will be for naught, unless there is a fundamental organizational acceptance of the methodology and importance of this kind of work. Senior management and the Board itself can create an organizational culture which is contrary to successful application of the basic principles learned during this training.



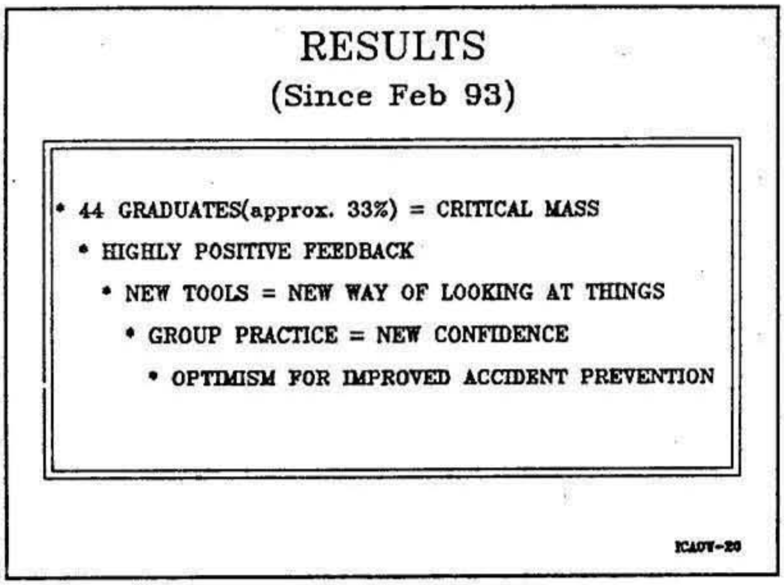
We must ensure that our overall organizational climate or corporate culture fosters building on the training. During the course, it was clear that the investigators had formed personal goals and commitments for the application of their knowledge, skills and attitudes towards investigating human factors. To the extent that they receive positive feedback and are given an opportunity to practice and refine their skills, we will receive tangible benefits.



However, if the real-world work environment gives them negative feedback, denies them the opportunity to practice and develop what they have learned, there will be unlearning with poor investigative results. Therefore, management may have to modify the organizational culture to encourage our investigators in the application of these skills.

Time will tell how successful we are with respect to these attitudinal and organizational changes. Suffice it to say that we are working from both ends of the equation to achieve these changes.

RESULTS



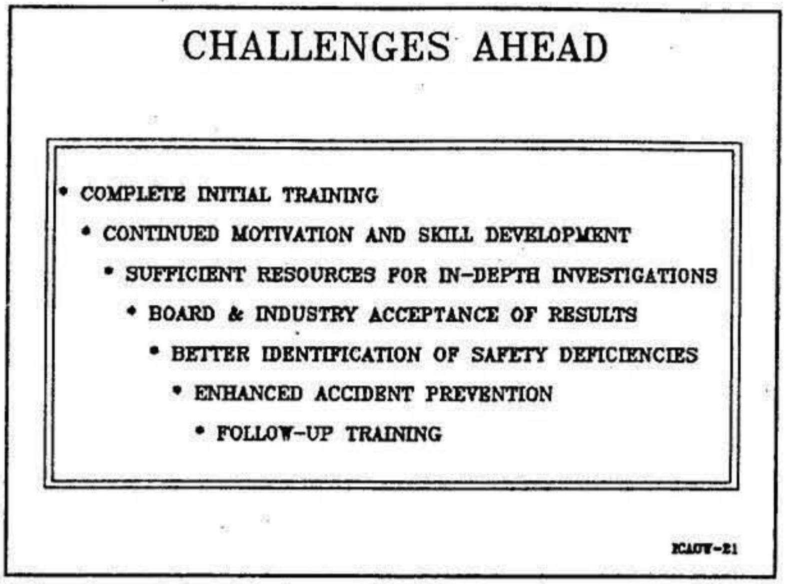
To date we have delivered two offerings of the course. 44 course members or approximately one third of our investigative and analytical staff have received this training. They constitute an important critical mass in terms of developing organizational momentum for applying this training.

As in many training programs, we daily seek feedback from the course members to evaluate our success in delivering the program. Feedback to date has been extremely positive. According to the course members, we have given them a new way of looking at the things they have been confronted with through the years. Practising these methods in uni-modal case studies has given them a new confidence to approach their daily work.

However, our real success will not be known for several months until we begin to validate the effectiveness of the training by going back to our course members and their supervisors in the field to examine the effectiveness of the training. At that time, we will re-assess the entire loop.

But, based on our early feedback, we have considerable optimism that there will be a safety dividend in terms of accident prevention.

CHALLENGES AHEAD



As Confucius said "A journey of a thousand miles begins with the first step". We have only just begun. We must complete this initial training program, modifying it as necessary - based upon the experience of our first course offerings. For those who have completed the initial training, we must implement an extension program to ensure their continued motivation and skill development. We must ensure that our investigators do have sufficient resources to draw upon for the conduct of the field investigations of all pertinent human performance issues. Both internally with our organization and externally in industry, we have a significant challenge in terms of credibly communicating the results of our human performance investigations in a way that will be accepted. If we do all of the foregoing well, our safety analysts should have better information available to them for the identification of the safety deficiencies inherent in the aviation system, thereby facilitating enhanced accident prevention. At no point will we be able to rest on our laurels; there will always be a requirement for further follow-up training.

DEVELOPING HUMAN FACTORS SKILLS

HUMAN FACTORS TOPICS IN CANADIAN PRIVATE PILOT TRAINING

Arlo Speer
Transport Canada
Ottawa, Canada

In the discussion which follows, human factors training for Canadian private pilots will be viewed from three perspectives: (1) work currently under way to introduce human factors topics into Canadian private pilot training programmes, (2) what we perceive as the need for further research into human factors training for pilots, and (3) the need to plan human factors programmes geared to the needs of beginning and recreational pilots. I present what we do, what we think and what we hope for not from a desire to have others copy our experience. Rather, it is my desire that sharing our experience and our ideas might allow us to join with other aviators and other aviation administrations and reap a synergistic benefit that can make us all stronger.

CURRENT CANADIAN PRACTICE

Initially, I would like to share some of the initiatives to introduce human facto s training into the Canadian private pilot syllabus. Sparked by the recent position taken by ICAO, Canada has introduced the requirement for human factors training, including pilot decision—making, as a mandatory part of our private pilot curriculum. The human factors component is largely theory based and is primarily associated with the licence's Knowledge requirement. It was considered essential to introduce a knowledge requirement for two reasons. The first was one of practicality; basic reference materials were readily available to guide instructors. The second reason was a pedagogical one; we felt that before we could address human factors skills to any great extent, we would need to ensure a firm knowledge base on which to build.

Transport Canada has also published Pilot Decision-Making—Manual for Private Pilot Training. Ideas, procedures and points of theory were consolidated from many sources. The end result has proven to be a readable manual that is usable by lay instructors and students alike. This fourteen-page manual was developed with three thoughts in mind. We wanted to improve flight safety by helping pilots make better, safer decisions. We also wanted to provide a common decision-making process around which instructors could model their teaching. Most important, we saw the need to bridge the gap between instructors (who were charged with providing their students with practical human factors information) and theoreticians and researchers (who, in many cases, provided excellent information but used a format that was less than "user friendly").

The manual suggest ways in which instructors can apply the decision-making process and concepts to the myriad of decisions, large and small, that make up the routine of every flight. Instructors are cautioned against making flight decisions for their students. Rather, instructors are encouraged to lead students through the decision-making process and to involve students in all of the decisions that must be made. Briefly, the manual provides a decision-making cycle that involves (1) recognition of a situation involving some element of risk, (2) identification of available options, (3) choosing the most favourable of options, (4) acting on that choice, and (5) evaluating the outcome.

Fortunately, the need for drastic and spectacular decisions comes infrequently, especially in most training flights. At the same time, each flight is filled with the opportunity to make many, many decisions. Which runway should we use? Where should we park to do our pre take-off checks? What take-off or landing technique is most appropriate? At what altitude should we fly? Should we refuel before this flight? What should we do if the ground station does not respond to our radio call? Should we fly if we cannot locate a particular aircraft document? These decisions may appear trivial, but they provide a wealth of opportunities to apply the decision-making process. Instructors are reminded of these opportunities and encouraged use them to guide students through the five step process.

Successful instructors tell us that a student learns best when the student flies the aircraft and less well when the instructor does all the flying. Instructors know that they have to let their students fly a lot and we encourage instructors to let their students decide a lot, too. In the same way that learning to fly a manoeuvre requires a sound description of the manoeuvre, a good demonstration and then lots of opportunity to practise, learning to make decisions requires a sound description of the decision-making process, a good demonstration and then lots of opportunity to practise making decisions. The approach suggested in our manual is a simple one: take advantage of the little decisions that occur naturally as part of each flight. Demonstrate how the decision-making process is applied and then give students as many opportunities as possible to make decisions for themselves. Just as for flight manoeuvres, initial attempts are watched very closely by the instructor to ensure that errors are not made. As student ability increases, the student is afforded greater autonomy.

In most schools, Human factors training is limited to training in medical facts and decision-making. For many years Canadian Colleges offering aviation programmes and some of the larger flight schools have introduced more extensive human factors programmes into their pilot training. Additional topics include the influence of stress, the identification of stressors, situational awareness, successful risk management, personality and others. Because of the opportunities for expanded academic programmes at colleges, many of these human factors courses take the form of full year college course equivalents. These human factors programmes provide much-needed training and cover the human factors in a depth which parallels that of many of the fine current books available on the topic.

We recognize that before human factors topics can be effectively introduced into pilot training programmes, instructors must be prepared to offer that instruction. Within the past year, the requirement to present human factors topics has been included as one of the qualifications for an Instructor Ratings. The pre-service training for new instructors now includes training in the presentation of human factors topics including pilot decision-making. Candidates attempting both initial and renewal Instructor Rating flight tests in Canada may, at the discretion of the examiner, be asked to demonstrate their ability to present pilot decision-making concepts.

Aside from pre-service training, we also devote our attention to the in-service training of practising instructors. Transport Canada sponsors an annual programme of Instructor Refresher Courses. Each year, 129 instructors are selected from a large number of applicants. These instructors attend one of six one-week refresher courses held in locations across Canada. Among other items, human factors and pilot decision-making are included in the topics discussed. At these courses, emphasis is shared between providing the instructors with human factors knowledge and providing suggestions about effective methods of teaching human factors topics.

In addition to instructors, flight test examiners are also given in-service training. All examiners who conduct flight tests for the issue of private or Commercial Pilot Licences or Multi-Engine Class Ratings are required to attend a workshop every second year. Like the Instructor Refresher Courses, these workshops include discussions of pilot decision-making concepts. The human factors content is intended, in part, to improve the human factors awareness and skills of the examiners. In addition, the examiners discuss ways they can integrate decision-making activities into their assessment of required flight test exercises.

What we have done in Canada is a start. Despite a very broad understanding of "human factors", the current Canadian emphasis thus far has been on pilot decision-making. We have published a decision-making manual. We require training in human factors including pilot decision-making for those applying for a private pilot Licence or for the initial issue or renewal of an Instructor Rating. We include training in human factors in Instructor Refresher Courses and examiner workshops conducted or sponsored by Transport Canada. This should not be taken to imply that we feel human factors training should be limited to decision-making. We recognize the need for the development of materials to allow us to proceed with other human factors. We have started, but we still have a long way to go.

RESEARCH SUGGESTIONS

Much research has been completed into the area of human factors. We need to make decisions about specifically which human factors should to be taught at what level. We then need to ensure that instructors have the appropriate background training and to ensure that appropriate things are being done at each level. This leads to the second perspective from which I would like to view human factors training. There is a need for further investigation to identify the level at which each aspect of human factors knowledge or skill is most appropriately taught.

The Transportation Development Centre, or TDC, is Transport Canada's central research and development facility. TDC has been tasked with human factors research on our behalf. TDC has been asked to identify various human factors that apply to each level of pilot licence from private to commercial to airline transport pilot. Certainly, there are many factors that apply to all pilots regardless of the level of licence or experience, but it is reasonable to assume that some factors apply more to operations in multi-crew, airline situations while other factors apply more to operations in light aircraft operating with a single pilot. Commercial flight operations involve certain risks and stresses unique to the commercial nature of the operation. We must recognize that personal and recreational operations are not immune from their own risks and stresses. We must also devote attention to identification of the special Human Factor needs of private and recreational pilots.

TDC has also been charged with investigating ways in which pilots learn to master human factors knowledge and skill. It seems unreasonable to suggest that those teaching methods which have proven successful in fostering physical pilot skills will be the same methods best suited to mastery of many human factors concepts. It is our assumption that no one teaching technique can provide optimum success in all areas. We wish to identify **how** the instructors can best teach each of the aspects of human factors. As well, teaching and learning activities must be accompanied by proper resources to support learning. TDC has also been tasked to identify the resources and activities that are available. We have also asked TDC to offer suggestions on the additional resources that can supplement what is presently available.

Aside from questions of teaching human factors, we need to address the question of evaluation. When new points of knowledge or skill are added to a curriculum, the question of assessment of student performance must arise. Currently, formal testing of human factors is limited to evaluating human factors knowledge using multiple choice written examinations. In recent years, human factors has received increased emphasis in our written examinations. Not only is the depth of human factors knowledge increasing, but more and more of our examinations are including human factors as an area for testing. Written examinations for private and Commercial Pilot Licences have for some time included questions on human physiology, psychology and decision-making. Similar topics are soon to be included in examinations required for other licences and ratings including flight instructor ratings.

Canada does not flight test human factors skills as such. While we do not test decision-making skill directly, we do encourage flight test examiners to incorporate decision-making activities into the assessment of the various exercises that make up our flight tests. For example, the flight tests for both the private and commercial aeroplane licences require the candidate to demonstrate the ability to complete take-offs and landings in non-normal situations. Examiners refrain from asking the candidate directly to demonstrate a short field take off clearing an obstacle and taking into account the crosswind from the right. Instead, examiners either place the candidate in a situation with readily available information or they describe as clearly as possible the situation. The candidate is then expected to collect the necessary information and make appropriate decisions. Assessment of performance is based on physical piloting skills, on the quality of information analysis and results of decisions made.

We need to determine the extent to which learning in human factors areas can properly be evaluated. We need to determine whether it is appropriate to measure performance in all areas of human factors knowledge and skill. For those areas where measurement is appropriate, we must identify strategies for assessment. Additional research is needed to determine if our current practice of testing human factors knowledge but not skill is correct.

NEEDS OF PRIVATE AND RECREATIONAL PILOTS

I have briefly outlined some of the steps Canada has taken to introduce human factors training into the private pilot programme. I have also expressed our desire for further research to supplement what has been done already. The third perspective from which I wish to view human factors training is related to the importance of human factors training in the initial development of a pilot. Instruction given to private pilots is fundamental to future pilot performance. While human factors training is becoming an integral part of in-service training of pilots at senior levels, steps must also be taken to ensure that human factors training is included in pre-service training for those working toward their very first pilot licence. It would be easy for one to form the impression from current literature and practice that human factors training is limited to training for the Airline Transport Pilot Licence and for currently employed airline pilots. This situation must be changed. Human factors training must also become an integral part of private pilot Training.

In Canada, we are fortunate to enjoy the opportunity for extensive recreational flying. Flight safety research reveals that accidents involving recreational pilots can be linked to the knowledge-skill interaction—the human factor. We must not forget the needs of the recreational pilot. Without reducing efforts directed toward commercial aviation, we must dedicate ourselves to identifying those aspects of human factors that are applicable to the private pilot. It is not reasonable to expect human factors knowledge to filter down from the more senior licences.

Training in Cockpit Resource Management and Crew Coordination is essential for a certain segment of the pilot population. Considerable publicity has been generated around successful programmes that have been developed and implemented to meet this particular need. It is now time to accept the need for similar effort to be directed toward identification of human factors topics appropriate for the beginning and recreational pilot. Simply assuming that whatever human factors component is needed can be picked up with future training at a more advanced level does a disservice to human factors as an area of study. More importantly, it does a disservice to those pilots whose formal training ends with a private pilot Licence. We must ensure that human factors skills (and not just decision-making) form a part of the training given to pilots from their very first lesson. In this way those pilots embarking on a career will have a foundation on which further training can be based. At the same time, those pilots wishing a licence for purely recreational purposes will benefit as well.

THE FUTURE

In Canada, we have made a start in the area of human factors training for private pilots. For us to continue, I ask for two commitments. First of all, a commitment from the research community to further investigate the human factors issue to: (1) identify the multitude of human factors that should be taught to pilots, and determine the licensing level most appropriate to each factor, (2) suggest teaching procedures best suited to presenting human factors topics and (3) comment on the question of evaluation of human factors skills.

The second commitment I ask is from the aviation community as a whole. We need a commitment to provide a human factors emphasis at the level of private pilot training that is at least equivalent to the emphasis currently given at more senior levels of the aviation industry. Certainly, it is crucial to continue work in areas such as Cockpit Resource Management, Crew Coordination and other areas relating to the operation of complex, multi-crew aircraft. At the same time, we must recognize that it is equally crucial to provide appropriately selected human factors training to those entering aviation. We must not forget that private pilot training is the foundation upon which all future aviation training rests. We also must not lose sight of the fact that, in Canada and other nations, a significant number of pilots obtain a licence for non-commercial purposes. These pilots deserve the opportunity to benefit from human factors training geared to their particular type of operation even if they choose to end their formal aviation training with a private pilot Licence.

Those who work actively at the heart of aviation rely on the research community to investigate better and different ways to address the many human factors questions. Front line practitioners rarely have the time or the opportunities to investigate complex issues to the degree necessary to break new ground. In Canada, we have taken a few small steps in recent years. We have introduced, as best we currently know how, some aspects of human factors training into pilot training at all levels. We recognize the need for further information to help us answer questions like: "What kinds of human factors information should we pass on to those training for a private pilot Licence?", "Are there more effective and efficient ways to help our students master human factors concepts?" and "Can we evaluate mastery of all human factors concepts and if so, how should we be attempting to complete the evaluation?"

If you feel that our Canadian experience can offer assistance or guidance to your particular application, I invite you to copy, modify or otherwise follow what we have done. I will happily provide more specific information to any members upon request. For those of you who have already exceeded our work, I would be most pleased to hear of your experiences in hopes that we can supplement our work based on your accomplishments. For those of you with technical knowledge and research experience and abilities, I urge you to consider our suggestions for areas of further research.

Just as I know that pilot training is today very different from what existed earlier in this century, it is my hope and my belief that as we move into the next century, we will see gigantic strides and new directions for human factors training. To do so will take more than the efforts of individuals and nations. It will take the combined and cooperative effort, skill and knowledge of literally a world full of specialists to maximize our results. It is through gatherings such as this that we can share ideas and plans. I look forward to the development and growth that I am sure will come.

ICAO Flight Safety and Human Factors Symposium
Washington USA April 13-16, 1993

Human Aspects Development (HAD)
-The Swissair Training Syllabus : by Dr. B. Schar (SWITZERLAND)

1. Introduction

Since January 1 of this year, Swissair has been conducting a two-day course devoted to Human Aspects Development for Line Pilots and Flight Engineers on a near-weekly basis. The course is held in a charming yet modern hotel in a picturesque village not far from Zurich. Away from the hustle and bustle of the airport, the building and its surroundings are a stimulating setting in which to promote the interpersonal aspects of being a cockpit crew member.

With few exceptions, the course managers and trainers are themselves active line pilots who have volunteered for this activity. They have all passed an assessment and completed special training.

Half of Swissair's 1,100 pilots will attend the course in 1993. The other half will undergo a standard route check in an aircraft. Next year the two sides will switch. By the end of 1994 all pilots will have taken a HAD course and a route check, both of which are compulsory prerequisites to obtain Proficiency standing. Furthermore the element "human factor" is part of the Standard of Performance as set down in the Flight Operations Manual (FOM).

The theme of the 1993/94 HAD course is Communication. The highly practical and interactive approach requires that participants become truly involved. They cannot remain passive. Through the activities in the course participants gain the skills necessary to communicate effectively, good communication being an element of optimum Cockpit Resource Management (CRM).

The introduction of these HAD Courses marks a bold step forward. In addition to checks and refreshers, which take place either in the cockpit of an aircraft or in a flight simulator, the development of human skills takes place in a less technological setting.

On the basis of our first three months' experience, we regard the HAD Courses as a success. Response has been thoroughly positive. Participant feedback indicates that the courses have had a positive effect on their skills and conduct and have made a discernible contribution to enhancing flight safety. Further indications show that close communication between participants, trainers and management pilots has a clearly positive effect on corporate spirit.

This brief review of the HAD course for line pilots serves as an introduction to the theme of HAD - The Swissair Training Syllabus.

What is the basis of this syllabus? What does it include? What is Swissair's rationale for the program? What approach do we take?

The following explanations will provide answers to those questions:

2. Swissair Positioning
Fundamentals of Swissair pilot training

Swissair's positioning is a determining factor in all training and advanced training activities for flying personnel, including HAD. Without well-directed training, we cannot hope to meet the challenges ahead.

Three main features identify Swissair's positioning, each relating to particular qualities:

- we aim to transport our passengers as safely as possible

- we aim to offer our passengers maximum reliability

- we aim to provide our passengers with individualised, top quality service

When it comes to flight safety, we make no compromise. Even if that involves great expense and on-going effort. This point applies particularly in economically difficult periods, which is when saving in the wrong areas is particularly unwise.

Flight training at Swissair is based on five principles which govern as well HAD. The first of these principles is the most important. The other four are placed in no particular order but are all dependent on the first principle.

The first principle:

Flight safety is the first priority of all training activities.

Since flight safety as an overall probability is made up by the multiplication of all probability elements in flying, no single probability element can be allowed to tend toward zero.

Therefore consideration must be given to all influential factors pertaining to flight operations.

The consequence then is easily expressed. We should strive for the highest possible level of quality in every aspect: namely,

- with regard to trainees and, by extension, selection
- with regard to trainers
- with regard to training equipment

As a consequence of this basic principle, HAD is indispensable.

The point is that it is no use having aircraft and cockpit crews which achieve the highest possible standards of technological and aviation capabilities, if the crew's interpersonal skills and conduct jeopardise flight safety.

The second principle is:
retain control over training

This does not mean that Swissair intends to do everything itself. The principle allows for cooperation and delegation of tasks. But it does mean that Swissair intends to retain control of content, procedures and results of any training.

Consequently, Swissair must, for the decisive tasks, have its own *trainers, own training material and its own technical resources.*

From Swissair's point of view, purchasing training services completely from outside sources would not be in keeping with the high standards of quality stipulated in our airline's positioning concept.

As a component of training, HAD is a far more delicate matter than the technical side of training. There is a strong likelihood that pilots will reject any pointless unsuitable training activities related to human aspects. Such misguided activities would ultimately do more harm than good, simply failing to advance the cause of flight safety. As we see it, this is the main reason why the introduction of practical programs has been so difficult worldwide.

Therefore, the second principle has the following implications for HAD:

- Experiences drawn from international practice and knowledge drawn from worldwide research are valuable. As such, they are integrated into Swissair training.

- Support and input from external experts is valuable and should be encouraged.

- HAD -- as a process and as training -- is a task that should be handled for the most part in-house, using in-house instructors. Further, HAD must be broadly supported and clearly endorsed by top management of the company.

The third principle states:

Flight training must be consistently geared toward practical aspects and the realities of the market.

In particular:

- All forms of training (basic, advanced, recurrent) must be geared toward the practical aspects of aviation. Consequently, active line pilots should be assigned on a secondary basis to participate as instructors in the training program.
- Wherever possible, training for cockpit and cabin crews should be carried out jointly.
- Pilots too must be willing to perform specific customer service duties. Without that willingness, a pilot is ill suited to fly a passenger aircraft. Technical and aviation skills are, of course, essential but not enough on their own.

From the orientation toward real flying operations follows:

- Social and interpersonal skills must be taught as more than theory. HAD must be geared as much as possible to practical applications. All participants should be able to apply in practice everything they learn and be able to register progress in their daily work.
- Trainers should be practice-oriented, with a recognisable flair and aptitude for instruction, and properly prepared for the difficult task ahead. In other words, the principle here is that HAD should be conveyed primarily from pilot to pilot, with outside specialists taking a supporting role. That approach minimises pilot rejection.

The fourth principle states:

All training activities should ensure that a suitable balance is maintained between technical/economical and interpersonal requirements.

Because of the nature of the exercise, a clash of objectives may arise that sets the pilots' own expectations and goals in conflict with the technical conditions and economic forçes on the company. Resolving this polarity may not be easy, particularly during periods of economic difficulty.

Nevertheless, an acceptable balance must be found that can be implemented by all those involved. Failure to do so may jeopardise the entire project. Management and trainers are challenged to constantly seek a workable solution.

HAD makes an important contribution to this balance in that it has a positive influence on corporate spirit and all forms of interpersonal relationships. Further, this principle contributes to making technical and non-technical training a holistic entity, with the long-range goal being integration of the two.

The fifth and final principle states:

Flight training must be efficient and effective.

This principle requires:

- The stated objectives and abilities are to be achieved with minimum of personnel and material resources (economy-of-effort principle).
- Flight training must be reviewed regularly to ensure that training is appropriate. The question is: Do we train the right things and the procedures are they adequate?

With regard to HAD, the following consequences apply:

- We determine what we want to teach and what we want to achieve. We endeavour to do so according to the principle of economy-of-effort.
- We constantly review whether our content and procedures are appropriate, making use of international contacts and experiences in the process. But feedback from those involved is also important. After all, HAD must prove effective in the cockpit and must also have a beneficial effect for passengers.

3. Swissair's HAD Concept

The Swissair HAD concept approved in 1991 pursues a central goal:
Special training, known as HAD, should complement existing training, which to date has been geared rather toward the operational/technical aspects of flying. It should contribute toward maintaining and/or improving flight safety to the highest possible level.
Further, HAD should foster all aspects of interpersonal dealings of the cockpit crew in the performance of their daily work in the aircraft and within the company in general.

This concept consists of three main elements:

1. HAD Schweizerische Luftverkehrsschule/SLS (Swiss Civil Aviation School): basic HAD training during the 18-month ab initio training as line pilot
2. HAD instructors "Train the Trainer Program" for all instructors involved in training flight personell. The trainers serve as examples and conveyors of information for the trainees. If they are inadequate in terms of "human aspects", i.e. if there is a gap between expectations and reality, then the entire HAD training is doomed to failure from the start.
3. HAD for line pilots: the focus here is on advanced HAD training, i.e. on the fostering of "human skills" as a pilot in the cockpit, as a team member in the aircraft, and as a colleague within the company. This advanced training should be an ongoing career-long process, just like checks and refreshers in the aircraft and flight simulator.

The HAD Concept is based on the following considerations:

- HAD is supported by corporate commitment as an essential element of training at the highest level.
- HAD is an integrated component of flight training and not an artificial appendage. Human skills and technical skills must complement each other as a cohesive whole.

- HAD means lifelong learning and further development. The appropriate knowledge and abilities cannot be learned on a one-shot basis. Real progress can only be made through repeated effort to foster non-technical skills.
- A commitment to the need for HAD means that the human aspects be given greater weighting in recruiting and qualification than thus far has been the case. A pilot trainee or a fully-trained pilot who later proves inadequate in terms of human aspects must, if we are to be consistent, be dismissed, even if he is a brilliant pilot from a pure technical point of view.
- Responsibilities are to be regulated in precisely the same way as applies to other aspects of flight training. But because of the highly interlocking nature of human aspects, the fields of Flight Operations, Flight Safety, and Flight Training must work much more closely together than they have in the past.
- HAD training is new and complex. So resistance and skepticism are quite natural. It is essential that participants come to display a high degree of acceptance. Therefore, the best approach is to be pragmatic and evolutionary, rather than revolutionary. A high level of applicability is essential, with the emphasis to be placed on suitable practitioners rather than external specialists.
- HAD training must be in line with international standards, recommendations and experience. In particular, such training must satisfy the regulations of ICAO and JAA, thereby ensuring international standardisation.

Responsibilities for HAD training, a key factor in ensuring that the objectives are reached, are regulated as follows:

- The Vice President Flight Services (Division O) issues the mandate to conduct HAD training, based on the concept as outlined.
- The Head of Flight Crew Recruiting and Training (OT) controls the HAD training program.

  A Steering Group, which consists of the Head of Cockpit Crews (OC), the Head of Flight Safety (OQ) and the Head of Training (OT) supervises the program.

- The Head of HAD Training (OTE) is in charge of the specialist unit for HAD, which makes its services available on a cross-divisional basis. The HAD unit counts approximately 30 co-trainers who are all line-pilots specially selected and trained.

4. HAD Schweizerische Luftverkehrsschule/SLS (Swiss Civil Aviation School)

The Swiss Civil Aviation School trains candidates starting from PPL in an 18-month training program.

The training program is divided into three main sections:
- Advanced Training PPL, aircraft type Piaggio 149
- Training for Commercial Pilot Licence (CPL) with Instrument Rating (IR), flight trainer/simulators and aircraft types Piper Seneca or Beech Baron
- Training for Airline Transport Pilot Licence (ATPL), simulators and aircraft type Piper Cheyenne or Saab 340

Upon completion of training, pilots then join Swissair and complete further training to become First Officers on the MD-80 or Fokker 100.

During their training at the Swiss Civil Aviation School, the trainees attend a basic HAD course lasting overall nine days, which corresponds to the standards set by the European Joint Aviation Rules Flight Crew Licencing (JAR FCL). This training serves as the foundation for all later HAD training during the pilot's entire career.

5. HAD Instructors

The purpose of the HAD program for trainers:
To teach and develop the skills necessary to enable instructional staff at all levels to set an example regarding human aspects to all trainees. Their conduct should have a positive mulitiplicative effect.

We are convinced that trainers without adequate interpersonal skills of their own cannot be permitted to teach trainees.

Instructor training is also geared toward the standards envisioned by JAR FCL. Instructors are to acquire basic training as a foundation before being permitted to teach. Thereafter, compulsory refresher courses are held at regular intervals. Beyond that, advanced training is offered, which provides further practical instruction.

6. HAD for Line Pilots

Motto for HAD Program for Line Pilots:

"To the best level of safety, service and well-being through development of human potential".

This training consists of two main elements:

First:
the two-day HAD courses which all pilots attend every two years, the course content being different each time. These courses are cost-neutral in that from 1993 onward they replace the previous system of annual inflight route checks (RC). On a biannual basis a ground-based HAD course can replace a costly line check in the air. The somewhat shorter Ground School Refresher (GSR) continues to be held yearly.

Second:
Special HAD training for First Officers (F/O), i.e. for young pilots in the early stages of a career. The training focuses on "followership" and leadership, crew performance, and process-oriented interaction.

The basic outline of the HAD-courses is as follows:
- 40-50 two-day courses per year
- Main trainer provided by the Flight Safety Department
- 2 co-trainers support and assist
- maximum 18 pilots per course, inclusive one management pilot

The main themes for the 1993/94 cycle is Communication. The focus here is on stimulating and fostering existing talents and improving communication skills. This process is designed to fulfil the objective of having a positive influence on pilot conduct, attitude and interpersonal understanding. It goes without saying that this in turn will have a positive influence on flight safety, thereby fulfilling the objective.

The content of the two-day course is consistently geared toward interactive, practical application. This means that the participants spend the two days communicating with one another in a real way, as they would while actually performing their duties. The emphasis is on practice, not theory. In other words, participants gain experience in hands-on training in communication.

7. Conclusion

What we do <u>not</u> want:
Inadequate communication, unsatisfactory cooperation, lack of mutual understanding, inadequate ability to solve problems in difficult situations, poor system management, diminished flexibility, poor cockpit/cabin cooperation, cockpit regarding passengers as a nuisance...
Summary: flight safety and performance unsatisfactory.

What we <u>do</u> want:
Effective communication and cooperation, a positive relationship based on mutual understanding and shared attitudes, clear expectations, reliable and appropriate problem solving in all situations, optimum system management, high degree of flexibility, positive teamwork between cockpit and cabin crews, cockpit regards passengers as partners and customers......
Summary: flight safety and performance satisfy highest standards.

Also <u>un</u>wanted:
Over-emphasis on technical aspects, resulting in non-technical aspects being neglected. Such an approach poses serious risks:
- flight safety stagnates or declines

- chances of maintaining market position are diminished
- corporate culture jeopardised
- chances of developing human potential impaired

Also unwanted:
Over-emphasis on non-technical aspects, resulting in technical aspects being neglected. Such an approach poses the same risks as referred to above.
We strive to establish an optimum balance between the two. We are convinced that:
- by doing our utmost to attain the highest possible standard of quality with regard to technical aspects of flight operations and training,
- by effectively incorporating non-technical aspects, i.e. "human" aspects,

we then live up to our responsibility to our passengers, in that we offer them the highest possible level of flight safety, thereby earning their trust.

At Swissair, we are convinced that our HAD Program:
- fosters flight safety
- develops in a positive way interpersonal skills and many other professional attributes of our cockpit crews
- thereby contributing to the well-being of all involved
- influencing corporate culture in a positive way
- enhancing the quality of our service and cost-benefit ratio.

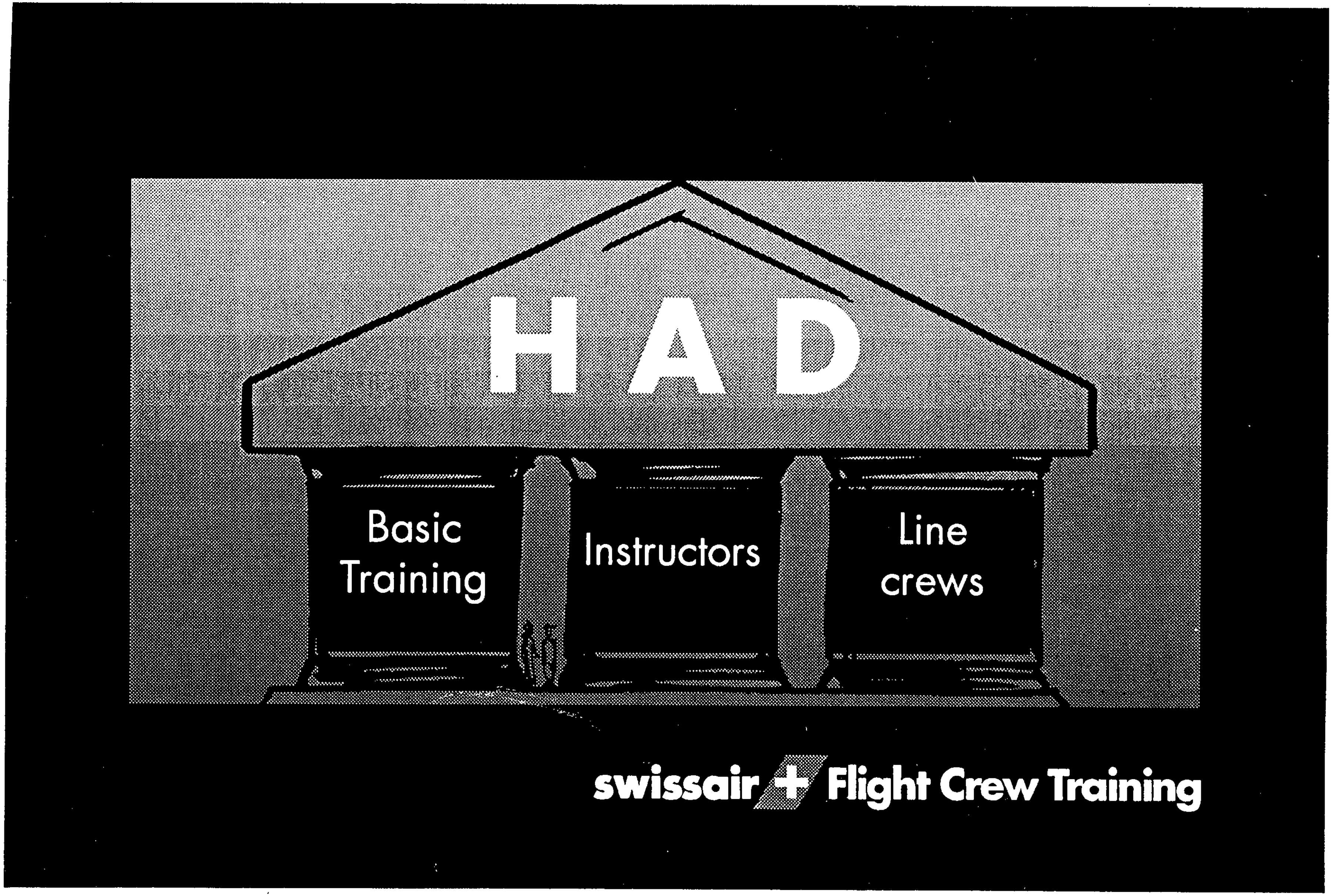
In doing so, we are acting in the interests of our passengers, our own company, and civil aviation.

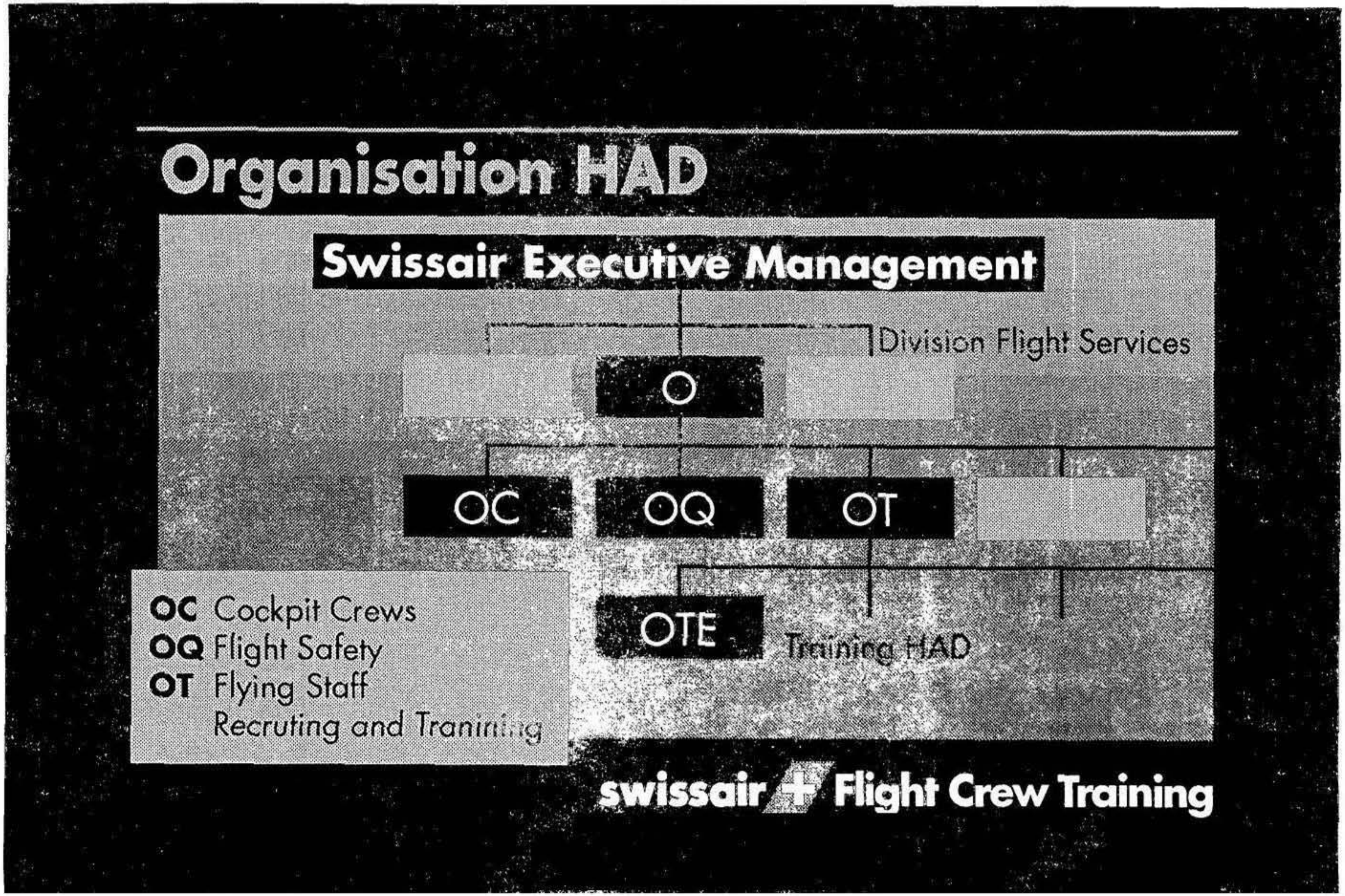
HAD

Human Aspects Development

The Swissair Training Syllabus

swissair Flight Crew Training


HAD
Basic Training
Instructors
Line crews
swissair + Flight Crew Training


Organisation HAD
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swissair Flight Crew Training

HAD – Line crews

1992

Safety Awareness
≈ 2h/y

RC	RC	FC	RC
GSR	GSR	GSR	GSR

1993/94

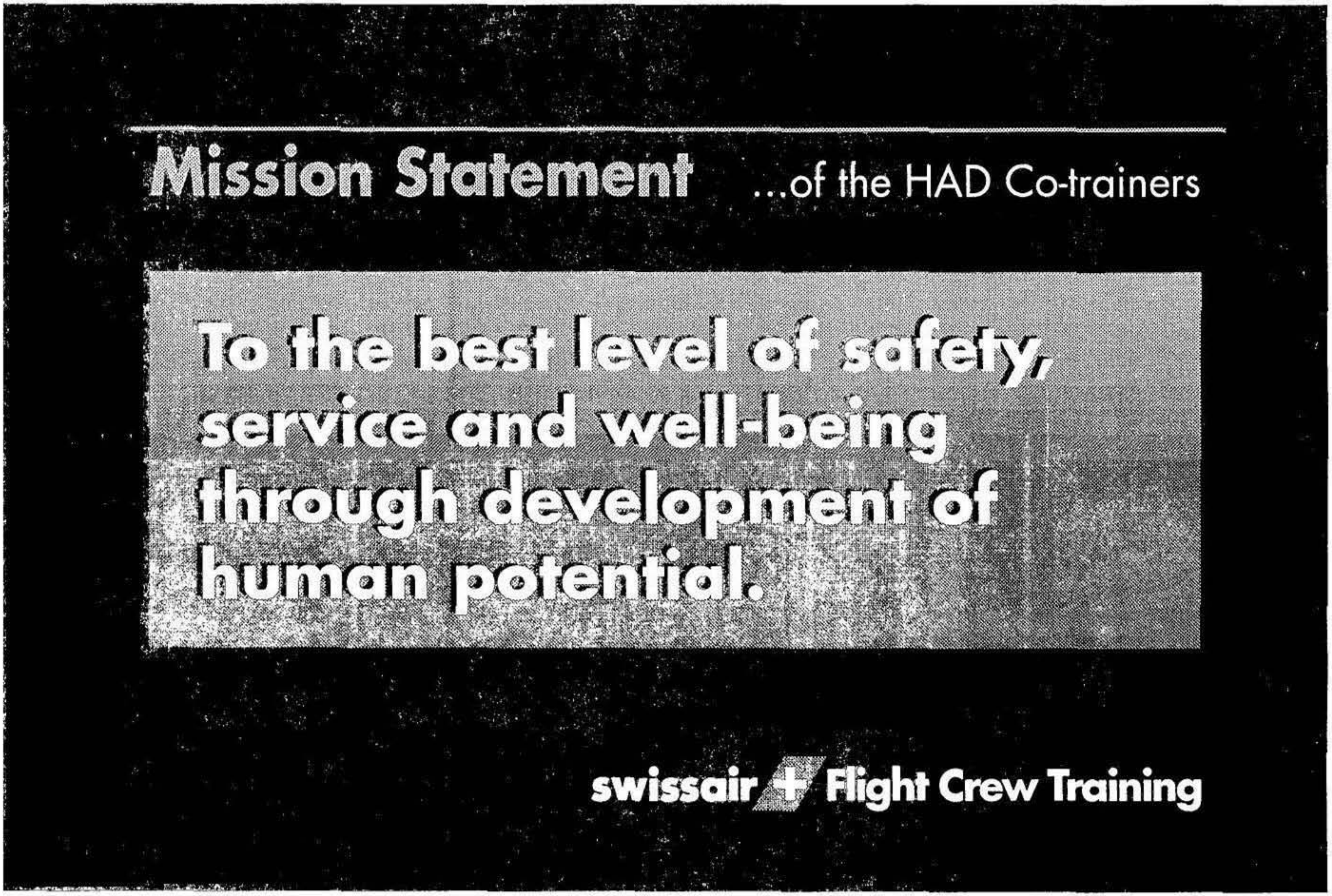
HAD Course
2d/2y

RC		FC	
	HAD		HAD
GSR	GSR	GSR	GSR

- a complement to
- alternating with

} Crew (line) Check

swissair Flight Crew Training


Mission Statement ...of the HAD Co-trainers
To the best level of safety, service and well-being through development of human potential.
swissair Flight Crew Training

HAD – Line crews

The Basic Setup

- 40/50 courses/year
- Main Trainers: Flight Safety
- Two Co-trainers: regular cockpit crew members
- 18 Participants: cockpit crew members of all fleets and ages mixed

swissair Flight Crew Training

HAD – Line crews

Course Program

First Day

- Introduction
- Personal experiences relating to line flights
- Some theory

Second Day

- Application
- Group exercise
- What I learned from this course
- Feedback

swissair Flight Crew Training

HAD – Line crews

HAD Cycle 93/94

- **Communication**
- Develop well selected talent
- Improve awareness: behavior, motives
- Provide limited basic theories
- Activate the sensors of the participants
- Get them interested in some further steps...

swissair Flight Crew Training

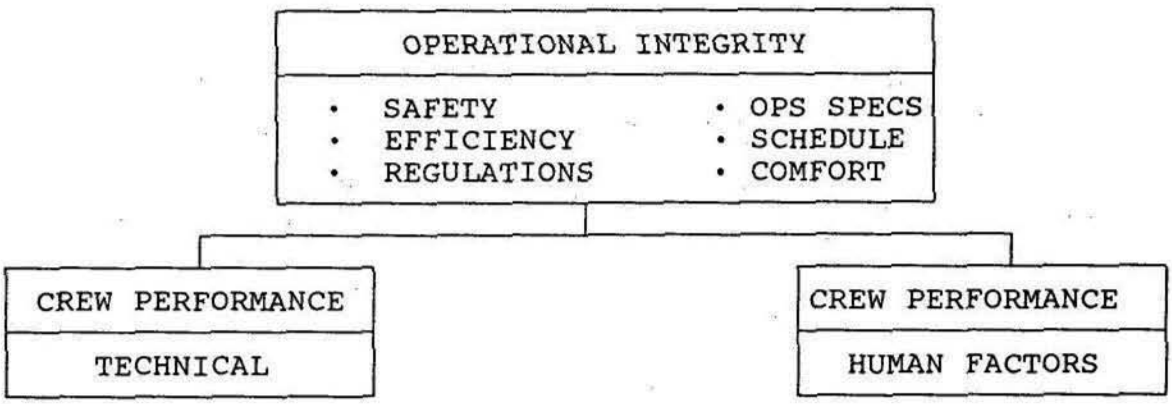
MAINTAINING OPERATIONAL INTEGRITY THROUGH THE INTRODUCTION OF HUMAN FACTORS TRAINING

Douglas Schwartz (USA)

Operational Integrity

Operational Integrity

Operational Integrity is a term that embraces the six imperatives of every flight crew. To assure that the flight is operated safely; the aircraft and resources are used efficiently; the flight complies with the established schedule; that passengers are provided with the most comfortable flight possible; the flight is operated in accordance with applicable government regulations; and that the flight is operated in accordance with company operating policies (often called operations specifications).



Operational Integrity is the responsibility of every flight crew.

THE COMPONENTS OF OPERATIONAL INTEGRITY

The performance of a flight crew to achieve Operational Integrity has two components.

The **technical component** of crew performance includes knowledge and skills relating to aircraft systems; normal, abnormal and emergency operating procedures; ATC procedures; instrument flight procedures; navigation and charts.

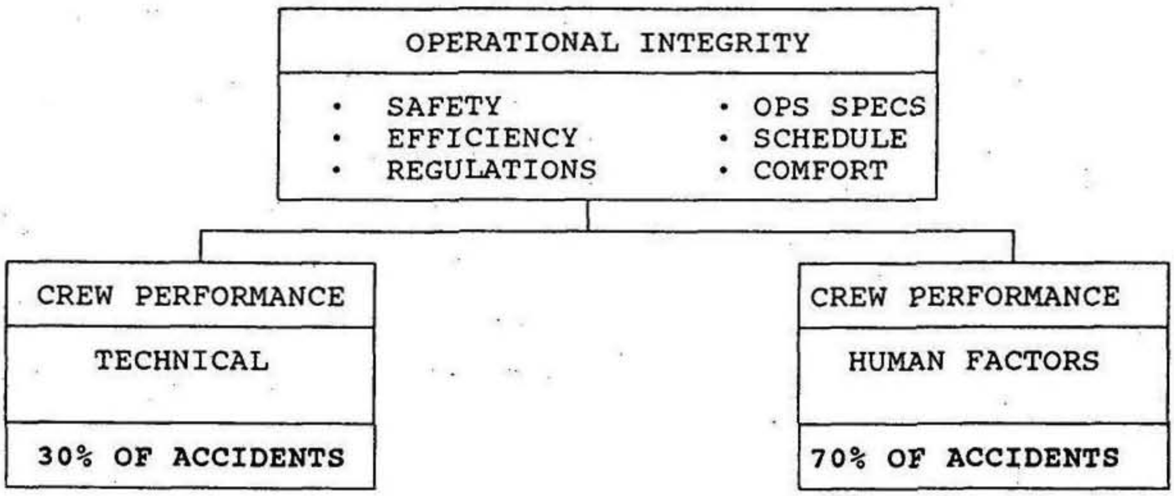
This area is well documented, thoroughly trained and rigorously checked. In fact, the airline industry is quite accomplished in the technical component of crew performance.

The **human factors** component of crew performance includes a body of non-technical knowledge and skills that influence the technical performance of flight crews. Communications skills; team building; the exercise of command and use of leadership; decision making; management of resources, workload and stress are among the subjects relating to this area.

Today, the airline industry is only just beginning to address the requirements of the human factors component of crew performance. It is poorly documented, rarely trained and almost never checked.

TECHNICAL VERSUS HUMAN FACTORS INFLUENCE IN ACCIDENTS

It is revealing to note that only 30% of crew caused accidents result from technical crew performance failure. However, 70% of crew caused accidents are the result of human factors crew performance failure.



Success achieved in the area of technical crew performance must be repeated in the area of human factors crew performance if we are to improve system safety.

This requires a different view of old issues. As an industry, perhaps even as a society, we have grown to expect technical solutions to resolve our operating problems. Today however, technical solutions are providing less and less margin of improvement while, at the same time, becoming increasingly expensive.

An example of the application of technical solutions to operating problems in the late 1960s and early 1970s was the use of flight simulators. Simulators all but eliminated the risk of accidents during training flights within the airline industry. And because simulators provided an effective tool for better pilot training, still more improvement in the line safety record was realized.

In the 1980s, the introduction of ground proximity warning systems helped improve the accident record by reducing controlled flight into terrain errors. As effective as these systems were, and continue to be, they did not have as much impact as the broad use of simulation.

TCAS, terminal collision avoidance systems, today are another example of technical solutions applied to operational problems. TCAS is a valuable resource and a welcomed addition to the cockpit that will help reduce the risk of midair conflicts. However, does the cost justify the benefit? When was the last midair collision involving an airliner? Many cannot even remember that it was in 1989 in the Los Angeles area when an AeroMexico MD-80 collided with a light single engine aircraft over Cerritos, California.

Is TCAS worth it? Probably yes. But it is an example of increasingly expensive technical solutions applied to operational problems that yield a declining measurable benefit to system safety.

SOLUTIONS TO BE FOUND IN HUMAN FACTORS TRAINING OF CREWS

We must recognize that human solutions to operating problems will provide more benefit for less investment than will technical ones. Flight crews require both technical and human factors knowledge and skills if they are to be as effective as possible. Training in the non-technical knowledge and skills normally referred to as Crew Resource Management (CRM) training will influence the technical performance of flight crews and provide an effective means to improve system safety.

Appendix

COCKPIT RESOURCE MANAGEMENT TRAINING

PROJECT OVERVIEW

Cockpit resource management training is designed to increase the safety and efficiency with which flight crews operate aircraft in scheduled service. Because the operating environment at each air carrier is different, the best CRM program is one that is customized to meet the unique requirement of the airline.

FlightSafety recognized this and suggests the following process which can be used to customize our basic two-day CRM workshop to your specific needs.

I <u>Strategy Meeting</u>
FlightSafety CRM experts meet with airline representatives to define the airline's goals and expectations for CRM training. FlightSafety personnel observe line flights from jump seat to develop better understanding of airline operating environment. CRM course outline defined; target dates established.

II <u>Facilitator Training</u>
FlightSafety will assist the airline in selection of CRM facilitators. Facilitator training is then accomplished in accordance with a prescribed facilitator training plan.

III <u>Courseware Design and Materials Production</u>
FlightSafety will modify our basic two-day CRM workshop program to meet the requirements established during the strategy meeting.

Instructor manuals, audio-visual materials and student handouts and manuals will be produced for delivery to the airline.

IV <u>CRM Program Implementation and Courseware Revision</u>
FlightSafety will assist in implementation of the Program at your airline, supervise the first classes by your facilitators and make a revision to the course following the second workshop.

V <u>Line check Airmen and Instructor Pilot Training</u>
FlightSafety will conduct a special two-day training session for line check airmen and instructor pilots describing how they can implement CRM behaviors during line training and checks.

VI <u>Follow-on Support</u>
FlightSafety will provide additional assistance and support, as required, to assure smooth and successful implementation of the CRM program.

CRM PROGRAM DEVELOPMENT: A TIME FOR INTERACTION

J Norman Komich
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In an interview in the Oct 1990 issue of the Airline Pilot magazine, Clay Foushee was asked about LOFT and CRM training. In his answer, he stated "If I were running one of these programs, I'd have a major exercise every year with my flight training and operations staff to completley revise the scenarios." I wholehearted support that statement, but I find myself wondering "Why limit the discussion to only the personnel within one's own flight operations department?".

Motivated by the need for a new CRM curriculum for recurrent training once a year, such an "annual review" has become common amongst CRM program developers. However, when these individuals responsible for determining the next year's curriculum, pool their thoughts, what is the source of their ideas? In spite of years of emphasis on the NEED for CRM training, there is still little formal guidance available on HOW to teach CRM concepts. Discussions on this subject with a number of air carriers, indicate that their ideas are typically spontaneously generated by those individuals within the group. Experience is proving to be THE mentor on teaching CRM. If this 'experience' is limited to those within one flight operations, I pose the following four questions:

1) How many years of a CRM program must pass before the "Law of Diminishing Returns" takes place within one flight operations group ?
2) How much redundancy of effort is presently occuring and if it is, can the CRM industry afford the reduced margin of safety associated with such reinventions of the wheel?
3) Are the line pilots all over the world getting the VERY best CRM training they can for the time, effort and expense put into their training?
4) Is this system addressing ALL the problem areas associated with CRM issues?

Taking each question in order, the answer to the first takes into consideration the basic CRM concept that synergism between members of a group produces a better outcome then efforts by individuals. Why is CRM program development any different? Which will have the better outcome, one flight operations department, or several working in concert? Perhaps its time to practice what is being preached.

The next question on redundancy is somewhat subjective but with regard to a safety issue as critical as CRM continues to be, the aviation industry can ill afford to waste time accomplishing something that someone else already has.

Historically, there was an initial reluctance to open one's CRM program to others. This was precipitated by the initial cost of establishing a program as well as the proprietary attitude associated with the "culture" of one's own airline. This attitude has changed over the year's and more and more CRM programs are opening their doors to outsiders; the CRM industry needs to strive for ALL programs to have such a policy. Additionally, the Northwest Airlines annual CRM workshop, held twice so far, is the first formal opportunity for such interaction between a variety of operations including various air carriers, the FAA, the military etc; the worldwide CRM industry needs many more of these.

The third question on the quality of CRM training being presently received is somewhat subjective. Entire presentations have been given on evaluating the quality of CRM programs. Suffice it to say here that while significant gains have been made in improving teamwork both in and out of the cockpit, the CRM industry needs to look at what must still be done, and not just relish what already has been accomplished. I base this conclusion on the fact that CRM "war stories" continue to be told in which an accident or incident did not occur but the safe arrival was simply too close for comfort. Because they don't result in an accident, just a reduction in the margin of safety, such "dirty laundry" is not typically aired for the public, but line pilots are acutely aware of them. As a current line pilot who also flew in three different military reserve units, each with pilots that I continue to question who come from a wide cross section of various air carriers, as well as querying extensive jump seat riders from other carriers on my flights, I continue to hear such stories. As an individual concerned over aviation safety, I point these out as evidence that while the CRM industry has come a long way, it still has a long way to go.

Before discussing the specifics of assuring the very best quality of CRM training, let me take a moment to discuss two idiosyncracies associated with training pilots. The first involves the 'students' and is that pilots attending training typically fall into three categories: 1) the first are extremely conscienscious to the point of furiously writing down everything that the instructor says in a notebook for future reference, 2) the second group are the the majority who sit and listen and depend on "recall" of their memory to carry out those important messages; ie if it was noteworthy enough, they'll automatically remember it, and 3) the last group are the ones who already know everything and have forgotten more than the instructor will ever know; they typically read the paper and daydream in class. Needless to say the three groups form a typical bell curve with 1 and 3 at the extremes and 2 making up the brunt of the middle.

The second idosyncracy involves the instructor; experience has shown that the 'better' instructors of pilots have two objectives with regard to any pilot training program:
1) they need to establish the "MEAT" of the program, ie the

message to be taken out of the classroom and carried into the cockpit, and then they have to
2) find a way to present it in an entertaining and stimulating manner so that the class accepts and retains the message; with regard to flight crews, "Savvy" instructors have achieved this through a variety of approaches including humor, shock, interactive involvement, and sex (before Anita Hill). Put another way, the savvy CRM program developer becomes a "translater" who interprets material provided by academia, the FAA, the NTSB, aircraft manufacturers etc. and puts it into a language that the line pilot will listen to, remember, and use on his or her next and ensuing flights. Such savvy instructors are typically born and only "made" with considerable effort. This effort necessitates the requirement for ALL the assistance available, not just within one group but within the entire CRM industry. This global perspective is necessary IF the goal is truely to provide the highest quality CRM training available.

Determining what constitutes the "meat" and then translating it into an "entertaining" presentation is the key to a successful CRM program. The introductory first class in any CRM program attended by those who have never heard of CRM before, is relatively easy. The subject is so new and different when compared to traditional ground training, that it is typically well received, even by many of the "group 3" crewmembers. However, once the newness wears off and the honeymoon is over, optimizing the effectiveness of the CRM class by keeping it fresh, stimulating, and productive is a constant challenge for the CRM program developer. With that in mind, I offer the following suggestions to the CRM industry to optimize the quality of <u>all</u> CRM programs; in addition, where applicable, I present my motivation for including them:

1a) To allow sharing of successes in developing CRM programs, the aviation industry needs to continue to work toward opening its CRM program doors to everyone. The following scenario just occurred in March of 1993 when I received a phone call from a pilot at a large regional airline who was seeking assistance in starting a CRM program on their property. I asked what sort of assistance they were getting from the large carrier they code shared with and I was very surprised at the response of "None". So while the CRM industry has made a lot of progress in this area of sharing, there is still a long way to go.

1b) Such attendance should provide the opportunity for "outsiders" to critique what they have observed. This does not require that all such critique be accepted, but the sincere avenue for its presentation should be made. CRM Program Developers need to be more open to constructive criticism from peers outside their operation. I make the observation that "CRM Program Development is a CRM ISSUE !". By that I mean that one CRM issue taught in every CRM class is the omnipotant captain who feels he knows everything and that the other two crewmembers have little to offer in the way of advice. Likewise, I see the enthusiastic CRM program developer so caught up in the excitement and power of their program that their receptivity to criticism is minimized. The CRM industry could use a little humility and humbleness when it comes to seeking outside critique in making one's CRM program the very best it can be. When one preaches two way communication in the classroom as a CRM concept, they need to be sure to take their own advice. I cite as an example of the need for this, the statement repeatedly made by the CRM program director for a major air carrier: "We still consider CRM to be "COCKPIT Resource Management" and not "CREW Resource Management" because our captains are going to ALL be properly trained in CRM skills and consequently the flight attendants do not have to be." When it was pointed out that it was unlikely that one eight hour class would bring every Captain into the CRM fold, he did not want to hear it. Such naivete could not only result in just a less effective CRM program, it could border on dangerous.

2a) Quality videotapes are an excellent teaching tool. I realize that the production of such items costs money. However, such items should NOT be looked at as a source of revenue but rather as an opportunity to make the whole aviation community safer. Initially, witholding such tapes and not sharing them generates NO additional revenues. Then after a period of time, such tapes are often shared, but by then they are outdated. I have raised this question with others and I have been challenged on the premiss that in addition to the monies involved, there is a reluctance to air one's dirty laundry when negative issues are presented. I understand such protectionism, but I offer the following: as with ALL negative issues raised in CRM classes, they should be introduced with the game rules that "we view these accidents and incidents with the intent of not looking backwards to say 'what a bunch of dummies' but rather to look to the future to assure that we don't make the same mistake when confronted with a similar situation in our careers". A quality CRM facilitator can oftentimes convey the concept of "there but for the Grace of God, go I" in such instances. As two examples of the need for the above, I cite the search for copies of the videos on the two DC-8 accidents: the freighter at Salt Lake and the fuel starvation at Portland. After calling every resource I could, I was told by one carrier that I could have the copies for one thousand dollars; I eventually got them for nothing through the Air Force. Regarding the L-1011 windshear accident at Dallas Fort Worth, after repeatedly viewing the video on that accident and repeatedly being denied a copy, I finally learned that it cost five thousand dollars and the signing of multiple legal documents to procure copies. Now it is becoming more readily available for nothing. Notwithstanding the legal ramifications of litigation following an accident, the CRM industry needs to reevaluate what and what doesn't constitute a revenue source when it comes to aviation safety and then reconsider making these videos more readily available to others.

2b) One of the greatest teaching tools for pilots is "Hangar Flying", the shairing of 'there I was' stories. There needs to be a forum for the CRM industry to share these highly effective devices for putting a CRM point across.

3) Methods of instruction of the various concepts of CRM vary widely in technique and success. Again, there should be the opportunity to share and exchange such technigues, with explanations of the evolution. Typically when a CRM program developer puts an annual curriculum together, this curriculum undergoes an evolution process as it is presented to flightcrews month after month. The final product might vary considerably from the first class. Again, it is a terrible waste to have another CRM program undergoing the same "reinvention of the wheel" when they make the same mistakes another program already experienced and discarded. There simply needs to be a more formal avenue to share such knowledge.

4) There are a wide variety of meetings which are held each year to discuss CRM issues. If the concepts, conclusions, theories, perceptions etc. which arise from each of these meetings do not make it to the line pilot, then I make such efforts analogous to the football team which struggles 99 2/3 yards to the one foot line but fails to score, thereby accomplishing really nothing. The airline industry can ill afford to waste such efforts; they need to assure that ALL such pertinant data makes it to the line pilot. Additionally, everyone should have access to these meetings whether a member of the organization or not. There needs to be an active worldwide "Network" listing of CRM program developers to assure they are aware of all such gatherings. Also, one should be able to reference ONE source to learn about what the CRM calendar holds for the future with regard to ALL pertinant meetings.

The last question of whether the CRM industry is addressing ALL the CRM issues it should, is pointed at the "meat" portion of CRM curriculum development and I offer the following subjects for consideration. One special point of interest regarding these subjects is that they are earmarked for special groups. It is no longer the development of a CRM program to cover the "masses" of the entire pilot force; rather, it is the design of a special curriculum to address the specific needs of specific individuals. Developing the two points above of the "Meat" and the "Delivery" of such a specialized curriculum is far more difficult than the generic CRM program and consequently mandates even further requirement for the CRM industry to interact. I acknowledge that some carriers have already begun to address these issues, but again, why does the industry tolerate such duplication of effort when someone else begins to address these issues for the first time?

1a) New Captain and new first officer upgrades deserve special CRM attention which addresses those specific issues they will be confronted with in their new position. Again, how does one determine what these issues are and how to effectively teach them?

1b) Over age sixty flight engineers. After flying as captain for many years, the individual is put into a subordinate seat. Most handle it well but what about the one who does not?

1c) Regression due to furloughs in which a Captain is downgraded to F/O and an F/O is downgraded to S/O. Both are significant changes, not coming by choice but rather by mandate. At present, the training for such downgrades only involves checking out in the equipment even tho there is much opportunity for disgruntlement.

2) Bringing other groups into the realm of CRM. Including Fight Attendants, dispatch, maintenance, agents, cleaners, etc in CRM classes effectively, takes a certain flair.

*3a) Overly assertive first and second officers. This issue has been around for a long time but the Detroit ground collision between the DC-9 and B727 during reduced visibity highlighted the requirement to address it.

*3b) The individual who says one thing and then does something else: "I want CRM in this cockpit" but then when someone challenges his decision, he fails to respond.

*4) Remedial CRM for an entire crew to appease the FAA on a "Voluntary Disclosure" issue. My carrier has successfully implemented this twice; have any others and how did they do it?

*5) CRM to cover intra cockpit stress due to a merger or post strike, two highly volatile issues that can generate conflict.

*6) In the authors' opinion, one of the biggest compromises to safety is the non team player, occasionally referred to as a "boomerang" but that suggests that there is actually a movement in the wrong direction. That fails to address the individual who just does not move off that far left postion or if he does move, it isn't enough. Both the boomerangs and the non movers generate many of the CRM war stories. In Sept 1989, ALPA ran a full day workshop on this subject titled "The Remedial CRM pilot problem", yet the war stories continue to be told. Similarly, one major carrier developed a remedial program designed around a nationwide network of councillors, but this program was dropped due to certificate jeopardy on the new FAA form. To date then, the results of an acute awareness of these individuals is just TOLERANCE; from a safety perspective, this in unacceptable. This is an issue that must be addressed more formally and one that MUST have interaction between groups, particularly when there is any note of success.

NOTE: I acknowledge that the above *'d items are typically highly sensitive from both legal and reputation perspectives; nonetheless, with the appropriate emphasis, they can be treated accordingly and interacted upon for the benefit of the entire aviation industry as opposed to being hidden away like some skeleton on a closet.

So let us not lose sight of the true goal of ALL CRM programs; let's remember that it is not simply the generation of an 8 hour class to fill the requirements required by the local inspector; nor is it the generation of an in house power regime to further one's own empire; nor is it to just generate revenue for a commercial venture; nor is it to generate statistical data for a research project. No it is none of these; the true goal of ALL CRM programs is to produce safer and more efficent flight crews for all of aviation. Pro-active interaction betweeen CRM program developers is one key method to achieving that goal.

CRM: FEEDBACK AND APPRAISAL SYSTEM

Ms. P. Antersijn and Ms. M. Verhoef (Netherlands)

Assessment of non-technical skills. Is it possible?

As you all know, airlines must start assessing non-technical skills in the near future. But is it possible, and how should we do it? At KLM we are convinced that, before you are able to assess non-technical skills, you have to make sure that your training in non-technical skills is adequate and sufficient. And that the people who will coach your cockpit crew on non-technical skills (and in the near future will assess them), have the right tools to do so.

In this presentation, I would like to give you some insight into KLM's approach to deal with this problem.

This presentation will cover the following topics:

1. The philosophy behind KLM's training approach.
2. Implementing a new training tool: the Feedback and Appraisal System.
3. First results of the try-out of the Feedback & Appraisal System in KLM's A310 and DC-10 division.

1. KLM's Training philosophy:

If you take training seriously, it is important to regularly evaluate your training package and training approach. At the end of 1987 KLM's Flight Crew Training Centre came to a major conclusion:

All important training items to ensure a good working cockpit crew were covered, but there was still something missing.

We had our skill training, LOFT training, Crew Management training, a training in Public Address techniques, our KHUFAC, but they were all separate courses or subjects; there was no real relation between the technical and non-technical training.

Subjects taught during, for instance, the Crew Management Course, were not reïnforced during simulator training. The instructors did not have a tool to do this.

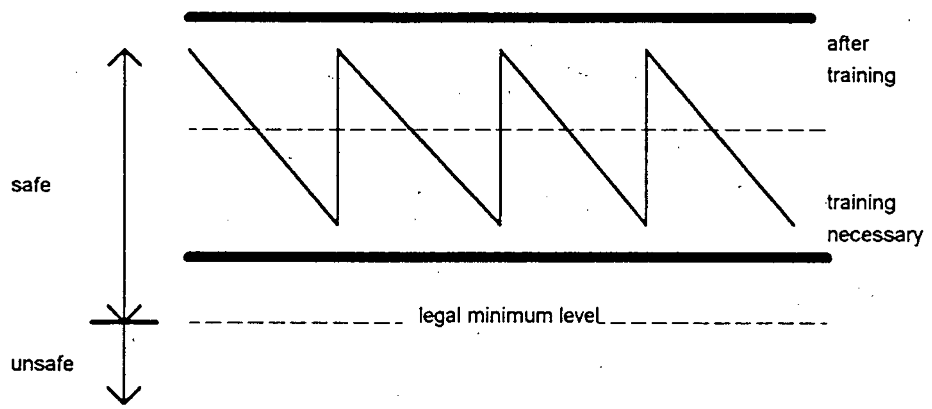
As a consequence the instruction of non-technical skills within KLM was not as effective as it could be.

The missing part was A STRUCTURALLY INTEGRATED TRAINING APPROACH OF TECHNICAL AND NON-TECHNICAL TRAINING.

This point of view was strenghtend by studies done in the field of didactics. They show that as soon as one has finished a course, skills which are rarely or never used, deteriorate.
Also a decline in the norm occurs for skills that have become routine. In a refresher training the participant's skills are brought back up to standard. This performance curve can be described as a sawtooth and can differ from person to person.

Traditionally, we accept and use this "sawtooth" curve as the basis for the setup of our technical training (our Type Recurrents and Proficiency Checks), but it is of course also applicable to non-technical training.

Figure 1: "Saw-toothed" performance curve

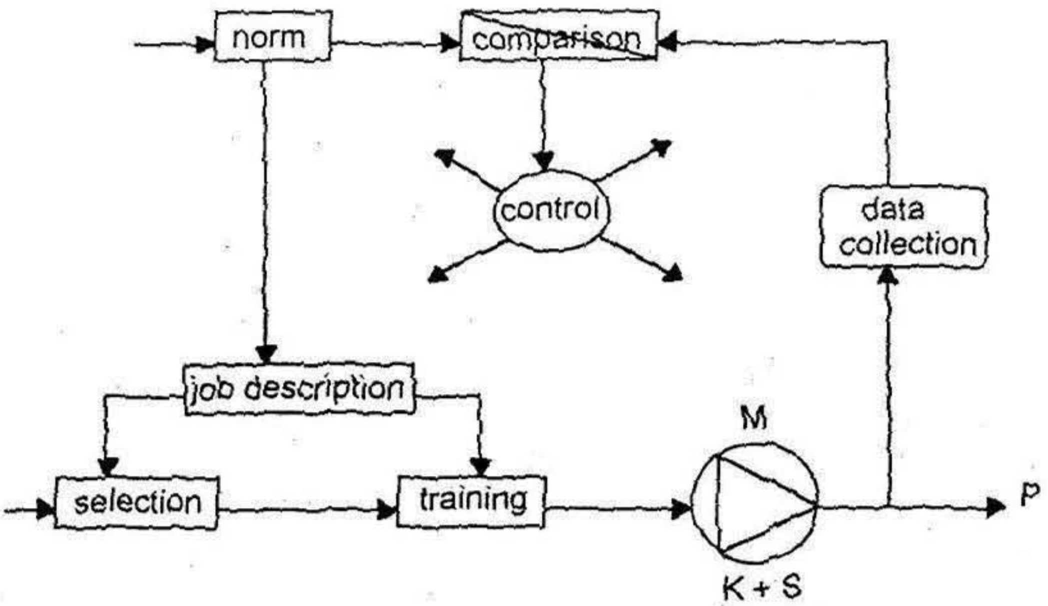


When this conclusion was reached at the end of 1987, the Flight Crew Training Centre was confronted with the question where to start. Non-technical training was up to then, a once in a lifetime activity. And instructors didn't have the tools to give effective feedback on non-technical performance of the cockpit crew.
At the same time KLM was confronted with other developments influencing the training process, such as:

- The ever growing competition between airlines.
- Changes in the corps of Pilots and Flight Engineers related to age structure, distribution of experience and cultural background.
- Operational changes such as long-haul flights.
- Changes in cockpit layout and ergonomics as a result of automation in the cockpit.
- And finally, general developments in the airline industry concerning Cockpit Resource Management Training and related laws.

To find out where to start, it was first necessary to map out the existing training process. In that way, it became clear which factors played a role and how they influenced each other. It also made clear where to start with integrating non-technical training into the existing training set-up.

Figure 2: Training Process



P = Performance

M = Motivation

K + S = Knowledge and Skills

I will not explain the complete diagram to you, but for KLM it pointed out that the main area's, were:
- job description,
- selection,
- the training itself,
- the process of data collection and comparing this to the norm,
- and the organizational structure for monitoring and controlling part.

The job profile plays an important role in this process.
- It is important for the selection criteria.
- It determines what must be trained.
- It forms a frame of reference to determine if a person is performing as required, or to determine the quality of the training and selection process.
- and it offers a frame of reference for the person himself. When someone's performance is being measured, that person has a right to know what is expected.

This is why KLM started the integration proces with the adjustment of the job profiles. By means of interviews among middle and higher management the missing items were added. And with the help of surveys among all pilots and flight engineers, its general completeness was checked.

Notwithstanding the other important items, I will focus the second part of my presentation on the development of a tool for instructors. This tool was to help them in the process of non-technical data collection and to help them to compare this data to the norm. We called it the Feedback & Appraisal System.

2. Implementing a new training tool: the Feedback and Appraisal System.

The Feedback and Appraisal System consists of two parts: a terminology part and a reference part.

When dealing with non-technical skills, it is important that both the instructor as well as the crew, know what they are talking about. That they speak the same language.
Miscommunication, misunderstanding and misintepretations are fatal for effective counseling or debriefing. Especially the acceptance of the crew of the instructors feedback is important. The quality of the feedback can be just as good, but if the acceptance is zero, the effect of the debriefing is zero.
This demands a carefully planned debriefing tactic from the instructor.

A frame of reference is important so that everyone knows what KLM expects. In training and assessment situations, the frame of reference gives the instructor a tool to be as objective as possible.
Of course, it is very difficult to describe a kind of norm for non-technical skills. The behaviour of a crew depends on the situation and on the individual crew members themselves, or does it?

If we want to assess non-technical skills, it is important that this be done as objectively as possible. At KLM we have been working on the Feedback and Appraisal System for 3 years now. We are not completely ready yet, but we have gone a long way in the right direction.

The strength of the Feedback and Appraisal System is that it describes in clear terminology the work of our cockpit crew; Clearly visible for everyone and with no psychology, at all.
This is because it was developed from on-the-job situations. More than 60 interviews with instructors, pilots and flight engineers resulted in over 600 cases where non-technical aspects play an important role in the safety of the operation. In the end, all these on-the-job situations were divided into five main categories, with the acronym WILSC:

WORK ATTITUDE
INFORMATION MANAGEMENT
LEADERSHIP
STRESS MANAGEMENT
CO-OPERATION

There are 14 subcategories.
A short definition is given of each subcategory and underneath the matching behavioural components that play a role in this category.

See for instance one of the subcategories of Work Attitude: Exercise of self-criticism.
The definition of this subcategory is: Being critical in relation to one's own functioning
With behavioural components as:

- evaluating one's own performance
- willing to discuss one's own functioning
- being open to criticism from others

and / or

- asking others for information about one's own functioning

All definitions and descriptions are available to the instructor as well as to the pilot and/or flight engineer. So the instructor as well as the person who receives feedback in the debriefing, know what is meant by certain terms, how this is translated into observable behaviour and what KLM expects from her crews.

This approach and setup is one of the most important points if you want to get acceptance for implementing a new tool. In order to gain acceptance from the users, it should be practical, visible for everyone and deal with their job, no hocuspocus or amateur psychology. The users must be part of the development of the system.

Other important items for an effective implementation are among others:

- Keep everyone informed during the development phase (users, management, unions).
- Try the system out under real circumstances and evaluate.
- Pick an implementation date, so that it is visible to the whole organization when the tool will be implemented officially; the instructors know when to use it in their training and the crew also knows when they will be confronted with it.
- Prepare the organization by means of informing and discussing implementation strategies with management, Chiefs Pilots and Flight Engineers, Chief Instructors, Planning and Scheduling Department, etc.
- Prepare each crew member by means of sending them information about the system and its implementation.
- Prepare the instructors to use the system and make sure they are properly trained in instruction techniques; briefing-, observation-, debriefing- and reporting techniques.

At KLM we started in July 1992 by trying out the Feedback and Appraisal System in our A310 and DC-10 Divisions. To introduce the system to all the pilots and flight engineers of these two divisions, we developed a special Type Recurrent program.
Instead of studying parts of the AOM at home, the crew was asked to read the information about the feedback and appraisal system.
In the briefing there was one hour to show a 15 minute video about FAS, to do a short exercise on non-technical behaviour and to discuss questions on this subject. The simulator session was a real LOFT session. And during the debriefing, the non-technical performance of the crew was discussed according to the new system.

To prepare our instructors we made sure that every instructor went to an advanced instruction training in which they learned how to use the feedback and appraisal system and in which a refresher of instruction techniques took place. An instructor was not allowed to give the Type Recurrent as long as he had not taken the course.
Close contact with chief instructors and especially the Planning and Scheduling Department was very important.

In our instructor training we teach the instructors to use the feedback and appraisal system in a very practical way. We use cases, video-analyses and debriefing roleplays. But first of all we let them think about the meaning of the main categories for themselves.

For instance, what do you think that the category INFORMATION MANAGEMENT means?
In the discussion that follows things come up like: getting information, using resources, deciding on priorities, planning, taking decisions, updating plans, structuring information.
After this, we looked at the definitions used in the system. The subcategories of INFORMATION MANAGEMENT are:

- Information analysis
- Planning and Anticipation
- Decisiveness

With for instance behavioural components of Information analysis as:

- actively and systematically searching for relevant information
- using available resources
- involving proposals and suggestions of others
- classifying information into main issues and side issues / cause and effect
- penetrating to the heart of a matter
- keeping an overview by continuously comparing new information to the actual information

The instructors had to conclude for themselves that the definitions matched their own thoughts, that the Feedback and Appraisal System really deals with their work and is in fact not something completely new but just an agreement on the terminology used when talking about non-technical performance. In short: that it is a tool for them to make their job easier.

3. First results of the try-out of the Feedback and Appraisal System in KLM's A310 and DC-10 division.

What are the results of the try-out of the Feedback and Appraisal System in our A310 and DC-10 division so far.
The main questions were:

- Will the system be accepted by instructors as well as pilots and flight engineers?
- Is the feedback and appraisal system really a helpful tool to assist instructors in coaching crew members in their non-technical performance?

and

- Is the system complete, are parts missing or superfluous?

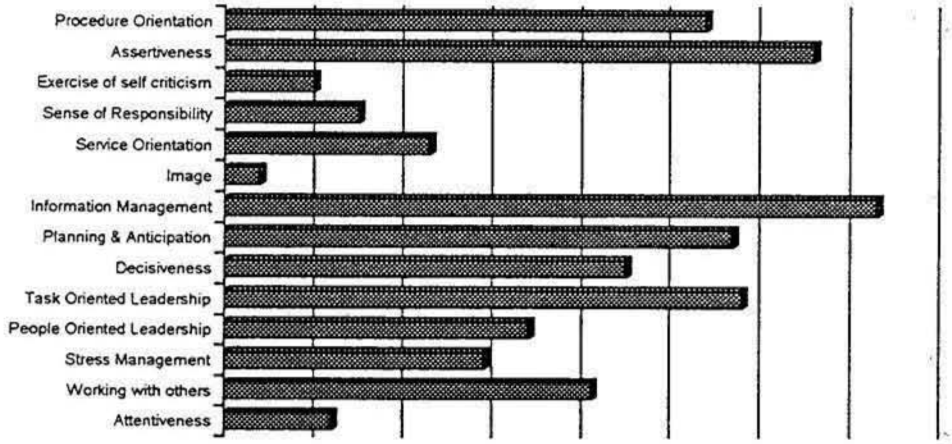
To get information to answer these questions, we asked instructors and crews to fill out a questionnaire after every Type Recurrent. In the period July to December this resulted in a total of 118 instructor questionnaires (a response of 99%) and 194 questionnaires from pilots and flight engineers (a response of 87%).

Some results:

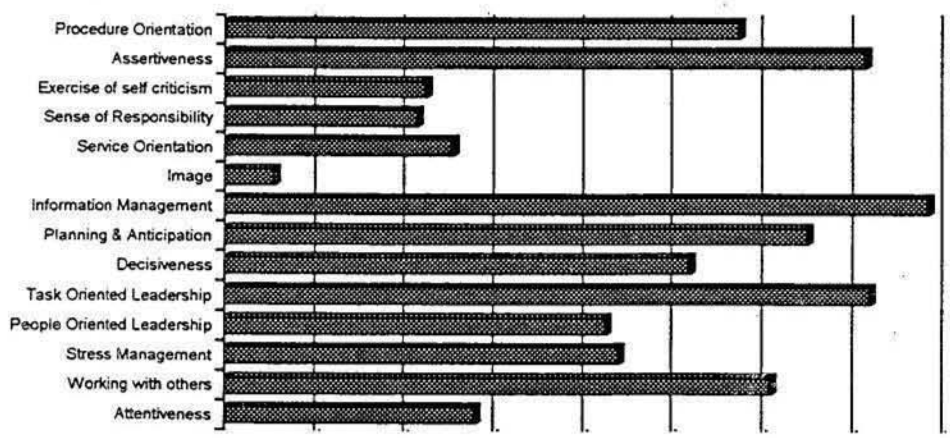
What categories are used during the debriefing?:

Figure 3: What categories are used during the debriefing?

Instructors:



Pilots / Flight Engineers



The responses of the instructors and pilots / flight engineers were more or less the same as expected. All categories were used but the 5 most used categories were:

- procedure orientation
- assertiveness
- information analyses
- planning and anticipation
- and task oriented leadership

and the 5 categories used less:

- exercise of selfcriticism
- sense of responsibility
- service orientation
- image
- and attentiveness.

The explanation can be found in the fact that the 5 less used categories are categories which are more visible during normal line operation and not during a simulator session. This contrasts with the 5 most used categories which are necessary skills to solve abnormals or emergencies trained during simulator LOFT training.

Other questions concerned the quality of the debriefing.

For the instructor:

- Were you able to discuss the items you wanted to debrief?
- and Was FAS a useful tool in this?

Figure 4:
Where you able to discuss the items you wanted to debrief?

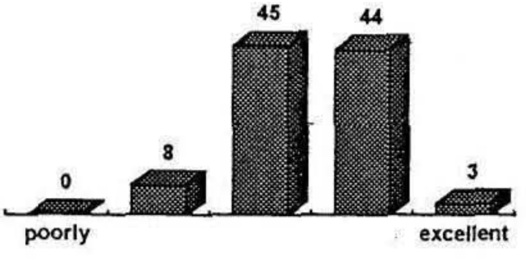
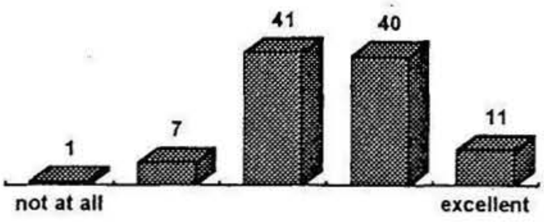


Figure 4 (contd.)

Was FAS a useful tool?



47% of the instructors were able to discuss the items they wanted to in a positive to excellent way. 45% were neutral, which means that there was no difference with the past.

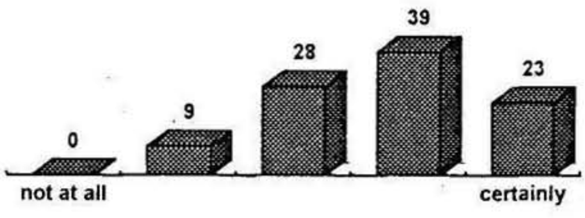
Over 50% was convinced that FAS was a very good tool to help them. 41% were neutral. Further research showed that the main reason for their neutrality was a lack of experience with FAS.

Concerning this subject we asked the pilots/ flight engineers:

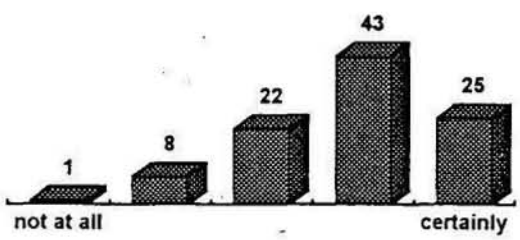
- If the debriefing was clearer because of the use of FAS?
- and if the use of FAS helped them to gain more insight into their performance?

Figure 5:

Was the debriefing clearer because of the use of FAS? (1%: no opinion)



Did the use of FAS helped you to gain more insight into your performance? (1%: no opinion)



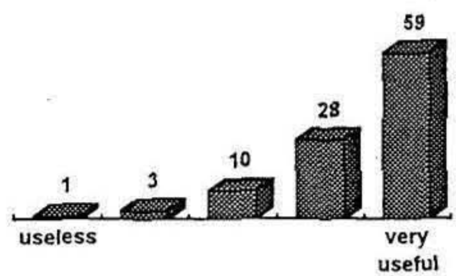
Over 60% of the pilots and flight engineers were of the opinion that the debriefing was more clear because of the use of FAS, 28% was neutral. And almost 70% found that FAS was a good to excellent tool for giving them more insight into their performance.

During the try-out of the Feedback and Appraisal System, we stimulated instructors to use video during the debriefing. 93% of the instructors did so and the pilots and flight engineers were very enthusiastic. 87% were of the opinion that it was very useful.

Figure 6:

To Pilots / Flight Engineers:

What is your opinion about the use of video during the debriefing?



To check the acceptance of the System, we asked the instructors:

- What is your opinion about the use of the FAS as a tool to debrief non-technical skills?

and the pilots and flight engineers:

- If they would recommend the FAS to other colleagues?

Figure 7:

Instructors:

What is your opinion about the use of FAS as a tool to debrief non-technical skills?

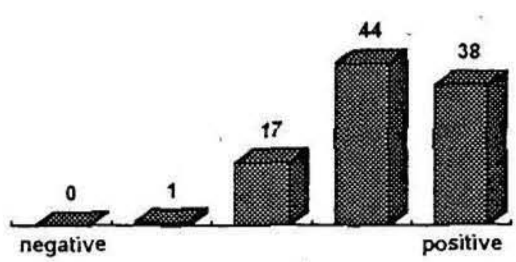
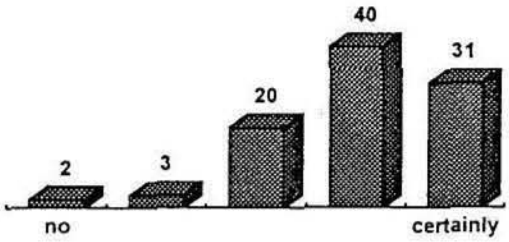


Figure 7 (contd.):

Pilots / Flight Engineers:

Would you recommend the FAS to other colleagues? (3%: no opinion)



99% of the instructors were neutral to very positive toward the use of FAS as a tool. And 71% of the pilots and flight engineers would strongly recommend it to other colleagues, 20% were neutral.

Although these figures are rough indications, they show a clear trend that we are on the right track.

At KLM we have already concluded that the try-out of the Feedback and Appraisal System is a succes, even though the try-out runs to July this year. And we have decided to start implementing the system in our other divisions.

To come back to our main questions:

- Will the system be accepted by instructors as well as pilots and flight engineers?

The answer for the A310 and DC-10 division is **YES**.

- Is the feedback and appraisal system really a helpful tool to assist instructors in coaching the non-technical performance of crew members?

The answer again is **YES**. But experiences of the last few months show that coaching the instructors is very important until the use of the Feedback and Appraisal System has become second nature.

- Is the system complete, are parts missing or superfluous?

We have the idea that, although more research is necessary especially during route training, that **YES**, the system is complete. Some categories are more useful during route instruction on normal flights while others are more important during simulator training.

But what about assessment?

Can the feedback and appraisal system be used to assess non-technical behaviour?

At KLM we think we are on the right track. We believe that we have now developed a very strong tool in training and coaching crews in a structured way. And most important of all, the try-out proves that the system is acceptable. If you want a system to assess non-technical skills then acceptance is an essential condition.

We are convinced that when instructors and crews are used to work with it in training situations, the Feedback and Appraisal System is a strong basis on which non-technical behaviour can be assessed.

Thank you for your attention.

DEVELOPMENT OF HUMAN FACTORS SKILLS AND PROFESSIONAL ATTITUDE OF OPERATIONAL PERSONNEL IN KOREAN AIR TRANSPORT INDUSTRY

April 12, 1993

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Contents

I. Introduction

In accordance with numerous aviation safety reports, more than two-thirds of world aviation accidents in the past were caused by human factor errors.

Therefore, we can not improve aviation safety and reduce aviation accidents effectively without efforts to reduce human factor errors.

Various definitions have been employed in attempts to describe the subject matter of Human factor. One such definition is referred here:

Human factors (or ergonomics) may be defined as the technology concerned to optimize the relationships between people and their activities by the systematic application of the human sciences, integrated within the framework of system engineering.

(Elwyn Edwards:1988)

While quite number of reseaches and analyses on the subject of human factor and flight safety have been presented so far,

very few studies have been made in the East Asian countries including Korea.

The paper briefs the major aviation accidents and their causes during the last 35 years in Korea. The paper discusses the present status of human factors training for operational personnel to improve flight safety by two flag carriers, Korean Air and Asiana. The paper particularly studies whether there should be any different human factors training because of different cultural norms (Oriental culture : Confucianism vs. Western culture : Christianism).

Finally, the paper presents summary of findings and suggestion to develop human factors training in future not only for Korean air transport industry but other countries if applicable.

The study is based on the data from Korean Civil Aviation Bureau (KCAB), the Ministry of Transportation, Korean Air and Asiana Airlines and tentatively verified through the interviews with about 50 officials, instructors, inspectors, pilots and professors who are concerned with flight safety from KCAB, Korean Air, Asiana and Hankuk Aviation University.

II. Review of Past Aviation Accidents in Korea

Total Number of aviation accidents in Korea during the last 35 years are 156 and resulted deaths of 543 persons. Periodical breakdown of the accidents are as follows.

Table 1. Periodical Breakdown of Aviation Accidents

Period	Classification off Accidents				Number of death
	hull losses	substantial damage	significant event	total	
1950s (56-59)	2	-	1	3	-
1960s (60-69)	3	7	28	38	12
1970s (70-79)	5	5	36	46	15
1980s (80-89)	14	13(2)	34	61	514[1)]
1990	1	-	7	8	2
Total	25	25	106	156	543

(Source : Korean Ministry of Transportation)

note 1) Including two case of explosion in the air by KE007 on Sep. 1983 and KE858 on Nov. 29. 1987)

If we analyze above accidents in accordance with the stages of flight, substantial number of accidents are occurred during the stage of landing. Other details are as follows.

Table 2. Analysis of Accidents per Stages of Flight

Period	Number of Accidents	Stages of Flight				Remarks
		Take off	Cruise	Landing	Ground	
1950s (56-59)	3	-	2	1	-	one case of cruise is hijacking
1960s (60-69)	38	3	5	20	10	one case of cruese is hi-jacking
1970s (70-79)	46	7	9	11	19	one case of cruise is hijacking
1980s (80-89)	61	6	21	27	7	two cases of cruise were exploded in air
1990	8	-	1	3	4	
Total	156	16	38	62	40	

(Source : Korean Ministry of Transportation)

If we analyze the accidents by causes, major causes of accident are human factors such as pilots and maintenance persons like the examples of other countries of world total. The detail breakdown are as follows.

Table 3. Aviation Accidents per Causes

Period	Nunber of accidents	Causes of accidents			
		Pilots	maintenance & others	aircraft	hijacking & others
1950s (56-59)	3	2	-	-	1
1960s (60-69)	38	23	8	4	3
1970s (70-79)	46	14	21	8	3
1980s (80-89)	61	44	13	2	2
1990	8	5	2	1	-
Total	156	88	44	15	9

(Source : Korean Ministry of Transportation)

Aviation accidents were increased periodically ; 38 in 1960s, 46 in 1976s and 61 in 1980s. However, if we consider the increased number of aircrafts and flying hours in 1980s, accident rates were decreased.

Table 4. Aviation Acidents and Flying Hours

Period	Aircrafts(as of the end of each decade)	Flying hours(as of the end of each decade)	Number of accidents
1960s	63	28,000	38
1970s	95	99,000	46
1980s	167	186,000	61

(Source : Korean Ministry of Transportation)

Based on data of accidents per stages of flight, 78 of total 156 accidents were occurred during the stages of take-off and landing which is equivalent about 50% of total accidents.

According to the above review of accidents, to reduce human errors, Korean Ministry of Transportation recommended flag carriers to introduce new education systems and to apply them in training flight crews such as CRM(Cockpit Resource Management)and LOFT(Line Oriented Flight Training).
These education systems are characterized as crew interaction, human redundancy, situational awareness, active monitoring, improvement of associated skills. And also working procedures of maintenance personnels should be carefully applied in accordance with the maintenance manuals and bulletins. Effective cooperations and communications between flight crews and air traffic controllers are absolutely required and so institutionally supported. In the long run, government and industry management should pay keen attentions to train sufficient pilots and other aviation specialists.

III. Present efforts to develop human factors skills and attitude relevant to flight safety of professional operational personnel in Korean air transport industry

To reduce human factor errors, various measures including CRM seminar, LOFT, lectures and regular meetings of instructors and etc. are presently undertaken by two Korean flag carriers, Korean Air and Asiana (started 5 years ago).

In this section, Korean Air CRM training program is introduced with the summary of their report as the most successful and representative model in Korean air transport industry.

1. Foreword

Korea Air has conducted cockpit resource management seminar for their flight crews for the purpose of minimizing the possibility of aircraft accidents. The seminar contributed greatly to minimizing the possibility of aircraft accidents caused by human error, therby achieving greater safety in flight operations.

This CRM seminar program was originally developed by United Airlines and Scientific Methods, Inc. and applied to Korean Air.

2. Main discourse

1). The composition of this program and background

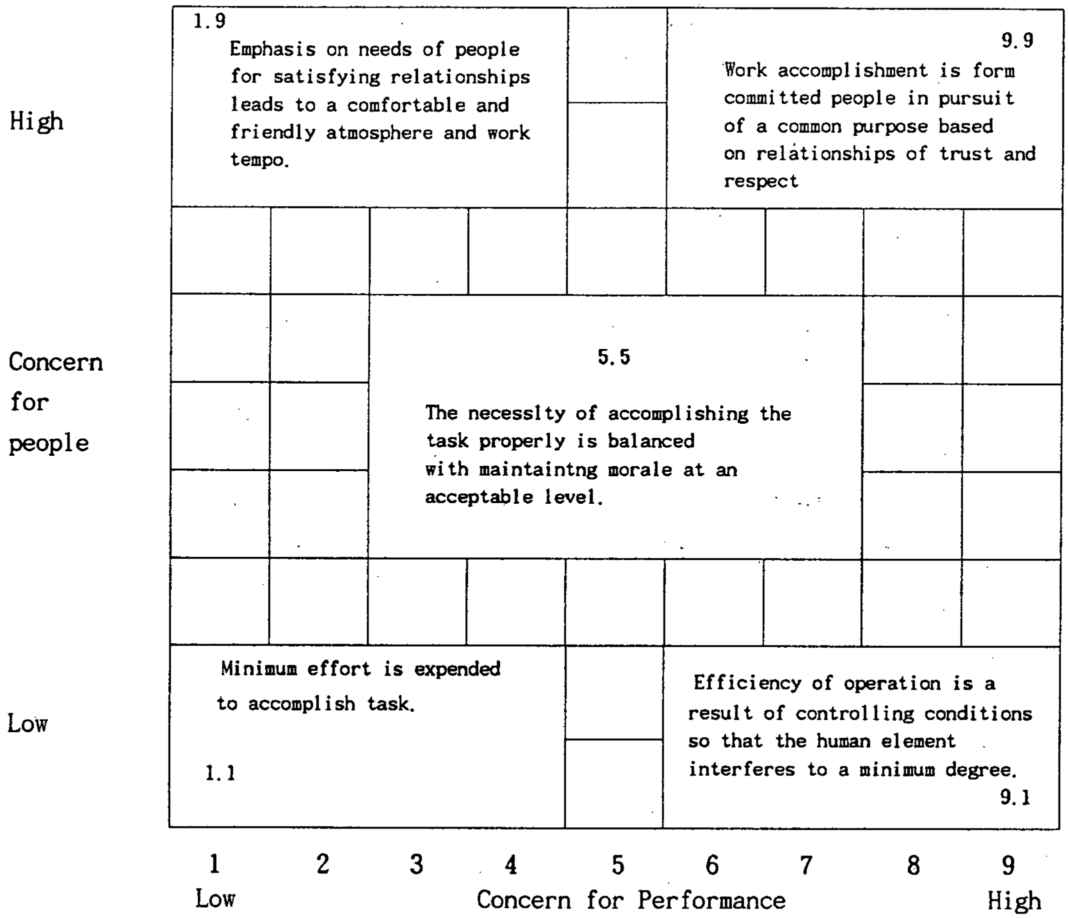
As sound aircraft operation is the process of working effectively with and through people to achieve high quality performance, the participants in this seminar learn to work as a team in order to study performance. This requires that members learn to contribute and commit themselves to achieving as much as they are capable of doing. CRM seminars promote learning and development and deal with several tasks which provide participants the opportunity to learn leadership concepts and styles. The period of each seminar is 4 days, This study is the result of 288 participants who completed the seminar course.

2). The concept of grid style and classification

The grid is a frame of reference providing a basis for understanding differences between people and a means of comprehending how and why individuals behave as they do in the performance of their jobs.

There are two basic dimensions in the framework : concern for performance, and concern for people.

Table 5. Frame of Grid Style



(Source : Korean Air)

There are 5 styles relating to the management of performance and people ; The 1.1, 1.9, 9.1, 5.5, and 9.9 styles. The characteristics of each grid style is described above.

3). Task Objectives in the seminars and their results

(1) Analysis of personal grid styles

The goal of this task is to use the grid as a framework in assisting each person to gain insight into personal behavior which can influence effectiveness as a crewmember. The resusts were as follows :

Table 6. Comparison of Grid Style between Pre-Seminar and Post-Seminar

UNIT: %

	GRID STYLE				
	9.9	9.1	5.5	1.9	1.1
PRE-SEMINAR	73	4	14	6	3
POST-SEMINAR	28	23	33	14	2

(Source : Korean Air)

This figure indicates that the majority(73%) of the participants belived themselves to be 9.9 style before the seminar. But after the seminar, only 28% of the participants evaulated themselves as 9.9 style.

(2) A comparison study of performance values.

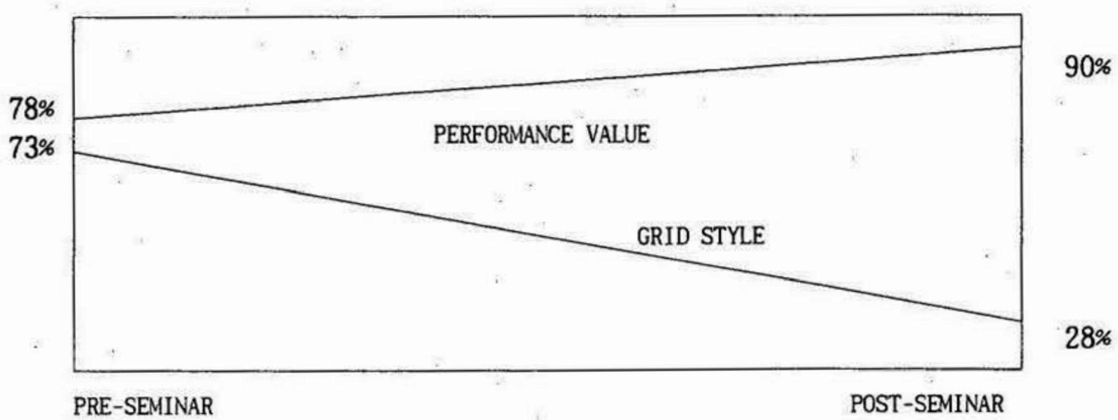
The goal of this task is to reexamine the performance values they hold now and compare them with the values they held prior to the seminar.

Before the seminar, 78% of the participants belived that they should manage their cockpit in 9.9 style. But after the seminar, the percentage shifted up to 90%.

(3) Perception of a gap

We can chart a comparision of the results.

Table 7. Perception of Gap between Pre-Seminar and Post-Seminar



They found the results to be significant. As you can see, the 9.9 performance values shift upward (78% → 90%) : Further away from what the flight crews consider to be their own behavior. This "TWO-WAY" shift indicates a greater perception of the gap between current style and desired performance value. And thus, a greater readiness to the implications of the results and begin moving behavior toward desired performance.

3. Evaluation

Flight crew effectiveness increases through greater teamwork and cooperation. The Korean Air experience with CRM seminars demonstrates that participants increase their self-awareness of current behavioral style compared to desired performance. It is this awareness that leads to changes in behavior, and thus, increased flight crew effectiveness. The goal of increasing flight safety by reducing human error is thereby achieved.

The participants evaluation of this seminar was expressed as " FULLY REWARDING ".

Korean Air has conducted 40 times of this CRM training course since December 1986 and completed for 750 crew members which is equivalant about 90% of total crew members. Korean Air has aleady started Line Oriented Flight Training(LOFT) through regular simulator training for those who completed the above CRM training from July 1992.

Asiana as the newly established airline has not started the CRM training and LOFT yet but is strongly suggested to follow the above Korea Air's program and practice in near future.

IV. Particular considerations to be given in human factor training in the Oriental culture society (influenced by Confucianism)

Confucianism is a philosophy based on the ideas of the Chinese philosopher Confucius. It originated about 500 B.C. From the 100's B.C. to the A.D. 1990's, Confucianism was the most important single force in Chinese life and also the lives of nearby countries(such as Korea, Japan and Vietnam).

It influenced their education, government, and attitudes toward correct personal behavior and the individuals' duty to society. Confucianism can more accurately be considered a guide to morality and good government.

Confucius believed his society could be saved if it emphasized sincerety in personal and public conduct. Confucius defined a gentleman not as a person of noble birth but as one of good moral character.

A gentleman was truly reverent in worship and sincerely respected his father and his ruler. He was expected to think for himself, guided by definite rulers of conduct.

Confucius believed that when gentleman were rulers, their moral example would inspire those beneath them to lead good lives. Virtuous behavior by rulers, he declared, had a greater effect in governing than did laws and codes of punishment.

Like thus, Confucianism emphasized sincerety in personal and public conduct, a gentleman of good moral character, respect to his father and his rulers, and particularly virtuous behavior by rulers rather than the laws and codes of punishment.

Then the question is what are the particular considerations to be given in human factor training in these Oriental culture society and if it is necessary.

A tentative finding is that we have to consider some particular factors in human factor training in these different culture society.

Through the interviews with the representative officials, professors, instructors, inspectors and pilots who are concerned in flight safety, the major common factors to be given particular considerations in human factor training are as follows.

First, Leadership, morality and quality of captain as crew team leader (ruler) is required.

Second, Team work and coordination among cockpit crew members are to be stressed. (Particularly for those with long military background)

Third, Personal relationship among cockpit crew members (based on education, training background, military experience : airforce, navy or military, native region, nationality, religion and etc.) is still one of important factors. The more homogeneous background of cockpit crew members gives the more positive effect in flight safety than the relatively heterogeneous background of cockpit crew members.

Fourth, Duty, responsibility and royalty to the organization of crew members are to be stressed.

Fifth, Understanding, cooperation and assistance of management and other departments for the promotion of flight safety are absolutely necessary.

Sixth, Flight accident investigation should be done primarily for the prevention of further accident and for the promotion of the flight safety rather than for the punishment of flight crews. Otherwise flight crews may not report full details of their errors or failures to protect themselves and it may result another accident.

The preliminary research demonstrates as follows :

(1) human factors (of personal and morale character) are stronger in the Oriental society of Confucianism than in the Western society of Christianism.

(2) The qualification of captain as team leader is the most imporant factor contributing to flight safety.

(3) To improve effective teamwork and coordination of cockpit crews which is also important factor in flight safety, personal relationship among crew members based on educational background (schools), military

experiences, native places, seniority and etc. should be also carefully considered.

(4) Understanding, positive cooperation and assistance of the managemant for the promotion of flight safety are very important and absolutely necessary.

V. Conclusion

This section presents summary of discussions and suggestions for future development of human factors training and promotion of flight safety in Korea.

In accordance with the review of the past accidents in Korea, major causes of accidents are human factors such as pilots and maintenance persons like the examples of other countries, and about 50% of total accidents were occurred during the stages of take-off and landing. Therefore, to reduce human errors, it is necessary to develop human factors skills and professional attitude of operationl personnel in Korean air transport industry.

To reduce human factor errors, two Korean flag carriers, Korean Air and Asiana, perform various measures including CRM seminar, LOFT, lectures, regular meetings of instructors and etc. Korean Air CRM training program is the most successful model in Korean air transport industry, Asiana as the young airline is suggested to apply this model.

Regarding the question whether particular considerations to be given in human factor training in these Oriental culture society, a tentative finding is that we have to consider some particular factors in human factor training in Korea as one of Orient culture society. However, this proposition and finding should be studied and tested further not only in Korea but in other Oriental society of Confucianism such as China, Japan and Vietnam.

In addition, government and industry management should pay keen attention and cooperate to train sufficient pilots and other aviation specialists in future. Effective cooperation and communication between flight crews and air traffic controllers also are absolutely required.

To prevent accidents caused by environmental factors, Korean government has to modernize airport facilities (including microwave landing system : MLS) up to the level of category II and category III and be well prepared with emergency procedures against bad weather (such as wind shear). In this sense, it is proper and urgently necessary for Korean government to build New Seoul Metropolitan Airport which is completed around the end of 1997.

Finally, they have to establish new permanent organization of aviation accidents investigation committee within the Ministry of Transportation with full-time experts and investigators to promote safety and prevent accidents in advance.

The committee members are to be composed of exports in aviation accidents investigation from the govermenrt, academic institution, industry. The committee also will study and introduce system and procedures of other advanced countries in civil aviation. In general, Korean government organization in civil aviation is needed to be promoted and enlarged to manage effectively and to cope with ever increasing demand and volume of domestic and international air transportation.

References

Civil Aviation Bureau, Ministery of Transportation, Civil Aviation in Korea, 1992. Seoul

Gyo-Tong Shin Mun Sa, Gyo-Tong Nyun Gam (Traffic Annual) (1990 - 1992), Seoul, Korea

Hong, Soon-Kil, International Aviation in the Changing Global Order. Hankuk Aviation University Press 1992, Seoul

Hong, Soon-kil, Aviation Policy-Making in Korea, Hankuk, Aviation University Press, 1990, Korea

Korean Air, Flight Safety (1990.1 - 1993.2), Seoul

Lee, Tae-Won, Modern Air Transportantion, (Korean) 1991, Seoul Computer Press, Korea

Wiener Earl L. & Nagel, David C. eds, Human Factors in Aviation, Academic Press, New York, 1988

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AIM, AIRCREW INTEGRATED MANAGEMENT

A MANUFACTURER'S EXPERIENCE IN CREW RESOURCE MANAGEMENT

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I- General

For Airbus Industrie and Aeroformation, since the beginning of the launching of the first Airbus, the paramount idea has been to obtain the best safety.

To do so, we have obviously used all the tools given by the technology, and also from the first transition courses given in 1972 with the first Airbus A300, we tried to integrate as much as possible, the Human Factors aspects within the technical ones.

In this context we decided to do again better in 1990, and to introduce in our transition courses, a Crew Resource Management module.

Our CRM course is named AIM, Aircrew Integrated Management, as it is fully integrated within the technical training of the transition course for crew members, throughout the five weeks they spend in our center.

In this paper, we will describe :

- the evolution of our concepts of Human factors throughout the years

- the process of implementation of this course, that has been a joint effort between Flight Safety International and Aeroformation

- the content of the course

- the feedback from the trainees and the impact of AIM on the results at the end of the transition course

- the analysis of the survey conducted with the help of the University of Texas (CMAQ = Cockpit Management Attitude Questionnaire)

- the projects of extension of AIM to the other categories of trainees.

2 - Human Factors in Aeroformation's transition courses

As we said previously, even before the implementation of our A.I.M. course, the Human Factors aspects and the cockpit resource management concepts, were taken in account in all our flight crew transition courses.

First, in the general philosophy of this course, explained to trainees in the Flight Crew Training Manual, F.C.T.M., we can read that "since crew members are bound to work together in an aircraft, the crew is considered as a unit as far as training in procedures an aircraft handling is concerned."

Then before trainees begin to learn the details of the systems they are provided with general information (concept, philosophy) regarding the fly by wire, the F.M.G.S., the E.C.A.M., and a chapter is specially devoted to the two crew member philosophy. In this chapter we can note the following points, very important in the cockpit resource management training :

- two crew member operations imply :

  . crew communication : reduction of non pertinent calls, use of standard phraseology, ability to be brief and succinct, good cockpit resource management

  . crew coordination : strict adherence to procedures (normal, abnormal, emergency) ; any deviation from these procedures should be avoided. If a deviation is thought to be needed due to special circumstances, this must be announced in advance; If time permits, a specific briefing must be made so that both pilots are aware of what is planned.

  . cross check : each pilot must know the intentions of the other

  . discipline : procedures and task sharing as defined in the official documents must be strictly followed

- the application of these principles to normal-abnormal/emergency procedures is then emphasized, for instance :

  . normal procedures : selections and actions made by one pilot are always checked by the other pilot independently of their P.F. or P.N.F. role at the moment.
  the autopilot must never be considered as a pilot at all times basic flight parameters must be monitored by the P.F.

Examples are given.

  . abnormal/emergency procedures : do not rush

  correct identification of failure by the crew

  request for appropriate E.C.A.M. actions or paper check list

  no irreversible action must be accomplished without a positive cross check and approval by both pilots

- the Captain will decide who will be the P.F. for the subsequent anormal/emergency procedure. He must clearly inform the First Officer of his decision by saying "I have control" or "you have control". If he says "you have control" he must immediately give also instructions concerning the desired flight path.

- throughout the Fixed Base Simulator (F.B.S.) and Full Flight Simulator (F.F.S.) sessions, the instructors check that trainees apply these concepts, and moreover in certain exercices like precision approaches (Cat II and Cat III), they check that the process of challenge-response very clearly and precisely written in the procedures, is strictly respected.

3 - Implementation of AIM

. AIM design process

The AIM program was designed through a cooperative effort between Aeroformation and FlightSafety International. Each brought important and unique experience to the process. Aeroformation contributed its broad expertise with the A320 and other Airbus aircraft and its experience in training Airbus flight crews. FlightSafety contributed its considerable experience in cockpit resource management and flight crew training.

The AIM program is based on a two-day CRM workshop which has been used successfully by FlightSafety for several years. The two-day course was then highly modified to customize it to the specific requirements of Aeroformation's training philosophy.

After careful analysis, it was decided that AIM should be composed of three distinct elements.

The first is a one-day AIM workshop. This course occurs immediately prior to beginning A320 VACBI training. It is a highly interactive format that relies heavily on discussion, exercises and group activity rather than lecture. The workshop will be described in more detail shortly.

The second two elements reflect the importance of integrating human factors considerations into the normal technical training curriculum. As a result, five sessions in FBS-B and three sessions during FFS training include dedicated AIM training activity.

. Facilitator training

The one-day AIM workshop is conducted by a group of twelve Aeroformation staff. These people are called AIM facilitators, rather than instructors, to represent the unique style of training used in an AIM workshop.

Facilitator training was accomplished in two distinct, but related phases. During phase I, each facilitator participated in ten days of training allowing them to become thoroughly familiar with the concepts and instructing techniques used in CRM type training programs. During phase I, each facilitator received initial CRM training and then began the process of becoming a qualified facilitator. They also provided valuable input to the AIM course structure which was undergoing final design.

Phase II of facilitator training accomplished final qualification as an AIM facilitator. During this phase, each facilitator became an expert in all elements of the Aeroformation AIM course. This phase involved sixteen days of training which ultimately led to full qualification of each facilitator.

. Instructor training

The unique feature of AIM is the integration of human factors training with technical training. This is accomplished during eight specific FBS-B and FFS training sessions. Accordingly, it was necessary to train simulator and flight instructors in AIM and their unique role in providing this training to Aeroformation pilot trainees.

Instructor training was accomplished in two phases, similar to the fashion of the facilitators.

In phase I, each Aeroformation instructor received three more days of training. This included a two-day CRM course followed by a briefing on the AIM project and the instructors' role in AIM training.

Approximately four months later, each instructor received three more days of training. This included the one-day AIM workshop followed by a special two-day instructor course. At the session, instructors were taught how to brief, observe, evaluate and debrief AIM performance during FBS-B and FFS sessions. At the conclusion of the training, each instructor was able to demonstrate their ability to use this material in training.

. Design process : Summary

The AIM design program began in July, 1990 with the final course being delivered in January 1991. In January thru March, 1991, all Aeroformation instructors were trained and the customer training began in April 1991. AIM training at the Airbus Training Center in Miami began in October, 1991.

4 - Content of AIM course

4.1 General

As we said previously the program designed to be fully integrated into the Airbus transition training program includes a one day workshop followed by emphasis on AIM techniques during FBS and FFS training.

Several concepts are studied, but as we think that an effective cockpit management results in a high level of flight crew situational awareness, this concept is the key theme of AIM.

But we don't want just to give theoretical concepts and AIM is designed to be a practical training, focused on skills and tools that can be used in the cockpit, so all the ideas learned will be applied by the trainees during the simulator session.

4.2 One day workshop

This workshop features short lectures, many facilitators and participants-led discussions, problem solving exercises, case studies of actual accidents, and a series of three constructive videos to illustrate Human Factors behaviour taught during the workshop. This workshop is a very dynamic, ever expanding program for both the participants and the facilitators.

The studied concepts are :

- Situational Awareness	(lecture, Slides)
- Error chain	(Idem)
- Error chain	(Exercise)
- Communication	(Idem)
- Communication skills	(lecture)
- Barriers to communicate	(Exercise)
- Synergy and crew concept	(Lecture)
- Synergy	(Exercise)
- Accident case studies	Exercise, video)
- Cockpit behavior	(3 parts video)

Before the workshop begins, the trainees are asked to fill a survey related to a NASA/University of Texas study, about cockpit behavior (CMAQ : Cockpit Management Attitude Questionnaire). The same questionnaire is filled at the end of the transition course, at FFS6, so that it is possible to measure the change in behavior due to this training. This study is a worlwide one, and U.T. provides us with our own results compared to chose of the rest of the aeronautical community. It is a powerful tool to improve our course.
A summary of the first results of this survey is given in chapter 6.

At the end of the day facilitators make a summary of the day and receive the comments from the trainees that are used, if necessary, to modify and improve our course through the annual revisions.

4.3 Simulator sessions

During 5 FBS and 3 FFS sessions, the simulator instructors, that have also been specially trained for that, reinforce some of the concept studied in the workshop and introduce other ones :

Reinforcement :	Situational awareness/Error chain
	Communication
	Synergy and crew concept
New :	Workload management/Task sharing
	Briefings
	Reliance on automation
	Decision making (plus an exercise)
	Stress

The concepts are developed in the briefing, and at the debriefing the instructor makes comments about the behavior of the crew during the session, related to this concept or to any AIM subject.

In our AIRBUS FFS are video camera allowing to record some parts of the session, and all the briefing rooms are equipped with video feeback system ; so the trainees may have a self debriefing of what they done.

This equipment is only used with the agreement of the crew and at the end of the debriefing the tape is erased in front of them.
At the end of FBS/14 the trainees are asked to fill a situational awareness plan, that they will try to implement during the FFS sessions.

At the end of FFS 6 they fill the CMAQ questionnaire, plus a short one precisely directed to AIM, rating the value of the different lectures and exercises, so that we can have a tool to improve our course.

4.4 Documentation

The trainees are provided with a complete documentation :

- AIM trainee guide ;

In this guide they find copies of all the flip charts and slides presented during the workshop, and of the flip charts used during the simulator sessions. They have room to put all the handouts given at the welcome or during the workshop.

- Practical cockpit management

In this book they find a summary of all the different studied concepts, articles from aeronautical reviews and extracts of communications in various seminars, related to these concepts.

- AIM check list

The trainees are provided with a Human Factors check list, Jeppesen size, that summarizes the main concepts of AIM, and that they can use in their cockpit if they wish.
This check list enlarged as a poster, is on the walls of each briefing room.

5 - Impact of AIM

5.1 At the last FFS session (FFS 6, just before the evaluation at FFS 7) trainees respond to a survey of 21 questions, allowing us to know what they think of the course and of the various items that form it.

The result of this survey keeps evolving, as each week we add data from a course of 10 pilots.

Up to now the main results are very good and very encouraging.

For instance at the question "Overall, how useful did you find this training" (one day workshop plus simulator briefings), nobody responds "waste of time" or "slightly useful", only 5.3 % respond "somewhat useful", and 57.9 % respond "very useful", and 36.8 % respond "extremely useful".)

The average rating of the items of the one day workshop and of the briefings during simulator sessions, is also very good, with often a better rating for the second than for the first ones. That shows that the idea to divide the course in two parts, and to use the simulator sessions to review concepts or introduce new ones, was a good one.

The results are as follows, with first the percentage for the one day workshop, and second the percentage for the briefings sessions :

Waste of time	1,1	0,8
Slightly useful	7,3	1,6
Somewhat useful	30,3	19,2
Very useful	38	46,4
Extremely useful	23	32

When we compare all these results to those of other CRM courses existing all around the world (by reading press articles or communications made in symposiums or seminars), we understand that our course is very well received by our trainees and highly rated by them.

For instance, in a communication of the ICAO seminar of Leningrad in April 1990, we note that for the question "Overall how useful did you find this training" for two airlines there was 2 % "waste of time", 5 % "slightly useful", 25 % "somewhat useful", 48 % "very useful", and 21 % "extremely useful", compared to us at 0 - 0 - 5.3 - 57.9 and 36.8 %.

5.2 Our simulator instructors and training Captains really see a very positive difference in behavior between the trainees having attended AIM and those not having done so. There is a better communication between the crew members, a better crew coordination, and so on, and the success at the first check is increased. The trainees say that applying the concepts of AIM during their training sessions is a powerful help that they appreciate very much.

5.3 Also, a great sign of interest of our customers for this course, is that several airlines have asked to us to extend this course, given up to now to their crews coming to Aeroformation, to the other pilots having been trained before the implementation of AIM or being trained in the airline itself.
Another interesting feedback is that the pilots of the airlines having a CRM course in house, find that AIM is very powerful as a recurrent or refresher training.

6 - Results of CMAQ (Cockpit Management Attitudes Questionnaire)

6.1 Aeroformation works with a team of researchers from NASA/University of Texas, directed by professor Robert HELMREICH and doctor John WILHELM, on a study related to the effectiveness of all of CRM courses, and based on the use of the CMAQ (Cockpit Management Attitudes Questionnaire).

The results given here are related to 44 courses, concerning 346 trainees, going from April 1991 to April 1992.

The NASA/UT's report underlines that AIM "is a unique approach which combines Human Factors and Technical Training into the initial and upgrade curriculum". It adds that "since integrated CRM training will become mandatory for air carriers and training centers opting to accomplish training under the FAA's Advanced Qualification Program, results obtained from this program (AIM) will be particularly interesting".

6.2 Generally speaking, AIM training is very well received ; the majority of our trainees responded to the question "How useful did you find the training ?" by choosing the "Very Useful" response. (Figure 1). The average rating of this item is 4,05 of a possible 5, and this can be equated with a global "Very Useful" response.

Rating of the utility of AIM for other crew members were similar to the rating cited above (Figure 2).

6.3 On figure 3 we see that almost 75 % of our trainees choose "Agree strongly" when asked to judge the statement "CRM training has the potential to increase safety and crew effectiveness".

Nevertheless we have a very small percentage (< 1 %) of "Disagree strongly" ; we don't know if it is related to the well known "Boomerang effect", but anyway it is far less than the usual percentage of this boomerang effect, that is of around 4 %.

Concerning the expected change of behaviour on the flight deck, Figure 4 shows that the biggest part is devoted to a "Moderate change" (35 %) and "Flight Change" (32 %), and this is normal for the first exposure to a CRM course ; anyway nearly 21 % expect a "Large Change" and this is very encouraging.

6.4 We can see on Figure 5 that a statistically significant attitude change is noted for the "Communication and Coordination" scale, in the positive direction, indicating improved attitudes about communication and coordination of activities between crew members after AIM training. This can be linked-up to the observations made by our instructors and our check-pilots (§ 5.2)

6.5 There is a large and statiscally significant change in attitudes taped by the "Reliance on automation" scale (Figure 6), and this reflects a good feeling about the airplane due to the transition course training. It is not at all an overconfidence or overreliance on automation, as we can see on the next figures :

- Figure 7 : "When using cockpit automation it is less important to double check crew member inputs automation", 85 % of trainees disagree strongly

- Figure 8 : "Increased automation reduces the need for crew communication" 75 % of trainees disagree strongly.

- Figure 9 : "Automatic protections reduce the requirement for crew members to monitor systems and flight status", 80 % of trainees disagree strongly

So, all that shows that pilots are confident in the use of the automation, but are vigilant in its use by the application of the rules teached during their transition training, that we could summarize by the well known concept "Trust but verify".

7 - Extension of AIM

At the beginning, in order to fine tune it and to test its effects, AIM has only been provided to A320 crew members in transition training, from April 1991. In September 1992 we began to extend this training to A340 pilots, and in early 1993 we also will extend it to A310 crew members, than later to A330, A321, A319, etc....

We are studying the feasability to implement a Human Factors course for maintenance people, but it is a more difficult question as the background of maintenance people varies widely from one category to the other, and as the duration of their stay in the training center is very different from one course to another. Anyway we work on this subject and we hope to implement such a module, next year.

Finally we will try also to develop a human factors module for flight attendants, as they contribute with the technical crew, to the safety of the flight ; for instance, for them, a very good communication and coordination with the cockpit is of a paramount importance in case of an emergency.

8 - Conclusion

Our AIM program is now in service for two years, and we are very happy of the results obtained, visible through the data reduction of the questionnaires filled by the trainees, and also through the better results in the check sessions. This course is evolving due to the feedback and comments of trainees, facilitators, instructors, and the Revision 1 is now implemented. We are sure that with this program we have brought a good contribution to the level of safety in the Airline pilots work.

OVERALL ATTITUDE CHANGE ON THE CMAQ "RELIANCE ON AUTOMATION" SCALE

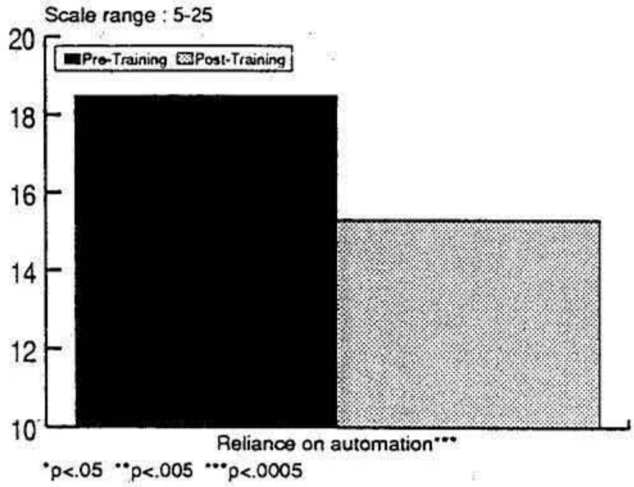


Fig. 6

POST-CRM RESPONSES TO THE ITEM : 4. WHEN USING COCKPIT AUTO., IT IS LESS IMPT. TO DOUBLE CHECK CREWMEMBER INPUTS

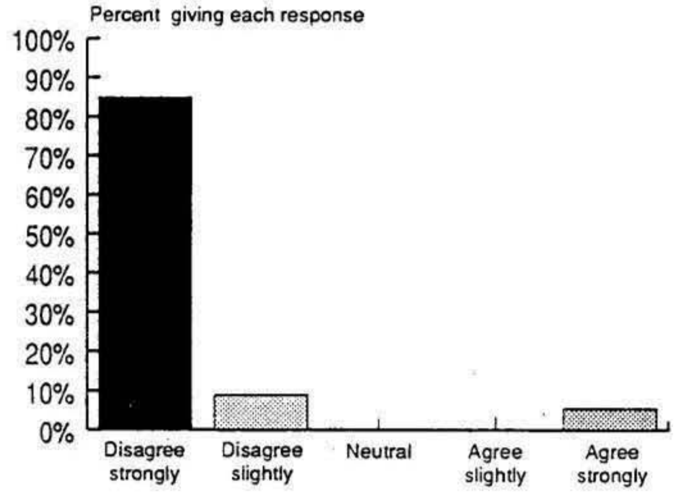


Fig. 7

POST-CRM RESPONSES TO THE ITEM : 5. INCREASED AUTOMATION REDUCES THE NEED FOR CREW COMMUNICATIONS

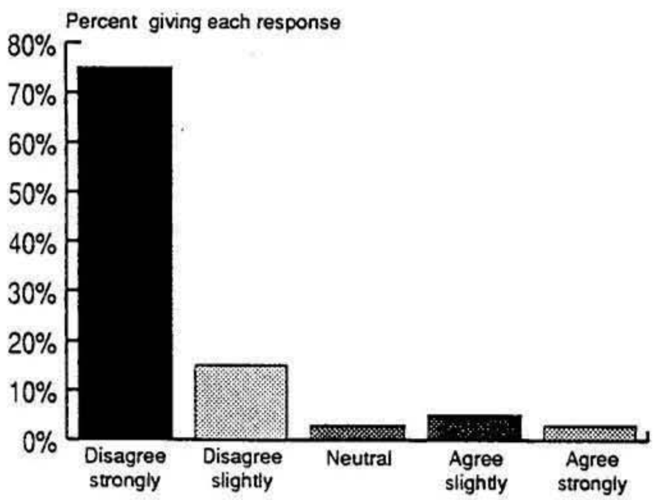


Fig. 8

POST-CRM RESPONSES TO THE ITEM : 20. AUTO. PROTECTIONS REDUCE THE REQ FOR CREWMEMBERS TO MONITOR SYS AND FLT STAT

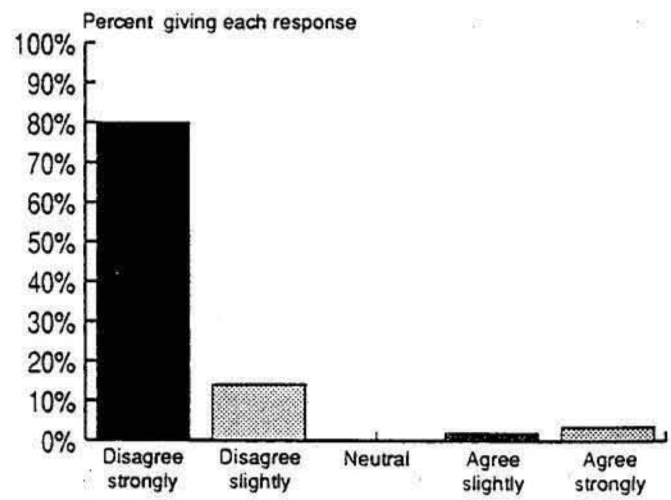
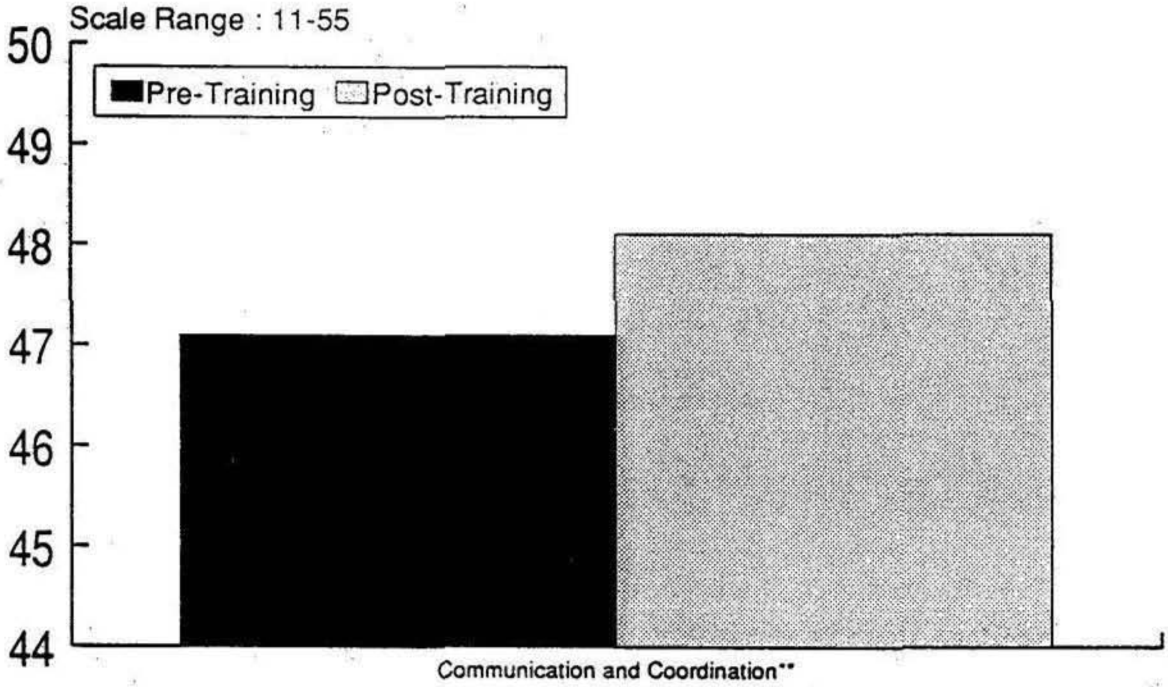


Fig. 9

OVERALL ATTITUDE CHANGE ON THE CMAQ "COMMUNICATION AND COORDINATION" SCALE



pre-post attitude change **p<.005

Fig. 5

OVERALL, HOW USEFUL DID YOU FIND THIS TRAINING?

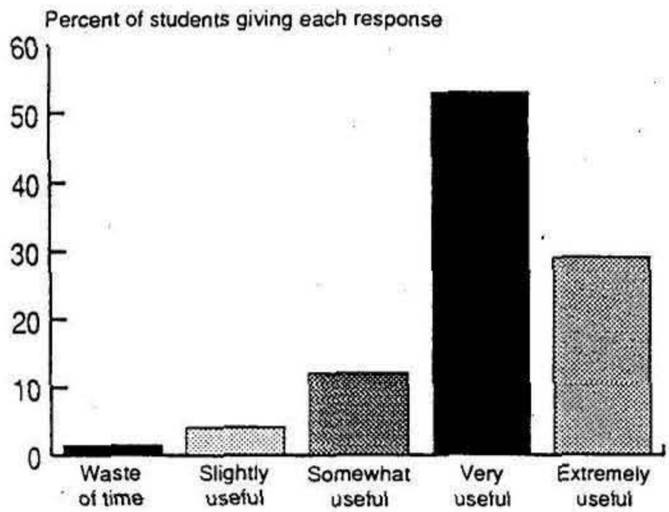


Fig.1

HOW USEFUL WILL SUCH TRAINING BE FOR OTHER CREW MEMBERS?

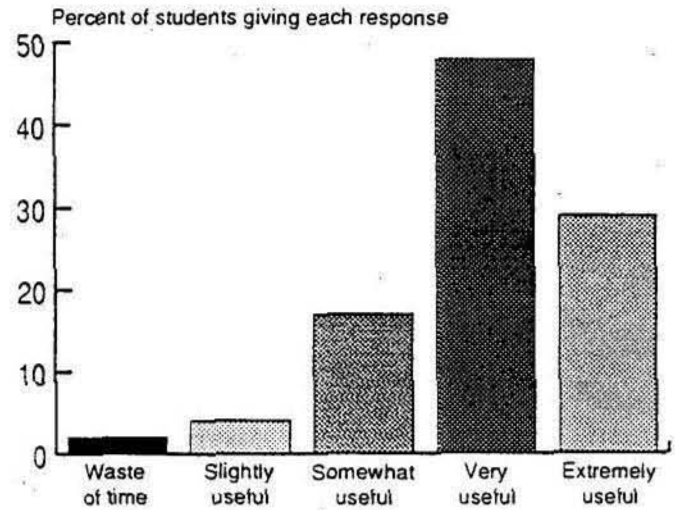


Fig.2

CRM TRAINING HAS THE POTENTIAL TO INCREASE SAFETY AND CREW EFFECTIVENESS

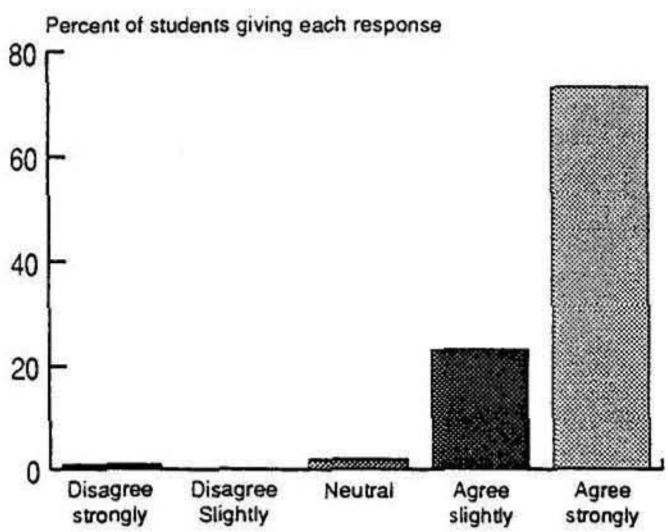


Fig.3

IS THE TRAINING GOING TO CHANGE YOUR BEHAVIOR ON THE FLIGHTDECK?

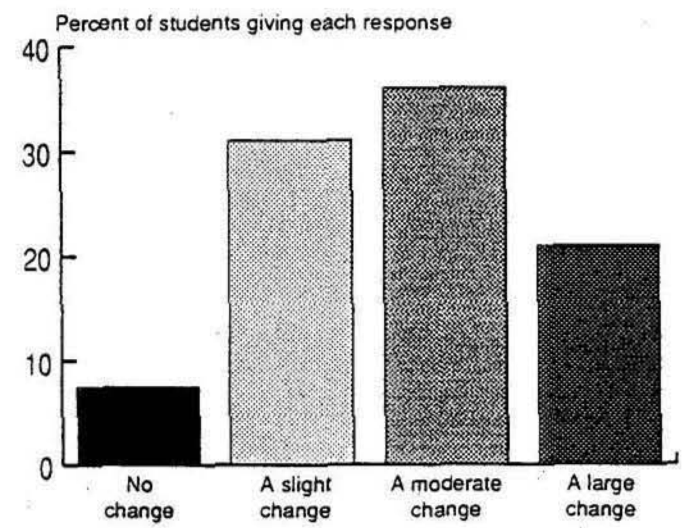


Fig.4

A HUMAN FACTORS COMMITTEE

by

Captain Flemming Kirkegaard
Chairman Human Factors Committee

Danish Civil Aviation Administration

To combat and to gain victory over human factors in aircraft accidents and incidents is like attacking a many-headed monster. Cut off one head and it grows out again in a new shape. Throughout the last four decades barely no reduction in the relative percentage of human factors caused accidents in air traffic has been recorded despite much effort.

The weapon to defeat accidents caused by human factors has yet to be designed, and if designed yet to be recognized and understood by its potential users.
We compliment all dedicated to the task of trying to reduce human factors caused accidents, but especially ICAO for its strong leadership in this field during the last decade.

I speak on behalf of the Danish Civil Aviation Administration (DCAA), Human Factors Committee (HFC). A committee which is appointed by the Director Aviation Inspection Department (Director AID) and which has 5 members.

The purpose of the HFC is to propose initiatives for the DCAA to reduce and prevent aircraft accidents caused by human factors. Initiatives which in a clear manner can be communicated to all involved. It is our belief, that a strong interplay between regulatory agencies and operators is required. We believe in the necessity to influence topmanagement to recognize human factors as a major target in the accident prevention efforts.

Sharing our experience

There are two reasons for our wish to present a paper at this symposium.
One reason is to inform the audience of the DCAA, HFC which we believe could be a model for smaller states. We have found our set-up encouraging. The other reason is to present an example of our work. An example which we feel quite strongly about and the conclusions of which we are assured will constitute a strong defence against the most often recorded cause factor in aircraft accidents: Deviation from Standard Operating Procedures (SOP). We have a very strong wish to share our experience with you and we hope that this experience somehow will be beneficial to the aviation society.

Aviation in Denmark

The flagcarrier in Denmark is Scandinavian Airlines System, SAS, a major international airline which also has Norway and Sweden as shareholders. In addition there are three major charteroperators, a number of commuters and general aviation companies. The total number of aircraft movements at Danish airports, including Greenland and the Faroe Islands amounts to 640.000 a year (1991). All operators perform flight safety work either through specialized functions or through appointed individuals. At higher levels the DCAA and the Aircraft Accident Investigation Board carry out flight safety work in the traditional manner.

No operator has a specialized human factors function as such or anyone specifically assigned to this area.

Civil Aviation Authorities and Human Factors

A few words on history.

A number of years ago the DCAA realized that it might be beneficial to look at flight safety more specifically than through regulations alone.
The DCAA therefore established a HFC drawing upon the expertise of persons from various parts of the aviation industry.

Through some years this HFC discussed a wide variety of subjects, but only in a few cases provided advice to the DCAA.

Generally the conclusions on a given subject were in those days insufficiently structured. An important reason for not fulfilling its own ambitions was that the HFC had the opinion that all conclusions had to be extensively documented and anchored in the existing regulations instead of simply being well argumented. This opinion sealed off the HFC from the outside world.

Thus the work of the HFC went more or less unnoticed. Despite this the members still maintained a fairly high spirit.

The Human Factors Committee of Today

It is a wellknown fact that the right crewcomposition is of paramount importance to mission effectiveness. And that teamwork is to pull in the same direction. And at the same time.

This was very clearly demonstrated approximately 4 years ago when the HFC was reformed and at the same time an additional new member was appointed. This caused an immediate and remarkable effect on the performance and the quality of the output from the HFC. More or less simultaneously a new Director AID was appointed. This director immediately realized the potential of the HFC. He showed interest in the work of the committee. What better motivation factor can be found?

The synergy effect was very strong.

The HFC really took off!

Composition of the Human Factors Committee

The HFC of today is composed of the following members:

- A captain representing the flight operations managers of all scheduled/nonscheduled operators in Denmark.

- A captain representing all pilot union organisations in Denmark.
- A senior aviation psychologist.
- A highranking administrator from the DCAA.
- The Head of the independant National Aircraft Accident Investigation Board.

No status is demonstrated in the sequencing. Everybody is of equal voice.

The operational expertise of the HFC is encompassing.

It has been demonstrated that the composition of the HFC is wise. Together the knowledge-bank of the members covers most of the aviation fields. They have at their disposal in the DCAA the required expertise in the field of aviation medicine.

The traditional, in Scandinavia at least, scepticism between the employer and the employee, has never been an issue as both parties are represented and are locked together in a common interest.

The HFC is advisor to the Director AID.

It is very important to emphasize that the HFC has an advisory role only and no authority except where specifically given by the Director AID.

Terms of Reference

1. To stay informed and in touch with developments and trends in the human factors fields in aviation.
2. To advice the Director AID on any issue in the human factors field which has or might have a bearing on flight safety.
3. To give priority to tasks concluded and to forward recommendation for action to the Director AID.
4. To conclude tasks appointed by the Director AID.

Authority

1. To select subjects by own choice.
2. To discuss any human factors related subject brought to the attention of the committee from outside- or inside sources.
3. To request assistance from specialists/experts.
4. To suggest formation of working groups to handle special tasks.

The HFC chooses its own chairman who decides upon frequency of the meetings. These take place approximately every 6-8 weeks and if required at shorter intervals.

Policy

To ensure that human factors are implemented in accident prevention efforts.

Standard

To forward to the Director AID conclusions which are concise, based upon facts, balanced and well argumented.

Major tasks concluded within the last 4 years:

- Advice on compulsory retirement age for airline pilots.
- Information folder on jet lag for aircrew (5000 copies)
- Analysis on the flightsafety effects/aftereffects of industrial disputes.
- Standard Operating Procedures.
- Structured guidance material to flying schools on the teaching of human performance and limitations.
- Policy on recertification of alcoholic flight crew members.

The last four years have to us demonstrated, once again, that it takes the right kind of persons, the right kind of organization and timing to breed success.

Success cannot be achieved unless you have the energy to reach the objective. All present members of the HFC have surely had that. Emphasizing this is the fact that all members are working on a voluntarily basis and without pay. Two members have so far been appointed for 15 years, one for 8 and two for 4 years. This demonstrates a strong motivation for the task.

An Example of Our Work

As mentioned the HFC would like to share with you the experience of one of our initiatives.

When speaking of our subject the interplay between the training- and the operational field is of paramount importance for flight safety.

The initiative is meant to be a strong defence against the most often recorded causefactor in aircraft accidents. We sure hope you will agree to our conclusions. We feel confident that you will.

The industry has clearly established and documented that the most serious causefactor in aircraft accidents is deviation from SOP's. Boeing studies document that deviation from SOP's is a causefactor in approx. 35% of all human factors related aircraft accidents.

As this figure was confirmed by accident - and incident statistics in Denmark, and as a large safety profit was to be gained by a reduction in this area we decided to analyse the SOP problem.

We will tell you in short how we came to a conclusion.
We were aware that a major cause for deviation was to be found in behavioural factors.
We knew that flight safety is based on sound policies and procedures in daily operations.
We had no reason to doubt that The DCAA approved policies and procedures applied in Denmark basically were sound. However, working through a number of operators flight operations/aircraft operations manuals a number of weak points nevertheless were revealed. Our studies also revealed that SOP were to be found in a variety of publications. We now listed a number of reasons as to why pilots might deviate from SOP. By this listing a clear picture surfaced.

This is the list:

1) Ambiguous procedures.
2) Insufficient review of procedures.
3) Poor knowledge of procedures.
4) Poor selfdiscipline by the Pilot-in-command.
5) Indifference to procedures.
6) Complacency
7) Insufficient training of procedures.
8) Chaotic presentation of procedures.
9) Pilot-in-command a "Besser-Wisser".
10) No training of procedures.
11) Home made procedures.
12) Poor quality control of procedures.
13) Flight instructors' application of procedures undisciplined (insufficient knowledge).
14) Supervisory captain's application of procedures undisciplined (insufficient knowledge).
15) Wrong procedures (those which then are not followed after a while).
16) Wrong presentation/no presentation of procedures.
17) New procedures trickling down the line but not documented in FOM/AOM.

We concluded that a reduction of accidents related to deviations from SOP's were possible by efforts in several areas, for instance simulator training in real-time, more emphasis placed on correct procedure application during simulator training with retraining requirement at poor performance levels and by management periodically communicating structured information on procedure awareness.

We found af cheaper solution though. A solution which would very much strenghten SOP by highlighting its structure and acknowledging its importance.
We concluded that a CAA enforced mandatory requirement for systemization of SOP's for each aircraft type could eliminate a lot of problems. By suggesting this we don't claim to have found the philosofer's stone. We are convinced that most, if not all, first level carriers have systemized their SOP's. But we are equally convinced that a very great number of operators have their SOP's presented hapharzardly throughout the operators and aircraft documentation.

What we want is to provide a pilot, whoever, working for whatever operator and with whichever level of experience with a tool easily managed by which an aircraft should be operated. We want all SOP now to be found throughout the Flight Operation Manual and aircraft documentation to be removed from their various chapters, collected logically and presented in ONE chapter, namely CHAPTER ONE in the Aircraft Operation Manual.

A systemization would simplify learning, reviewing, checking, correcting, confirming, presenting.

And so on.

We also feel assured that a systemization would throw a bridge across to crewmembers having difficulties with SOP in daily operation. The tyrannical captain would have a harder time trying to enforce his own homemade procedures when company SOP are stated clearly, unambiguously and are easily found in one place.

The nonassertive co-pilot would have strong weapon to use against the tyrannical captain by simple referring to CHAPTER ONE which is easily consulted.
CHAPTER ONE is to be named "Ground and Flight Procedures" and is to consist of the following subchapters:

- Normal checklist/Expanded checklist

- **General:**

  Maneuvering, Thrust management, Braking, AFS, Navigation, Icing, Turbulence, Stall, GPWS-procedure, Trimming.

- **Ground operations:**

  Maneuvering, Use of lights, Use of thrust, Use of brakes, Use of anti-ice systems, De-icing, Parking, Turn circle, Aircraft ground clearence, Safety distances (Thrust).

- **Take Off:**

  General, Flaps/slats/thrust setting, NAP, Speeds/Trim, Navigation, Normal/abnormal T/O and climb out proc./profile, Discontinued T/O, X-wind T/O, T/O on contaminated RW, Met.conditions affecting T/O such as Temp./Press./Windshear, Anti-ice systems.

- **Climb:**

  Thrust setting, Speeds, Turbulence; Anti-ice systems.

- **Cruise:**

  Flight level selection, Speeds, Turbulence, Stability.

- **Descent:**

  Speed, Profile, Anti-ice systems.

- **Approach:**

  General, Maneuvering, Flap/slat setting; Speeds, Std. instrument app., CAT II/III, Patterns, Call-outs, G/A's on all eng./ with eng.fail., VMC app., Low circuit patterns, Anti-ice systems, Windshear, App. with eng.fail.

- **Landing:**

  Speed, Trim, Thrust management, Braking, Normal landing, Stopping techniques, X-wind landings, Aircraft control, Abnormal flaps/slats, Landing with eng.fail., Overweight landing.

The CAA regulation might be worded very brief as follows:
"An operator engaged in scheduled or non-scheduled commercial airtransport using multicrew aircraft must for each such aircraft type operated develop and document SOP's. SOP's must be presented separately and must at least include standard procedures for all normal, abnormal and emergency procedures. It is the operators responsibility to ensure compliance with standardized application of SOP's."

CHAPTER ONE which we envisage as a DESIGNATOR known with time by pilots worldwide as THE STANDARD OPERATING PROCEDURES CHAPTER would typically for a modern technology heavy aircraft contain about 40-45 A4 pages.

Finally let me mention that in Denmark we have, in more that one case, experienced difficulties during transition from old - to modern technology aircraft. DCAA inspections have clearly identified insufficient structure of SOP's as one reason.

References.

1. Sears,R.L. "A New Look At Accident Contributors and the Implication of Operational and Training Procedures". 38th International Flight Safety Foundation Symposium, Nov. 1985.

2. Lautman L.G. "The Air Safety Story: Where We've Been And Where We're Headed". Flight Safety Foundation, 42nd IASS, Athens, 1989.

THE DEVELOPMENT OF HUMAN FACTORS SKILLS AND PROFESSIONAL ATTITUDES

Capt. Hans Sypkens
Chairman, IFALPA Human Performance Committee

Good afternoon Ladies and Gentlemen,

I thank ICAO for the opportunity to address you today on behalf of IFALPA.
It is a great honour indeed to participate in such an extensive programme as the one ICAO has undertaken in Human Factors.

Introduction

IFALPA thinks of training for Human Factors skills as being of high value. Worldwide developments have come a long way, yet we can improve a lot. Looking at this process of development I would like to make some specific comments and remarks but with a word of caution.

With all the emphasis given today on various CRM training, LOFT and new developments such as instruments for precise feedback on specific behaviour patterns in the cockpit, it is quite possible that one loses the broad context in which solutions for the Human Factor problems are being sought. Training in Human Factors Skills using LOFT scenarios is **NOT** the complete answer to the H.F. problems but is only **PART** of the answer. There is some kind of paradox here. It is what I call the training paradox, and this I will explain later.

Discussion

Ladies and Gentlemen, because the aim of this Symposium is to explore new developments in training for Human Factors Skills of Proffesional Attitudes, allow me to explain our ideas as to how we see an ideal integrated training in the future based on the knowledge and findings of today in this area.

Starting from scratch we would give ab-initio pilots a formal education in Human Factors, part of which includes knowledge of aviation physiology and psychology.
Educating the ab-initio pilot during his first years of basic training in physiology is as difficult as educating him in aerodynamics or aircraft instruments.

Educating a pilot in physiology will acquaint him or her with the physical limitations of the body. The pilot taking an exam will find questions on such items as hypoxia, hyperventilation, spatial disorientation, visual illusions, intoxication by tobacco, alcohol and drugs. They will also include fatigue, body rhythms and sleep strategies.

How important is it to have knowledge of these subjects?
An example. Did you realize that you can actually suffer from mild hypoxia when flying a normal trip of 4 or 10 hours at a cabin altitude of 8000 feet?
Did you know that this reduces your night vision and that it reduces your colour distinction ability by up to 40%? Smoking, even passive, aggravates these effects significantly.

This is perhaps more common to you, the visual illusion. This runway tells us we are more or less on a normal 3 degrees glide slope.
However this is a projection of a runway with equal length but standard runway width. In fact we are **high** on the approach as we take out the first runway, causing dangers of high sinkrates and/or late touch-downs. Our senses fooled us.

Chapter 2 of the 8th edition of ICAO Annex 1 now has the compulsory requirement that pilots should have appropriate knowledge of human performance and limitations. But how many countries have actually examinations in physiology in place nowadays?
But it is important for pilots to understand their physical limitations.
It is thus important to have such mandatory examinations in place in the very near future.

What about Psychology?

Educating people in relatively easily understood subjects like aviation physiology just mentioned is one thing but educating pilots in professional attitudes towards their job and towards other people is quite another.
Doesn't that belong to one's character? Are we talking about changing one's character?
No, we cannot change the traits of one's character. A trait is quite a stable quality of any one person. Even if one is willing to change one's character, it is very hard to do so, if at all possible. It is not necesarry either.

On the other hand we **can** change our behaviour. Behaviour is the way we act, the way we talk and what we say.
Actually, we are looking for effective behavioural patterns inside and outside the cockpit. In this respect a good pilot is aware of what his own behavior does to others.

It is possible to train people in this manner. We have seen this in the CRM Feedback and Appraisal System presentation this morning and in Professor Helmreich's presentation.

There are a number of Human Factor skills we should master. Realize that subjects like Decision-making and Leadership are skills which can actually be learned.
When given proper feedback we can improve on our Professional Attitudes such as Assertiveness and Self-Criticism as well.

IFALPA very strong believes that this kind of CRM-related training should be given from the beginning when the pilot-to-be enters a flying school.
The motivation to these people is very high and they will virtually do and learn everything necessary in their great desire to become a pilot. We still know this feeling from our younger years.

The bottom line is that they are more open-minded to these relatively "non-technical" issues than at anytime later in their career. They are young, can still be moulded and absorb these things better.
This non-technical training should be fully integrated in the day-to-day training programmes so as to develop sound attitudes.
The big advantage is the availability of sufficient time, normally a couple of years, to accomplish this.
This compares to CRM courses with the rather unfortunate duration of 3 or 4 days. Or, if you are lucky, some more days during a second follow-up course, as is the case nowadays. The people attending these CRM courses are already pilots, there is no essential need for them to do hard work on these issues.

They are already rather set in their ways, they probably even have to "unlearn" some practices. This is a waste of energy really.

Still following the lines of this ideal integrated training, there will be no need anymore for airline pilots to attend to CRM courses simply because they had been well educated at flying school.
In the airline however we will by all means see Recurrent Training in Human Factors Skills.
Feedback should be given on specific behaviour and behaviour patterns related to Human Factor Skills and Professional Attitudes, using LOFT, video feedback etc.
The objective being in the end that all training **and** checks is "Human Performance Impregnated".

But even when starting today it still takes the time of a whole career to train every pilot in this manner. In the meantime we need Human Factors/CRM "conversion" courses as we know nowadays.

As I said before even an ideal training is only part of the answer to the Human Factors problems. The field of Human Factors is far broader, ranging from cockpit displays and the design of controls to organizational philosophies. All these affect the performance of the human in their own way.

Let us therefore have a look at the role of the pilot in this "Aviation System".

If we compare the "Aviation System" with a football match, the goalkeeper represents the people on the working floor; the mechanic, the air traffic controller, the pilot.
He has to stop all the shots at goal which result from mistakes apparently made earlier in the system. By giving the goalkeeper more and better training, such as CRM training, he is able to stop the results of even more mistakes. In other words we have created a "Super Keeper" and the performance / flight safety level will probably increase. However, if we are at the same time not improving our defences, the mid fielders, the strategy, the organization etc. there is no use in having a very busy "Super Keeper".

Here is the training contradiction.

The better crews are able to cope with deficiencies in the system, the less likely it is that the root causes of these deficiencies will be dealt with.
Why? Because advanced training will show improvement in overall safety. For many people this is proof that the problem has been adequately dealt with. They will be very reluctant to address these deficiencies which costs effort and money.
Relying on training as an answer to a flaw in design or organization is not a good strategy.
Because of these deficiencies/latent failures, the pilots will be set up, time and time again to make errors. One day, in a different set of circumstances they will make that fatal error in spite of advanced (CRM) training.

This is not an argument against such programmes as CRM and LOFT. On the contrary. But it shows that it is only **Part** of the answer and that we have more to do.

Before I conclude, I would just add a few words on the present situation in Europe regarding Human Factors skill tests.

The Joint Aviation Authorities (JAA) regard Human Factor skills as very important. Consequently they are proposing new requirements for Multi-crew Type ratings and ATPL skill tests. As well as for profchecks in the Multi-crew concept. Applicants shall be checked on issues as crew cooperation, effective communication, setting priorities and decision making.

Summery.

We believe that CRM training should be fully integrated in the ab-initio training schedule. Recurrent training in Human Factor skills should be ongoing. Feedback should be directed towards specific behaviour (patterns).
We should realize that advanced training is only part of the answer. Much more effort must be directed at solving existing deficiencies rather then trying to train them away.

To err is human. Even so, let us try to find out **WHY!!**

___ **DOCUMENTATION**

___ **SOFTWARE**

___

___ **PHYSIOLOGY**

CRM TRAINING

___ **PSYCHOLOGY**

___

HUMAN FACTORS

___

___

___ **DESIGN**

___ **INCOMPATIBLE GOALS ORGANIZATIONS**

___ **ATC**

FULLY INTEGRATED CRM TRAINING IN AB-INITIO TRAININGS SCHEDULES

ONGOING RECURRENT TRAINING IN HUMAN FACTOR SKILLS AND PROFESSIONAL ATTITUDES

FEEDBACK DIRECTED TOWARDS SPECIFIC BEHAVIOUR PATTERNS

ADVANCED TRAINING CRM/LOFT, IS ONLY PART OF THE ANSWER TO HUMAN FACTORS PROBLEMS

HUMAN FACTORS AND TRAINING ISSUES IN CFIT ACCIDENTS AND INCIDENTS

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INTRODUCTION

A controlled flight into terrain (CFIT) accident or incident is one in which an aircraft, under the control of the crew, is flown into terrain (or water) with no prior awareness of the impending disaster on the part of the crew (*Wiener, 1977*). Statistics suggest that close to 45 per cent of aircraft losses during the period 1979-1990 fall into this category (*Flight Safety Foundation, 1992*). This has led the international community, including the International Civil Aviation Organization (ICAO), the International Federation of Airline Pilots Associations (IFALPA), the Flight Safety Foundation (FSF) and the International Air Transport Association (ATA), to multiply its efforts to reduce CFIT accidents and incidents.

Concern over CFIT occurrences was first reflected in regulations the 1970's, after a B-727 struck a mountain during a non-precision approach to Dulles, Virginia. A premature descent was attributed to ambiguous pilot-controller communications and unclear information in the approach chart (*NTSB-AAR-75-16*). This was one in a series of accidents in which otherwise airworthy aircraft were flown into the surface by properly certificated flight crews. The solution was deemed to lie in the implementation of the Ground Proximity Warning System (GPWS) requirement for large, turbine-powered airplanes engaged in international operations (*ICAO Annex 6, 1978*) and its ground counterpart, the Minimum Safe Altitude Warning (MSAW) as a feature of the automated radar terminal system (ARTS-3) (*Loomis and Porter, 1981*). Although GPWS has reduced CFIT occurrences, it has still fallen short of fulfollingthe expectations with which it was introduced. *Slatter (1993)* provides an excellent account of the shortcomings in the introduction of the GPWS as well as operational solutions to improve GPWS effectiveness as a safety net.

During the 1980's, efforts to find solutions to CFIT occurrences were directed at enhanced flight crew performance. Several approach and landing accidents attributed to breakdowns in crew coordination and discipline acted as triggers. Crew resource management (CRM) and Line-Oriented Flight Training (LOFT) (*Cooper, White and Lauber, 1979; Lauber and Foushee, 1981; Orlady and Foushee, 1986, Wiener, Kanki and Helmreich, 1993*), emphasizing the need for improved intra-cockpit communication, exchange of relevant operational information and situational awareness boomed across the airlines. This was accompanied by the inevitable, age-old exhortations about cockpit discipline and professional behaviour, elusive terms which escape sound definition and only generate unimaginative solutions with rather dubious results. As with GPWS, although the contribution of CRM and LOFT to aviation safety has been monumental, the continuing pervasiveness of human error in CFIT occurrences suggests that Human Factors training is only a partial solution to CFIT occurrences.

Reducing CFIT occurrences requires recognition that such accidents are system-induced (*Wiener, 1977*), i.e., they are generated by shortcomings in the aviation system, including deficiencies in the organizations which constitute it. The accident in which a DC-10 crashed into an active volcano in Antarctica (*Aircraft Accident Report No. 79-139*) because incorrect navigation coordinates in the computer-generated flight plan deviated the aircraft from its assumed track has been asserted as an example of these shortcomings and the systemic nature of CFIT occurrences (*Mahon, 1981; Vette, 1984; Johnston, 1985; Mcfarlane, 1991*). Deploying people and funds -- always finite resources -- in furthering regulations, design or training will not likely improve CFIT statistics. Actions aimed at reducing CFIT should address system failures and organizational deficiencies (*Reason, 1990*), since these are the areas where the greatest gains in safety improvement can be realized.

BACKGROUND

In dealing with CFIT occurrences, the industry has so far followed a time-honoured approach. Upon observing one particular safety deficiency (CFIT), remedial action, essentially backwards-looking and aimed only at that deficiency led to regulations (Annex 6 and others), design (GPWS and MSAW) and training (CRM and LOFT). Such remedial action based on regulations, design and training worked reasonably well in the past, when the level of technology aviation employed to achieve its production goals (transportation of people and goods safely and efficiently) was relatively low, and the interactions between people and technology therefore simple and predictable. On the other hand, the relatively low level of technology utilized up to the 1970's imposed considerable limitations on system goals, which in turn denied the system opportunities to foster human error. Examples of these limitations include, among others, simple air traffic control systems, high weather minima, flexible schedules, shorter legs, and more layovers which alleviated circadian disrhythmia. Most important, equipment was simple and transparent in use, it demanded basic cognitive skills and it responded to well-rehearsed mental models.

Although systemic elements can be found in accidents and incidents since the beginning of aviation, human error in times of low technology was more a consequence of operational personnel improperly applying their knowledge and skills (due to shortcomings in equipment design, deficient training or silent regulations) than a result of stringent system demands. Within this context, strengthening or adding local defenses (*Maurino, 1992*) through regulations, design or training appeared a sensible approach to follow. The "sterile cockpit rule", enacted as a consequence of an accident in which a Douglas DC-9 crashed 5,3 km short of the runway at Charlotte, North Carolina (*NTSB-AAR-75-9*) stands as a good example. Such an approach provided considerable yields and elevated aviation to its status as the safest mode of transportation. The irony behind this progress is that equipment designed to provide wider berth to human error eventually imposed greater demands over the very humans they were supposed to alleviate, by increasing system production demands. Technical advances are seldom used to increase the safety of the aviation system as a whole by creating wider safety margins. They are frequently used to stretch system limits, leaving safety margins largely unchanged.

Aviation in the 90s has become an extremely complex and sensitive system, in the sense that even the smallest interference can lead to catastrophic consequences. To minimise human error and maximise production, high-technology has been introduced on a large scale. Those who watched this introduction with impartiality suggest two basic flaws in the process: (1) the introduction was technology-driven rather than human-centred (*Billings, 1992*), and (2) it stopped short at the micro rather than at the macro level of system design analysis (*Meshkati, 1992*). The consequence of the first point is that technology has not eliminated human error but rather displaced it (*Wiener, 1988*). The consequence of the second is that the system complicated and difficult to grasp conceptually. New high technology is inherently opaque. As of today, the consequences of the interactions among people, technology and other system components in the safety of the system remain largely unknown (*Reason, 1992*).

People and technology interact at each human-machine interface. Both components are highly interdependent, and operate under the principle of joint causation (*Pidgeon, 1991*), i.e., people and machines are affected by the same causal events in the surrounding environment. Furthermore, these interactions do not take place in a vacuum, but within the context of organizations, their goals, policies and procedures (*Bruggink, 1990*). Understanding the principle of joint causation and the influence of the organizational context upon the aviation system operations is central to understanding CFIT occurrences and their prevention. Such understanding will preclude the piecemeal approaches based on design, training or regulations which have plagued past safety initiatives. Looking into the organizational context will permit one to evaluate whether organizational objectives and goals are consistent or conflicting with the design of the organization, and whether the operational personnel have been provided with the necessary means to achieve such goals.

DISCUSSION

The success of the windshear training aid package (*FAA, 1987*) in reducing windshear-induced accidents has lured the aviation community into adopting similar approaches to solve other observed safety deficiencies. The recently produced takeoff training aid package (*FAA, 1992*) stands as a good example, and it will undoubtedly contribute in reducing aborted takeoff, overrun accidents. Not surprisingly, many advocate a training package to reduce CFIT occurrences. However, neither technical nor Human Factors training are *the* solution to reducing CFIT statistics. Furthermore, any CFIT training package would be redundant with existing training curricula and therefore an unnecessary and unproductive waste of resources.

The success of the windshear -- and hopefully of the rejected takeoff -- training aids resides in the fact that both situations present inherent factors which can be punctually addressed. In both cases specific knowledge, skills and mental models must be developed,acquired or revised. Examples of this include understanding the dynamics of windshear and its consequences in terms of aircraft performance, as well as the aerodynamics involved in an encounter, the certification conditions behind demonstrated takeoff distances, the sequence of controls selection or manipulation, etc. Specific skills must be developed and mental models changed to fly at high body angles, to apply maximum braking, etc.

There are no factors inherently specific to CFIT occurrences. All factors listed as contributing to CFIT occurrences (*Slatter, 1993*) are addressed by existing training curricula: navigational errors, non-compliance with approach or departure procedures, altimeter setting errors, misinterpretation of approach procedures, limitations of the flight director/autopilot, etc. Those factors not covered by technical training are included in CRM training: maintenance/loss of situational awareness, deficient intra-cockpit interaction, flight crew communications etc. A dedicated training package would be a meagre contribution to reducing CFIT occurrences.

The answer to CFIT occurrences lies in looking at them from a systems perspective and acting upon the latent failures which have slipped into the system, ready to combine with operational personnel active failures and adverse environmental conditions to produce an accident (*Reason, 1990*). Examples of these latent failures include poor strategic planning of operations, absence of clear channels of communication between management and operational personnel (a widely lamented but seldom acted upon, typical system failure), deficient standard operational procedures (a direct consequence of the aforementioned), corporate objectives which are difficult or impossible to achieve with existing resources and corporate goals inconsistent with declared safety goals, among others.

It is impossible to act upon a problem unless awareness about it is gained. Therefore, it is advanced that the first answer to reduce CFIT occurrences is education. Education and training are terms loosely used among operational personnel. They are, however, quite distinct and not interchangeable (*ICAO, 1989*). While familiar with training, operational personnel are seldom exposed to education, since it is assumed that it forms part of the basic qualifications required for employment. Given the complex and opaque nature of today's aviation system, it has been suggested that it is time to review the need to further education in aviation (*Kantowitz, 1992*).

Rather than a training package, what is needed to decrease CFIT events is an educational package, to acquaint both managers and operational personnel with the concepts of high technology system failures, how they manifest through organizational deficiencies, how they may lead to incidents and accidents and the ways to cope with such failures and deficiencies. The next step is to take into account Human Factors considerations during system design, both at the micro and macro level. At the micro level, the Human Factors analysis must go beyond knobs and dials in the traditional ergonomic sense, towards the more complex cognitive, information-processing and communication processes between people and between people and technology. At the macro level, the interface between the human-machine sub-system must be considered within the context of the aviation system as a whole, including the declared system goals and the resources allocated to achieve them. If education takes place, this second step is perfectly achievable.

A CASE STUDY

In November 1975, an airliner with six crew members and sixty-five passengers on board crashed while attempting to land, following a circling, non-precision night approach in poor weather conditions at a remote location in South America. In a "textbook" approach and landing, CFIT accident, the aircraft hit the densely forested, sloping terrain less than one mile short of the intended landing runway. The aircraft was completely destroyed, and although there were three injured (one of them the captain) there were no fatalities. The investigating agency took the view that the accident was attributable to pilot error. The pilot was fined by the civil aviation authority and demoted by the airline. Less-than-appropriate consideration was given to the difficulties of the immediate environment, replete with visual illusion-inducing conditions and with precarious navigation and approach aids. Neither did the investigation address the reasons which induced the crew to attempt an approach in such adverse conditions. The safety and prevention lessons which might have been learnt were effectively buried by the honest, but undoubtedly misdirected investigation, limited to the cockpit activities immediately preceding the accident.

When looking from an organizational perspective, multiple latent failures within the airline become evident. The most obvious organizational deficiencies include lack of strategic planning regarding this fleet operation and incompatibility between the corporate goals assigned to the fleet and the resources provided to achieve them. The type had recently been introduced into the airline and the process had been plagued with problems, including the adequacy of the qualifications of the airline training staff as well as the stability of the training organization. Ground school was conducted in-house with inappropriate means and with scant consideration paid to the fact that student captains had no previous jet experience and student first officers were being inducted into the airline. No flight simulator was available at that time, so all training was conducted in the aircraft, with its inherent limitations. Notwithstanding the mentioned lack of jet experience, line-indoctrination was hurriedly completed, due to the pressing need for crews to meet an ambitious commercial schedule.

Management's inability to establish clear lines of communication with operational personnel was another serious organizational deficiency. This translated into deficient crew scheduling and pairing, improper consideration of environmental and equipment limitations when scheduling regular commercial services into destinations with doubtful infrastructures and unfriendly environments, and lack of guidance to flight crews in terms of standard operational procedures as well as the limitations inherent to the operations. Because of these deficient lines of communications, newly qualified flight crews had no clear guidance as to which were the operational behaviours management expected from them. This lack of guidance -- and support -- has been recognized as an organizational failure which contributes to flawed decision-making by operational personnel (*Moshansky, 1992*).

Lack of strategic planning, incompatible goals, failure to communicate goals and to properly train personnel to achieve them are but a few examples of latent failures. They generate working environments replete with conditions which foster human error. Most important, such environments oftentimes make violations inevitable if tasks are to be achieved. An example of violation-producing conditions are those air traffic control procedures which generate nuisance GPWS warnings. They force crews to ignore warnings, thereby generating violations to operational orders to fulfil such procedures. Eventually environment or task conditions which generate errors and violations lead to system-induced accidents. Accident databases are replete with CFIT occurrences which support this contention.

CONCLUSION

When looking for solutions to CFIT occurrences, it is imperative to think in collective rather than individual terms (*Beaty, 1991*). It is naive to brand an entire professional body as being mainly responsible for aviation safety. It is equally impossible to anticipate the many disguises human error may adopt to bypass even the most cleverly designed safety devices. Lastly, it is an unattainable goal to eliminate all system deficiencies leading to accidents.

The solution rests in securing a maximum level of system "safety fitness" (*Reason, 1992*), by working upon latent system failures, such as incompatible goals, poor communication, inadequate control, training and maintenance deficiencies, poor operating procedures, poor planning and other organizational deficiencies which modern accident causation approaches indicate as being responsible for disasters in high-technology systems.

Periodic checking of these system "health condition" markers and continuously actioning upon them remain the single most important keys to reduce CFIT occurrences. Such efforts in CFIT prevention would also have dividends in many other safety-deficient areas.

REFERENCES

Beaty., D. (1991) The Last Frontier in Aviation. Flight Deck, Issue 3, Winter 1991. British Airways Safety Services.

Billings, C. E. (1991). Human-Centred Aircraft Automation: A Concept and Guidelines. NASA Technical Memorandum 103885.

Bruggink, G. M. (1990). Reflections on Air Carrier Safety. The Log, April 1990.

Cooper, G. E., White, M. D, Lauber, J. K. (Eds.) (1979). Resource Management on the Flight Deck. Proceedings of a NASA/Industry Workshop held at San Francisco, California, June 26-28, 1979. NASA Conference Publication 2120.

Federal Aviation Administration (1987). Windshear Training Aid, Vols. I and II. February 1987.

Federal Aviation Administration (1992). Takeoff Safety Training Aid. August 1992.

Flight Safety Foundation (1992). Report of the International Advisory Committee. Arlington, Virginia: Author.

International Civil Aviation Organization (1978). Annex 6, Operation of Aircraft.

International Civil Aviation Administration (1989). Fundamental Human Factors Concepts. Human Factors Digest No. 1, Circular 216-AN/13. Montreal, Canada.

Johnston, A. N. (1985) Erebus. The Log, December 1985.

Kantowitz, B. H. (1993). Human Factors Knowledge Requirement for Flight Crews. Paper presented at the Second ICAO Global Flight Safety and Human Factors Symposium, 12-15 April 1993, Washington DC.

Lauber, J. K. and Foushee, H. C. (Eds) (1981). Guidelines for Line-Oriented Flight Training. Proceedings of a NASA/Industry Workshop held at NASA/Ames Research Center, January 13-15, 1981. NASA Conference Publication 2184.

Loomis, J. P., Porter, R. F. (1981). The Performance of Warning Systems in Avoiding Controlled-Flight-Into-Terrain (CFIT) Accidents. Paper delivered before the 1981 Symposium on Aviation Psychology, Columbus, Ohio, 20-22 April 1981.

Macfarlane, S. (1991). The Erebus Papers. Avon Press, Auckland, New Zealand.

Mahon, P. T. (1981). Report of the Royal Commission to Inquire into the Crash on Mount Erebus, Antarctica of a DC10 Aircraft operated by Air New Zealand Limited. Wellington, New Zealand.

Maurino, D. E. (1992). Shall we add one more defense? Keynote speech at the Third Seminar in Transportation Ergonomics, Transport Canada Development Centre, 7 October 1992, Montreal, Canada.

Meshkati, N. (1992). Ergonomics of Large-Scale Technological Systems. Ergonomics, No. 165

Moshansky, V. P. (1992) Commission of Inquiry into the Air Ontario Crash at Dryden, Ontario. Final Report, Volume III. Ottawa, Canada.

National Transportation Safety Board (1975). Trans World Airlines Boeing 727-231, Berryville, Virginia, December 1, 1975. Report No. NTSB-AAR-75-16. Washington, DC,: Author.

National Transportation Safety Board (1974). Eastern Airlines Douglas DC-9-31, Charlotte, N.C. Report No. NTSB-AAR-75-9. Washington, DC,: Author.

Office of Air Accidents Investigations (1979). Aircraft Accident Report No. 79-139. Air New Zealand McDonnell-Douglas DC10 ZK-NZP, Ross Island, Antarctica, 28 November 1979. Wellington, New Zealand: Author.

Orlady, H. W and Foushee, H. C. (Eds) (1987). Cockpit Resource Management Training. Proceedings of a NASA/MAC workshop held in San Francisco, California, May 6-8, 1986. NASA Conference Publication 2455.

Pidgeon, N. F. (1991). Safety Culture and Risk Management in Organizations. Journal of Cross-Cultural Psychology, Vol. 22 No. 1, March 1991.

Reason, J. (1990) Human Error. Cambridge University Press.

Reason, J. (1992) Collective Mistakes in Aviation: "The Last Great Frontier". Flight Deck, Issue 4, Summer 1992. British Airways Safety Services.

Slatter, R. T. (1993). ICAO Initiates Comprehensive Programme to Prevent Occurrence of CFIT Accidents. ICAO Journal, January/February 1993. Montreal, Canada.

Vette, G. (1983). Impact Erebus. Aviation Consultants Ltd. Newtown, Auckland, New Zealand.

Wiener, E. L. (1977). Controlled Flight into Terrain: System-Induced Accidents. Human Factors, 1977, 19(2).

Wiener, E. L. (1988). Cockpit Automation. In Human Factors in Aviation, Wiener, E. L., Nagel, D. C., (Eds). Academic Press.

Wiener, E. L., Kanki, B. and Helmreich, R. L. (1993). Crew Resource Management. Academic Press.

Enhancing the Impact of Human Factors Training

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Introduction

Aviation training has become much more capable over the last 15 years with the advent of Advanced Simulation, Crew Resource Management and Objectives-based Training. It is easier now to isolate and modify specific behaviors. The power of new training tools and techniques has in some cases however been under utilized. At the same time, little progress has been made in learning how the airline training function can support efforts to deal with organizational precursors to crew-preventable accidents. Further changes in the training mission and the design of training itself can help in both cases.

Overcoming Flightcheck Limitations

It is no secret that many Operators limit their training to the target of passing the inevitable government checkride. Thus most Recurrent training in the U.S., for example, tends to be aimed at preparing crews for the FAR 135.293/.297 or 121.441 Checks. The arguments against limiting training in this *fashion derive from the limitations of the check itself:*

* Since the "checkride" tends to consist of an unrelated string of maneuvers and procedural tasks, it doesn't reflect the real-world way in which emergencies tend to unfold nor the environment in which they develop.
* Checkride challenges may not match the real-world ones that lead to accidents. Checkride content just does not reflect all of the hazards crews must cope with such as runway incursions, wind shear or altitude deviations while complying with complex ATC procedures, for example.

So, it is asserted that both the content and execution of the checkride may not provide the best test of the actual proficiency crews need to fly in today's environment. Thus training limited to the scope of the check is similarly limited in value.

Of course, problems with government requirements are well known and are being addressed to some extent. In the U.S., the Advanced Qualification Program initiative (SFAR 58) is tackling the issue by encouraging Operators to determine which training tasks are critical and how often they need to be trained. But AQP is expensive, requiring as it does a fresh task analysis, and may therefore be limited to only a subset of Operators. But to the extent that AQP is successful and feasible, it will bring more real-world oriented checking with it. In the interim, progressive checking will help if not resolve the situation.

Under special circumstances, checkride tasks can be integrated into a training course and accomplished "progressively". Check accomplishment then becomes much more meaningful when embedded in mission-oriented simulator training sessions that reflect realistic flight scenarios. SimuFlite Training, International was the first to conduct advanced simulator proficiency checks for Corporate Operators in this so-called "progressive" manner and recently initiated semi-progressive checks (spread over two days) with air carrier Clients. Progressive checking builds realism into the check and bolsters the Operator's confidence in the pilots who pass it.

Mission-Oriented Training

LOFT advantages are being realized more and more in the course of regular simulator training sessions through greater use of mission-oriented training presented in the form of Line Operational Simulations--or "LOS" for short.

The conduct of simulator and airplane training preceding checking has been modeled for years on the check itself. Thus conventional simulator training emphasizes trial and practice of series' of procedures which are often introduced without regard to the way in which real-world emergencies and abnormals develop. Such training in the hands of inadequately trained and indoctrinated Instructors often deteriorates into simulator "gotcha'" games where crews unwittingly collaborate with Instructors to see how many faults and emergencies can be tolerated while keeping the airplane airborne. Often the stimulus for this kind of training comes from no more sophisticated a rationale than an Instructor's efforts to fend off his or her own boredom or the Check Airman's desire to set the stage for the sale of his or her particular "pet" procedure.

Recurrent simulator training sessions, especially, ought to be shaped to mirror as closely as possible realistic flight conditions from preflight planning on. Then, and only then, can emergency and abnormal conditions develop as they do in real life and be dealt with in a realistic environment that reflects the demands of coping with problems while continuing to maintain situational awareness and deal with ATC distractions.

Guidelines for Mission-oriented training sessions or "LOS" (Line Operational Simulation) sessions have recently been outlined in an Advisory Circular by the FAA.

New Training Packages

We as an industry are getting better at developing focused training tools. This has led to more self-contained training regimens designed from the outset to combat specific hazards. The Wind Shear Training Aid is an excellent example as is the Takeoff Safety training aid also developed under Boeing's leadership.

But there are limitations. First, the economics of training can limit the payoff of these programs. Take the Wind Shear Training Aid, for example. Does your training organization take an hour of simulator time to implement this or are your crews basically just being "exposed" to one or two shear encounters? If you are in the latter situation you are not alone. Wind Shear training, like other new items on the training menu, takes time. And Operators often have neither the budget nor crew man-hours to take full advantage of these programs.

Another problem is integration. Unless we are talking about ab initio or transition training, the more mission-oriented or realistic the training, the better. But it takes planning and resources to integrate things like the wind shear training exercises into full mission simulators scenarios.

Decision-making training and evaluation should be interwoven into recurrent training curricula as well. Why? Because the maximum impact of dedicated training packages such as Windshear, TCAS, CFIT and the like most certainly depend upon the individual and team's ability to make an informed, prudent decision. While the authors of these regimens have won half the battle by defining decision criteria and prescribing behaviors to employ following the decision, their efforts can come to naught when a Captain or crew's ability or inclination to make a decision is handicapped.

Consider, for example, the inability of some crews to extricate themselves from imminent CFIT accidents. For not all such accidents hinge on a completely complacent crew at a loss for situational awareness. On the contrary, many of these accidents reflect a palpable air of uncertainty and in some cases even concern on the flight deck preceding impact yet the crew was unable to make the commitment to exit the situation. I would suggest that crews would benefit from dedicated training "practicing" escapes from terrain-separation uncertain situations--not so much to optimize pull-up techniques but to give the crews practice in making the decision to change their plan and abandon the approach. Instructors are familiar with an analogous situation. Pilots who are more comfortable executing missed approaches seem to have an easier time "deciding" to do them.

Integration makes training powerful. But it takes frequent re-designing of the entire training regimen to effectively integrate new programs and techniques.

Better Evaluation Will Yield Continuous & Prescriptive Training

One of the most exciting developments for training has been the specification of the "CRM Performance Markers" by Dr. Robert Helmreich, et al at the University of Texas. These provide the first concrete, easy to use measures of crew resource management. Their biggest payoff could be the restoration of "evaluation" to its rightful role in the management of training. After all, without concrete evaluation, we can honestly measure neither the need for training nor the effectiveness of training. Better evaluation tools will allow us to truly tailor training in terms of both time and content.

Conventionally, training is aimed at restoring performance to arbitrary intervals. It doesn't tell you about either performance decrements or improvements over time. Nor does it answer certain key questions like... Was the training given too soon or too late? Did crew performance deteriorate below minimum acceptable levels between training events? How do you "know" when its time to train again? These questions and others are usually never addressed. Instead, training frequency, like training content, is most often dictated by regulatory requirement.

Thus, you have no assurance of continuity of performance. If you have a "weak" pilot or a systemic problem (e.g. lack of standardization) can you reasonably expect it to be fixed with one "dose" of training administered without regard to the entry-condition of your crews?

Better evaluation tools will allow you to more accurately pinpoint when its time to train and on what. As a consequence we will learn how to deliver compensating training in smaller, more efficient doses and gradually flatten-out the retention curve. Training in its smallest doses usually comes in the form of coaching. Have your Check Airmen or Captains been trained as "coaches"? Line Check Airmen can learn to identify crew resource management deficiencies and through structured debriefing, coach against the problem there and then. If you think about it, much of the behaviors that we see in cockpits are habitual. They are thus much more amenable to change through frequent coaching versus once-a-year training. Of course, to realize this vision, airlines will have to invest in better training for their Check or standardization pilots and place greater emphasis upon evaluation.

More Powerful Evaluation Restores Management Control

Research into the organizational precursors of accidents to which our industry has recently turned points to the critical nature of leadership and communication throughout the operational organization. Reason's concept of "latent failure" coupled with Westrum's view of the capacity of the organization for "thought" leads to the conclusion that communication, especially up the chain and through unconventional pathways, is critical to safety. For when organizations, be they a flightcrew complement, flight department or airline, become constrained from acting on or communicating observations of hazards they become less able to conceive of such hazards. [Westrum, 1990, p.109]

How does this happen to the organization? By becoming intolerant of "bad news" and by focusing excessively on maintaining the organization's structure. The resultant pathology of organizational thought tends to choke-off **both** the "bad news" and the innovative solutions they might stimulate. It also progressively limits which kinds of conditions are perceived to be genuine "problems" in need of solutions. This pathological corporate "thinking" and concomitant impoverishment of intra-organizational communication can permeate the organizational culture. Cycles of safety lapses and cover-ups hide deficiencies until, as in the case of the Space Shuttle Challenger, they take their toll. The situation is not unlike that which conventional CRM training works hard to attack at the flightcrew level: blockage of communication from the second-in-command to the pilot-in-command and an inability of the PIC to perceive the threat to the flight. Perhaps this model of organizational "thought" explains why so often, when a Chief Pilot says that he or she just couldn't have "conceived" of a particular accident happening, we should take him or her at their word. Perhaps the organizational context in which they operated just did not allow for such a chain of events to be admitted to consciousness.

More powerful evaluation of flightcrew performance can foster integration into Management's sources of control feedback. And the strong yet flexible leadership required of "healthy" organizations depends upon a commitment by Management to both lead and control. By solidifying the connection between crew performance evaluation and Management control a communication path is established that sends a clear message of "responsibility" to upper Management.

In short, more accurate evaluation of safety at the cockpit level aids communication of management-controlled precursor "latent failures" up the organization which, in turn increases the probability of resolution and maintains Management's ability to conceive of and become alarmed at the occurrence of such failures.

Crews Can Acquire Self-Training Skills

Crews can be taught self-diagnostic and self-correcting skills to hold them in good stead between training or coaching opportunities. In the future more training organizations will work with crews to sharpen those skills. The process fosters openness among crewmembers and can provide an early-warning system for hazardous crew behaviors, poorly conceived procedures and the like. Otherwise, it left to the accident investigator to search back for these hazards.

Instead of passive "experience" from which we formulate lessons-learned we can teach crews to actively analyze their own performance and the infrastructure supporting their mission.

At SimuFlite, we call this "self discovery" and it is a technique used upon completion of the flight to facilitate self-critique by crewmembers. The goal is to develop in the crewmember a skill for critical self-appraisal that will accompany him or her into the field.

Of course, teaching "self discovery" to crews is a delicate process that requires carefully indoctrinated and trained Instructors. But the payoff for this investment in personnel is tremendous.

Training Can Aid Employee Development

Traditionally, Training has been aimed at "restoring" instead of improving performance. Why do we not aim for improvement over time? Once we do, we will probably find it to be a powerful employee development tool. The business world has long used training and concomitant performance improvement as weapons against complacency and slipping motivation.

Are there not certain areas of knowledge and even certain skills that we would reasonably expect to improve over time? Pilots, as compared to other professionals tend to spend a greater portion of their time restoring skills instead of improving them or adding new material to their knowledge base. Designing training for improvement instead of just restoration can add to job enrichment for the individual pilot, can rejuvenate trainers and of course, create more competent pilots. Once again, this places a burden on current evaluation habits however. Improvements, especially in skills, can only be demonstrated using measures that are valid and reliable. And evaluators must receive sufficient training and practice.

Training Will be Thought of Increasingly as a Management Tool

Greater use of evaluation will allow Management to really use training as a management tool. Training should be held "accountable" for certain incidents/accidents and should be the first focus of attention instead of the individual crewmembers. Again, the burden falls on training evaluation systems to provide management with adequate feedback to realize this management control.

Greater Management involvement in, and concern for, training has already been shown to improve CRM training effectiveness. vc Certainly, the same can hold true for the training directed at removing organizational precursors to accidents--an approach we call Organization Resource Management.

References

Diehl, Alan E. "Human Performance and Systems Safety Considerations in Aviation Mishaps." The International Journal of Aviation Psychology, Volume 1, Number 2, 1991

Helmreich, R.L. and Wilhelm, J.A. (1991). Outcomes of Crew Resource Management Training. "*International Journal of Aviation Psychology*", Vol. 1, No. 4, pp. 287-300.

Irwin, C.M. (1991). The Impact of Initial and Recurrent Cockpit Resource Management Training on Attitudes. "*Proceedings of the Sixth International Symposium on Aviation Psychology*".

Kotter, J.P. and Heskett, J.L. (1992). "*Corporate Culture and Performance*", The Free Press, A Division of Macmillan, Inc., New York.

Lautman, L.G. and Gallimore, P.L. (1987). *Control of Crew-Caused Accidents*. Proceedings of the Flight Safety Foundation 40th Annual International Air Safety Seminar, Tokyo, Japan

Reason, J. (1991). How to Promote Error Tolerance in Complex Systems in the Context of Ships and Aircraft.

Westrum, R.(1990). Management Strategies and Information Failure

Westrum, R. (1988). Organizational and Inter-Organizational Thought, Presented to World Bank conference on "Safety Control and Risk Management", October 1988.

HUMAN FACTORS RESEARCH DATA APPLIED TO THE *TAKEOFF SAFETY TRAINING AID*

SECOND FLIGHT SAFETY AND HUMAN FACTORS SYMPOSIUM
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INTRODUCTION

This study provided human performance data to support the development of the *Takeoff Safety Training Aid.* The goal of the Training Aid is to reduce the number of rejected takeoff (RTO) related accidents and incidents. The objective of the human performance study was to provide quantitative and qualitative data to aid in better understanding the areas in which decision making and performance can be improved and generate data-based recommendations for Training Aid content and direction.

Previous research (Foxworth & Marthinsen, 1969; Snyder, Drinkwater, Fry, & Forrest, 1973) has focused only on performance and then only in response to a single event (engine fire or failure, respectively). The present study attempts to evaluate decision making, execution of procedures, and performance in the presence of an array of events chosen to represent the types of events that occur in line operations. Choice of the particular events used was based on reviews of accident/incident data on RTO overruns conducted by Boeing Product Safety as well as material presented by Chamberlain (1991) and Strauch (1990).

Variables in the study included: type of non-normal event, availability of autobrakes, crosswind conditions, and which pilot was flying. Pre- and post-run interviews were conducted to obtain background data on the pilots and to assess decision making processes, crew coordination, and procedure accomplishment issues.

Decision making was evaluated in terms of the Go/No Go decisions made in the presence of non-normal events. Decision time as a function of engine versus non-engine related events was also evaluated. Stopping performance was evaluated as a function of crosswind conditions, autobrake availability, and exchange of aircraft control. Procedure accomplishment was judged against the RTO procedure policy of the subject's company.

METHOD

Subjects

A total of 48 pilots type-rated in the B-737 participated in the study. Of these, 24 were Boeing instructor pilots and 24 were airline captains. Airlines solicited volunteers from their line captains . No more than eight captains were used from any airline to avoid biasing the results.

One of two Boeing training captains served as the first officer for all subjects. Both had considerable line experience and were able to closely emulate the characteristics of an average line first officer. This procedure eliminated the inherent variability associated with varying the first officer.

The test run scenarios under which takeoffs were executed were:

Normal takeoff, captain flying
Engine failure at 8 knots prior to V1, captain flying
Engine failure at 8 knots prior to V1, first officer flying
Engine failure at 2 knots after V1, captain flying
Engine failure at 2 knots after V1, first officer flying
Fire Warning at 5 knots prior to V1, captain flying
Blown tire at 10 knots prior to V1, captain flying
Master Caution light at 10 knots prior to V1, captain flying

The order in which subjects encountered the above listed conditions was varied across the subjects. Four combinations of crosswind and braking conditions were also varied across the eight trials per subject. The four crosswind and braking conditions were: 1) calm wind, manual braking required; 2) calm wind, autobraking available; 3) 15 kt crosswind, manual braking required; 4) 15 kt crosswind, autobraking available.

The following is a representative scenario of trial conditions:

1. Engine failure at V1-8, captain flying, calm wind, autobraking available
2. Fire warning at V1-5, captain flying, 15 kt crosswind, autobraking available
3. Engine failure at V1+2, first officer flying, calm wind, manual braking required
4. Master Caution at V1-10, captain flying, 15 kt crosswind, manual braking required
5. Engine failure at V1+2, captain flying, calm wind, autobraking available
6. Engine failure at V1-8, first officer flying, 15 kt crosswind, autobraking available
7. Normal takeoff, captain flying, 15 kt crosswind, manual braking required
8. Blown tire at V1-10, captain flying, calm wind, manual braking required

A pre-test questionnaire was developed to assess the subjects' experience and knowledge of factors related to V1. A post-test questionnaire was developed to obtain additional comments on RTO decision making, procedure execution, and crew coordination.

Procedure

Testing was done in one of Boeing's 737-300 full flight simulators. All takeoffs were conducted at a runway limited condition, meaning that for the initial conditions, the computed accelerate-stop distance was equal to the field length. The speeds at which the events occurred prior to V1 were chosen to provide approximately 1-2 seconds before V1 in which to "decide" whether to continue the takeoff or reject.

After normal introductions, pilots were briefed that they were participating in a takeoff study. They were then given the pre-test questionnaire to complete. Airline captains were briefed on the differences between the flight deck they were used to and that of the simulator. These pilots were also given a familiarization takeoff and flight around the pattern before testing began. The appropriate sequence of eight takeoff trials was then administered.

Following testing, the pilot returned to the briefing room for post-test debriefing.

RESULTS

Boeing pilots and airline pilots as groups had surprisingly similar profiles not only in terms of background and experience but also in the distribution of RTO's across test conditions and total number of RTO's. The number of RTO's per event varied by only 1 in all cases except engine fire. Therefore, findings on performance and decision making are based on all 48 pilots as one group.

Decision Making

The timing and nature of the events triggered during the takeoff trials were designed to produce situations in which pilots could appropriately reject the takeoff on 3 of the 8 trials. The acceleration rate for 737 under the conditions used is between 4 and 5 knots per second, thus pilots had from about 1 second (V1-5) to slightly more than 2 seconds (V1-10) to decide whether to reject or continue the takeoff.

Pilots did not reject takeoffs as often as was anticipated in the "classical" cases that are normally trained; namely, engine failures and fires. Almost one-third of the pilots rejected for the blown tire although the only indication was a vibration. There were seven RTO's for a Master Caution light which in this case came on due to a relatively insignificant hydraulic pump overheat 10 knots below V1. Boeing, along with most airlines, specifies that "Once thrust is set and takeoff roll has been established, rejecting a takeoff solely for illumination of the amber MASTER CAUTION light is not recommended".

Stopping Performance

Stopping performance, as measured by runway remaining, was averaged for all rejects for each event condition presented. Pilots were able to stop the airplane with the greatest margin in the few cases when they rejected due to a Master Caution light illuminated 10 knots prior to V1. In this case, the pilot had reverse thrust from both engines and the malfunction occurred more than two seconds before V1. The worst case was the RTO initiated after V1, followed closely by the rejects for the blown tire.

The effect of crosswind (15 kt versus calm) on stopping margin, while in the direction expected, was negligible. Under calm wind conditions, average runway remaining was 119 meters; with a 15 kt crosswind, average runway remaining was 100 meters.

Most U.S. carriers and all those who participated in this study have the policy that the captain both calls for and executes all RTO's. This obviously involves exchange of aircraft control when the first officer is the Pilot Flying (PF). Although current Boeing manuals are written with the PF doing the RTO, the Boeing pilots were told to use the policy they preferred. With captains as the PF, the average distance remaining to the end of the runway was 152 meters (500 ft). With first officers as PF but under the "captain call and execute" policy, average distance remaining was also 152 meters (500 ft.). When first officers executed the RTO either on their own initiative or with the captain calling the reject, the distance remaining was 94 meters (310 ft.). Finally, with the first officer as PF and performing the reject only if the captain called for it, the average distance remaining was 56 meters (183 feet).

Clearly, there is an exchange of control effect on stopping margins, but the effect is not straightforward. Stopping margins achieved when the captain was the PF or was deciding on and executing the RTO were substantially greater than those where the first officer as PF had the responsibility to decide and/or execute the RTO. Variations in the ability of the first officer to make the reject decision and what technique would be used if the reject decision was made were a direct result of the captain's takeoff briefing. The quality and extent of these briefing varied greatly across subjects. Post-test interview data on crew coordination issues indicated: a) none of the pilots reported briefing RTO procedures on every takeoff, and b) the briefings that are given relate primarily to local conditions. Captains typically assume a great deal with regard to what first officers know about crew roles in RTO decision making and execution. During first officer takeoffs with the captain performing the reject, there were few crew coordination problems. However, in the situation where the first officer performed the reject, there often were crew coordination difficulties. There is an inherent delay when the captain is required to make the reject decision, verbalize it, and then have the first officer execute the procedure. There is also often a delay when the first officer must decide on rejecting the takeoff and the criteria for that decision are not clear and/or the cues from an event are ambiguous.

Stopping performance was also evaluated as a function of the availability of the autobrake system versus manual braking. Boeing procedures and airline policies agree that the first step in the RTO procedure is simultaneous application of maximum braking and closing the thrust levers. Few pilots did this, but rather applied braking as the third or fourth step in the procedure. Some pilots "pumped" the brakes, rather than holding full maximum pressure. Others released brake pressure prematurely then had to reapply maximum pressure to avoid overrunning the end of the runway. These actions reduce stopping margins.

The availability of RTO autobrakes substantially increased stopping margins. Average distance remaining to the end of the runway with the autobrake system armed was 137 meters. Average distance remaining using manual braking was 82 meters. Since autobrakes come on as soon as the thrust levers come to idle, autobrakes typically give a 1-2 second earlier brake application than manual braking. The autobrake system also applies more consistent braking force. The negative side of autobrakes is that they can be inadvertently disengaged resulting in no braking force being applied for a few seconds until the crew notices it. Maximum stopping margin is achieved if pilots let the autobrake system bring the airplane to a complete stop.

Procedure Accomplishment

All Boeing pilots have the following procedure: "Simultaneously close the thrust levers (disengage the autothrottle, if required) and apply maximum brakes. If RTO autobrakes are selected, monitor system performance and apply manual wheel brakes if the AUTO BRAKE DISARM light illuminates or deceleration is not adequate. Rapidly raise the speedbrakes and apply maximum reverse thrust consistent with the conditions." Some of the airlines represented also have this as their procedure. Others have a procedure that uses the reverse thrust levers to raise the speedbrake lever. The percentage of incorrect procedure occurrences, was significant. In each case, the error was selecting reverse thrust prior to raising the speedbrake lever manually. No procedural errors were made by pilots whose company policy called for speedbrake deployment using the reverse thrust levers.

During the course of the study, a new variable was unintentionally introduced. Due to a simulator malfunction, the autospeedbrake deployment feature failed occasionally. This provided an opportunity to observe whether pilots using the autospeedbrake deployment feature actually monitored speedbrake deployment. In nine cases where the speedbrake failed to deploy automatically and the captain's company policy dictated automatic deployment, only one captain noticed that the speedbrake had failed to deploy.

A question of interest was the effect of the nature of the event on decision time. Decision time in the study was defined as the time between event occurrence and the first stopping action. As might be expected, decision times increased for events that were more difficult to recognize, required crew coordination, and/or that are not as well practiced. The shortest time from event to first action occurred for the engine fire warning at V1-5. This time was taken as the reference for comparison across events. The results of this comparison are shown in Figure 1.

Fire warning at V1-5, captain flying	Reference time
Engine failure at V1-8, captain flying	Reference time + .2 seconds
Master Caution at V1-10, captain flying	Reference time + .4 seconds
Engine failure at V1-8, first officer. flying	Reference time + .6 seconds
Blown tire at V1-10, captain flying	Reference time + .6 seconds

Figure 1. Decision time represented as the time between event and first stopping action

It is noteworthy that errors in procedure accomplishment have a high positive correlation with decision time. For those pilots whose company policy was manual speedbrake deployment, 32% of the RTO's were done using auto speedbrake deployment. The percentage of procedures incorrectly performed by event were:

- 42% for blown tire, captain flying
- 35% for engine failure at V1-8, first officer flying
- 30% for engine failure at V1-8, captain flying
- 25% for master caution light, captain flying
- 14% for fire warning at V1-5, captain flying

Uncertainty, whether in event recognition or crew coordination, leads to longer decision times and more mistakes in the RTO environment.

Post-Test Debrief Findings

In the post-test debriefing, a number of questions were asked of the airline captains relative to decision making, crew coordination, and procedure accomplishment. The conclusions drawn from the responses to these questions are as follows:

- Company policy, as reported by pilots, varies considerably both between and within companies in terms of the guidelines provided for RTO decisions.
- Many had a personal "pad" for V1, but its size and the conditions under which it is used vary widely.
- The impact of padded V1's on height over the end of the runway is not always considered in making the RTO decision.
- Captains appear to rely heavily on the first officer's memory and common training experience to provide coordinated action during a RTO. Understanding of RTO procedures is often assumed by captains, not confirmed.

CONCLUSIONS AND RECOMMENDATIONS

Decision Making

The pilots tested were more "go" oriented than anticipated. This may be due at least in part to the fact that many pilots use an informal "pad" with respect to V1. This pad, which ranged between 5 and 20 knots, was the speed beyond which they would not begin a reject when in a runway limit situation. It was not clear that pilots considered the impact of such a pad on screen height as a part of the RTO decision.

The vibration associated with a blown tire appears to induce pilots to reject with no other malfunction indications.

In spite of recommendations to the contrary, a number of pilots rejected for illumination of the Master Caution light in the high speed regime.

Recommendations - Training related to RTO's should:

- Impart an accurate meaning of V1 assuring an understanding of the Go/No Go margins;
- Illustrate the effect of the reduction in screen height resulting from a continued takeoff with an engine failure prior to V1;
- Include academic training emphasizing the impact on stopping distance of a blown tire;
- Provide simulator training to demonstrate the "feel" of a blown tire and the merits of continuing the takeoff.

Stopping Performance

A substantial reduction in stopping margins was observed when first officers executed the RTO either on their own initiative or when the captain called it. The smallest distance remaining was observed when the captain called the reject and the first officer executed it. No crew coordination problems were observed when the captain both called and executed the RTO even though exchange of control of the aircraft was involved in those test runs where the first officer was the PF.

The use of RTO autobrakes substantially increased stopping margins over manual braking even though the most common technique was braking initiated by the autobrake system and completed by the pilot.

Recommendations - A recommendation for a standardized policy of having the captain call and execute all RTO's appears to be appropriate. This would reduce the uncertainty regarding crew roles when rejecting a takeoff. Greater emphasis should be given to the value of RTO autobrakes, however, optimum manual braking techniques should still be emphasized in training.

Procedure Accomplishment

With pilots who operate under the manual speedbrake deployment policy, 32% of the RTO's were done using incorrect procedures. Further, there was a strong correlation between percentage of procedural errors by event and decision time.

Recommendations - Exposure of pilots to "non-classical" as well as the more common engine fire or failure events in training should reduce the uncertainty and ambiguity in the decision process and perhaps lead to less regression to the well-practiced procedures of the landing sequence. Proper accomplishment of the RTO procedure needs additional emphasis to promote improved crew communication and coordination.

IMPLEMENTATION

The study was vital to the development of the *Takeoff Safety Training Aid.* The insight gained on pilots' understanding of V1 was extremely useful in structuring the Training Aid. The data on Go/No Go decision making with a blown tire led to special emphasis on this event. Stopping performance data led to specific recommendations regarding crew coordination and the use of autobrakes during RTO's. The procedure accomplishment data led to special emphasis on training and procedures.

The Training Aid was distributed to all operators of western-built commercial jet transports, many governmental and regulatory agencies, pilot groups and airplane and engine manufacturers in September of 1992. It includes a video, academic material and recommended simulator training profiles. To date, many training groups throughout the industry have confirmed that they are incorporating at least a portion of the recommended training in their courses. The video is being widely used throughout the industry.

REFERENCES

Chamberlin, R.W. Rejected Takeoffs: Causes, Problems, and Consequences. Paper presented at The Ohio State University Sixth International Symposium on Aviation Psychology, May 1, 1991.

Foxworth, T.G. and Marthinsen, H.F. Another Look at Accelerate-Stop Criteria. AIAA Paper No. 69-772, AIAA Aircraft Design and Operations Meeting, July 14-16, 1969, Los Angeles, CA.

Snyder, C.T., Drinkwater, F.J. III, Fry, E.B., Forrest, R.D. Takeoff Certification Considerations for Large Subsonic and Supersonic Transport Airplanes Using the Ames Flight Simulator for Advanced Aircraft. NASA Technical Note, NASA TN D-7106, March 1973.

Strauch, B. Factors Affecting Pilot Decision-Making in Rejected Takeoffs. Third Human Error Avoidance Techniques Conference Proceedings, SAE P-239:902344, December 1990.

HUMAN FACTORS TRAINING FOR AUTOMATION

LIFE IN THE SECOND DECADE OF THE GLASS COCKPIT

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Address before the ICAO Flight Safety
and Human Factors Symposium
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We now find ourselves in the second decade of the glass cockpit. I would like to give you a brief report card.

The decade of the 1980's saw a dizzying acceleration of flight-deck automation, enabled by the development of the microprocessor. Suddenly cockpit technology was running at fast-forward, but the human factors profession was not. In 1980 McDonnell-Douglas introduced the DC-9-80 (later called MD-80), which brought to the short and medium haul airliner avionic sophistication previously found only in wide-body transports. But technologically this was a small step compared to what lay ahead - when in 1982 Boeing introduced the 767, the first commercial aircraft with a glass cockpit and an advanced flight management system.

Coincidentally the decade of the 80's also witnessed the recrudescence of a type of accident that we thought was a bygone day: poor cockpit communication, inadequate performance of procedures, and faulty use of the checklist, or no use at all.

I have said before, and will continue to say as long as I can find an audience, that the most important safety device in the aircraft is not ground prox, is not TCAS, is not color radar, in fact does not come in a box at all. You can take it off the airplane and go down to your local quick xerox store, and for 3 1/2 cents they'll make you another one.

The checklist is the conductor's baton: it sets the tone, the rhythm, and the cadence for all that happens in the cockpit. Yes, it is a mere piece of paper, and the human factors profession has never had a high regard for paper - we like boxes - but the importance of the checklist and its associated behavior cannot be exaggerated.

I am happy to report that this class of problem has been brought under control, largely as a result of emphasis on procedural standardization (Degani and Wiener, 1990) and the cockpit resource management training now offered at most airlines
(Wiener, Kanki, and Helmreich, 1993).

Back to the glass cockpit. Glass displays are not merely computer-graphic replications of traditional instrumentation. They allow features that were never possible before -- six different pilot-selected modes can be displayed on the HSI, including one that enables the pilot to step through the waypoints one-by-one and display the course on the map, as a pre-flight check of lateral navigation. Pilots can select or deselect information to be displayed on the map, such as airports capable of taking the aircraft, navaids, and the like. Color radar can be superimposed on the HSI map, allowing a fusion of weather, present position, and lateral course information. This combination of weather and course information is regarded by pilots as one of the biggest advances found in the glass cockpit aircraft.

The latest models of glass aircraft, such as the 747-400, MD-11, and the A-320, can display system schematics for diagnosis and management. Other features enabled by glass displays include a path predictor vector, which shows where the plane will be 20, 40 and 60 seconds ahead, and the "green arc" which predicts at what point on the map the aircraft will reach its target altitude. The green arc makes a lot of difficult mental computations very easy. I can tell you from my field studies in the 757 and MD-88 that it is immensely popular with the crews. With the green arc, making a crossing restriction becomes child's play.

------- GLASS DISPLAYS -------

The glass cockpit was, and is, an ingenious development, a generation step forward in aircraft design. But it is not without its critics, of which I have been one (Wiener, 1988). In CRM training we distinguish between "critique" and "criticism." Criticism is all negative; critique balances the inevitable good and bad that one finds in anything that is carefully examined. I hope the reader will regard my remarks as critique.

In all fairness, before looking at the problems, let's look at the record, because it is quite impressive. No passenger has ever been killed or injured in an accident involving a U.S.-operated glass cockpit aircraft. There has been only one serious accident that I am aware of - a rejected takeoff resulting in damage to a 757 at San Jose, Costa Rica. The 767/757 have the best introduction record of any aircraft in history.

I must be brief today; let us look at some of the promises and problems.

------ CONCERNS OF THE GLASS COCKPIT -------

1) The interface is often difficult to operate, and confusion of the various autoflight modes is not unusual. I believe that it is true that every impartial investigator who has looked at the glass cockpit has discovered that mode confusion is a serious problem. The manufacturers have often brushed this off as a training problem. The distinguished researchers Don Norman and Ed Huchins call this the "blame and train" approach.

When well trained, well motivated, well standardized pilots are still confused about the implications of the modes they have selected, it is not a training problem; it is an interface problem.

2) Equally serious, the promised reduction in workload has not occurred. If anything, the result has been somewhat paradoxical, in that automation appears to <u>increase</u> workload when

it is already high, and decrease it when it is low. Time and again pilots that I have interviewed have reported that when the going gets rough, they "click it off" -- that is, revert to more manual modes of operation. This is a paradox.

When I take an observation flight in one of the glass airplanes, I always "break the ice" with a somewhat bland question to the captain. I say, "Captain, how do you like this airplane?" The response is stereotyped and predictable. It goes something like this: "I love this plane. I love the power, the wing, and I even love this stuff" (with a movement of the hand toward the flight guidance area of the cockpit - meaning the automation). And then he or she will add, "But I'll tell you one thing - I've never been so busy in my life." The operative word is busy. I hear it time and again. Suffice it to say that the relationship between automation and workload is not a simple one. Is this a training problem? No. It's an interface problem. Let me give you an example.

------- LAT AND LON WAYPOINT -------

3) A related problem is "head down" time in the glass cockpit. This is a tough one. Everyone who observes the crews in a glass cockpit is struck by the amount of time two heads are in the cockpit, especially below 10,000 feet, near an airport, at the point where the pilots need to be looking out the most.

Now I hope no one will be tempted to say that this is not a problem, since TCAS will protect you from other aircraft. That would be a classic example of what Renwick Curry and I, in 1980, labeled "primary-backup inversion" (the primary becomes a backup, and the backup takes over as primary)> ATC's responsibility aside, the primary cockpit device for collision avoidance, in VMC conditions, is the human eye, love it or not. TCAS is a backup.

I don't know the answer to the head-down problem. But I can assure you that it is not a training problem, it's an interface problem.

Head-down time may also turn out to be the undoing of datalink communication, which is right around the corner. Datalink displays, compared to voice radio communication, suck the pilots' eyes right back into the cockpit. Using traditional voice communication, the pilot can easily continue extra-cockpit scan, needing to look down only long enough to change frequencies, which they can do rather quickly.

4) Another problem in all forms of digital systems in error vulnerability. The glass cockpit is good news and bad news. The bad news is that it is very easy to enter erroneous information into the flight guidance computer. The good news is that the glass displays can make many errors, especially course errors, very apparent. This is what I call an "error evident" display. The system does not prevent the error -- but it makes it conspicuous. Let me give you an example and contains both the good and bad news:

------- TEPEE -------

5) I hear a lot of talk from my colleagues in human factors about "situational

awareness", the buzz word of the 90's, and the assertion that situational awareness suffers in the highly automated aircraft. Maybe the problem lies in the fuzzy definition of the term, and that is a problem, in fact you can bring a panel discussion on the subject to a stand-still by asking what the speaker or the panel what they mean by the "situational awareness". As I understand the term, I do not see an automation problem. It seems to me that situational awareness is enhanced, not degraded by advanced instrumentation. Look at all of the information available to the pilot in the enhanced displays that I have already described - think of the path predictor, the green arc, the ability to know (laterally) where you are at all times with respect to waypoints, navaids, the course, weather, and the airfield. Think of the ability to instantly locate the closest adequate airfield in the event of an extreme emergency. I have a name for what can be gained from that type of information: situational awareness.

Furthermore, in its ability to monitor and display system status, EICAS (note that I am using Boeing terminology; other manufacturers have their own names and acronyms for essentially the same systems) is a marvelous improvement over the forest of engine and systems displays, of warnings and alerts that we find in traditional cockpits. When it comes to aircraft systems, EICAS would have to be regarded as an enhancement of situational awareness.

Yes, it is possible to become overly dependent on automation, and lose track of what is happening, if that is what the critics mean by a loss of situational awareness. But as I understand the term I would give the glass cockpit high marks for enhancing, not degrading, situational awareness.

Ask any pilot who has made the "backward transition," returning to traditional aircraft after flying glass. This has become a serious training problem at some airlines, especially where senior first officers in glass aircraft transition to captaincy in traditional aircraft, such as early models of the 737, and the DC-9.

I have been polite enough to call the older aircraft "traditional". Pilots have some other terms for them:

------- NAMES FOR OLD COCKPITS -------

I believe that these facetious names show a certain contempt for the ancient cockpits, and reverence for the modern aircraft.

TRAINING

A word or two about cockpit resource management, and training for automation. I believe that the CRM movement will some day be viewed as one of the great advances in flight safety. I further believe that CRM, and its companion, LOFT, is particularly necessary and helpful in the advanced technology, two-pilot cockpit. The management aspects of flying the glass cockpit are demanding, and crew coordination of the two pilot crew is a serious matter. The value of CRM training has not be proven in any statistical sense, but it is there for anyone to see. On my report card, I would give high marks to the first generation of CRM and LOFT training, and look forward to what will be done in future generations.

Many U.S. airlines have experienced varying amounts of trouble with transition of crews from traditional cockpits to glass. Much of this is lack of preparation, and considerable apprehension, and in many cases misinformation on the part of trainees before they attend ground school.

One airline, Delta, chose to face that problem head on, but devising a new course entitled "Introduction of Aviation Automation". Every pilot transitioning to a glass airplane for the first time takes the course before ground school. It is model-independent; it is not a substitute for ground school -- it's purpose is to prepare the pilot for the training he or she will receive. Delta considers the course a big success, and it has numerous imitators. Delta deserves much credit to being the industry leader in this field.

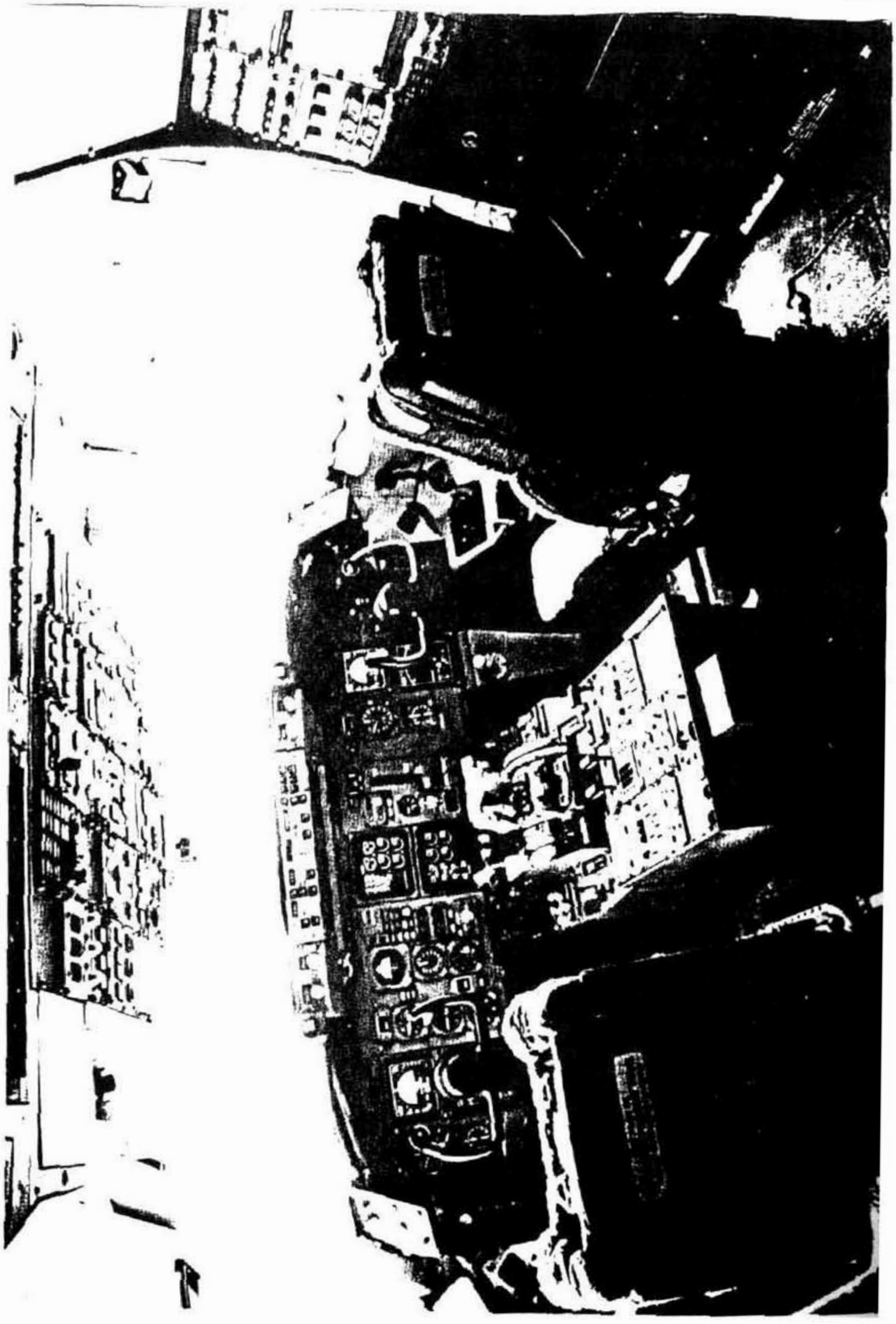
In conclusion, the glass cockpit will soon no longer be the "oddball" of the fleet, but the mainstay. I would give high, but not perfect, marks to the glass cockpit aircraft. Their safety record and reliability are impressive, and we have learned many valuable lessons about the impact of automation on pilots. More work lies ahead in improving interfaces that are difficult and time-consuming to operate, in fine-tuning flight training, LOFT, and CRM. There is no question in my mind that the industry is up to the challenge, and that automation will be the servant of the pilot and not the other way around.

REFERENCES

Degani, A. S., and Wiener, E. L. (1990). Human factors of flight-deck checklists: the normal checklist. *NASA Contractor Report No. 177549.* NASA Ames Research Center, Moffett Field, CA. May 1990.

Wiener, E. L. (1988). Cockpit automation. In E. L. Wiener and D. C. Nagel, *Human factors in aviation.* San Diego: Academic Press.

Wiener, E. L., Kanki, B. G., and Helmreich, R. L. (1993). *Cockpit resource management.* San Diego: Academic Press.



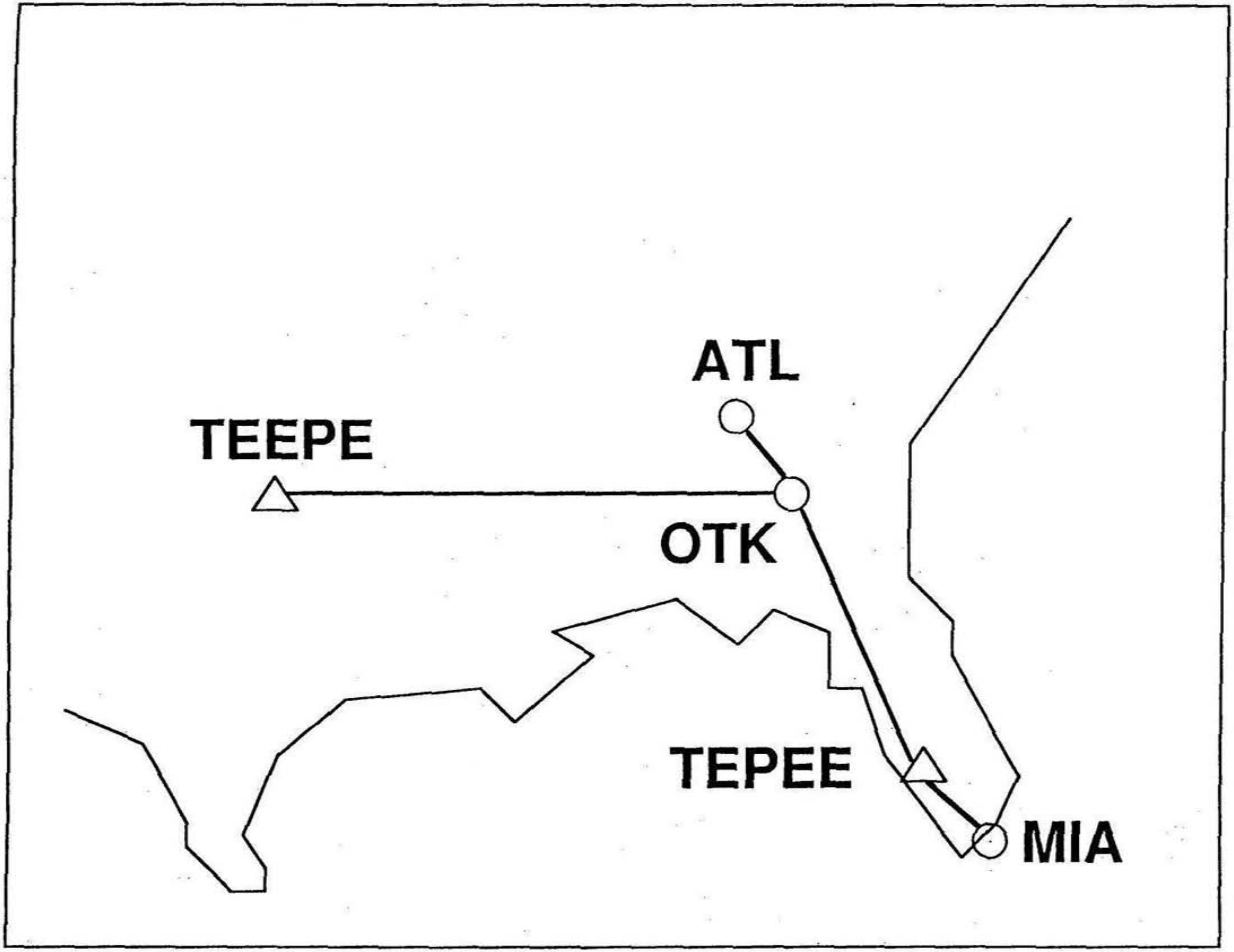
CONCERNS IN THE GLASS COCKPIT

- Difficult interfaces
- Workload management
- "Head-down" time
- Error vulnerability
- Situational awareness

LAT & LON WAYPOINT

"After Wilson Creek cleared direct 37 degrees, 45 minutes north, 111 degrees, 05 minutes west, then direct Farmington."

3745N/11105W   N3745.0W11105.0


ATL
TEEPE
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MIA

NAMES FOR TRADITIONAL COCKPITS:

Steam Gauge

Rope Start

Pterodactyl

MANAGING THE MODERN COCKPIT
A MANUFACTURER'S VIEW

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Managing the modern cockpit is a statement that applies, both to the way in which modern cockpit design is accomplished, and to the way in which pilots operate the highly automated airplane. In the context of this paper the modern cockpit refers to those Boeing airplanes which are equipped with features including advanced autopilots, Electronic Flight Instrument Displays (EFIS); advanced alerting systems; and a final feature that is most characteristic of the modern cockpit, the Flight Management Computer (FMC). Collectively, these design elements comprise what we at Boeing refer to as the Flight Management System (FMS). Airplanes with FMS's are often referred to as glass cockpit or high technology airplanes. The modern cockpit airplane is not really new; in fact, the 767 entered revenue service in 1982 and was a predecessor of other Boeing modern cockpit designs. Other airplanes with modern cockpits are the 757, the 747-400, and the later 737 series airplanes (the -300/-400/-500.) Of these airplanes, the 757 and 767 were all new flight deck designs and were essentially common. The 747-400 was also all new and incorporates improvements on the 757/767 flight deck design. The 737-300/-400/-500 are upgraded designs from much earlier flight decks. Collectively, these airplanes, as of December 31, 1992, numbered nearly 2,500 airplanes in revenue service.

Some have said that making available the modern cockpit is akin to letting the Genie out of the bottle. They suggest we have unleashed significant power but may lack the means to appropriately control it, or that the power or capability we have provided was not well thought out in the first place. One researcher has suggested that in the modern cockpit, people are not sure they understand what is happening. In fact, he indicated in his research the most frequently asked questions in the glass cockpit were: "What is it doing?" "Why did it do that?" and "What will it do next?.

Other questions have been asked by researchers and pilots regarding the modern cockpit. "Is pilot workload up or down?" "Is heads down time excessive?" and, of most concern of all, "Is the modern cockpit taking the pilot out of the loop?". The comment, "taking the pilot out of the loop" might be compared to the situation with the genie; who's in charge, the person who uncorked the bottle, or the genie?

When one makes an attempt to assess the success of the modern cockpit, one finds there is limited data available. However, accident statistics are available and perhaps are the most important data of all. After all, the principal objective, in terms of design of airplanes and in terms of their use, is safety.

To understand the influence of the modern flight deck on safety, let us begin by first looking at hull loss accident rates for the entire history of the worldwide commercial jet fleet. From the very late 1950's until the early 1960's the accident rate with such jet transports was comparatively high. We saw a dramatic decrease in accident rates during the period from the early to mid 1960's. The accident rate continued to improve until the mid 1970's but since then has seen only very slight improvement. For the past several years hull loss accident rates for U.S. operators have been in the neighborhood of or less than, one per million departures. For non-U.S operators the hull loss accident rates in recent years have been two to three per million departures.

To make further assessment of safety, it is next necessary to understand what the primary cause factors are for hull loss accidents. Data for the worldwide commercial jet fleet through 1992, shows that the flight crew has been found to be the primary cause factor in approximately 70% of all such accidents. The percentage of accidents for which the flight crew has been found to be the primary factor has decreased only slightly (approximately 5%) over the past 10 years. The airplane itself is the primary cause factor in only 11 to 13% of accidents. Clearly then; our most significant opportunity for improvement is in the human factors area and a major goal must be elimination of such human error as an accident cause.

Let us next look at accident rates as a function of airplane designs. First generation jet transport airliners, those designed in the late 1950's and early 1960's, airplanes such as the 707 and DC-8, had comparatively high accident rates, approximately five to six accidents per million departures. These airplanes were followed by another group of airplanes introduced in roughly a ten year period from 1963 to 1974, which included second generation airliners such as the 727, DC-9, and 737-100/-200 series. This grouping also includes airplanes such as the 747-100 /-200/-300 series, the DC-10 and L-1011. While accident rates for these airplanes is somewhat variable, they averaged rates in the neighborhood of one to two accidents per million departures.

The final group of airliners are those with modern flight decks. As indicated earlier, these airplanes entered revenue service beginning in 1982 and include the 767, 757, 737-300/-400/-500 series, and the 747-400. How have these airplanes fared? Very well indeed! The 767, the first of the airplanes introduced, had a hull loss accident rate at the end of 1992 of 0.35 per million departures, and the 757 had a rate of zero! The 737-300/-400/-500 airplanes with their somewhat less advanced flight deck designs had an accident rate of 0.57 accidents per million departures. Although the 747-400 has only been in service three years, like the 757, it had a zero accident rate. From review of this data we find the airplanes with modern cockpit designs have the lowest accident rates of all commercial jet transport airplanes.

It would appear something is happening which is very right with our modern cockpit airplanes. Perhaps a way to further illustrate the area of benefit is to look at rates for hull loss accidents which are crew caused. The 707 had a crew caused hull loss accident rate of just under four accidents per million departures. Second generation airplanes, the 727, early 737, and early 747, had an average crew caused hull loss accident rate of approx 0.60 per million departures. Airplanes with updated flight deck designs, the 737-300/-400/-500 series, had a crew caused hull loss accident rate of only 0.23 per million departures. And the all new flight deck designs, the 757, 767, 747-400 had a crew caused hull loss accident rate of zero! From review of safety related statistics, one can only conclude that the modern cockpit, from a standpoint of safety, appears to be serving the industry very well indeed.

Review of other available data, such as dispatch reliability, also indicates modern airliners are performing well. In fact, there is no data, particularly from a standpoint of safety, that would suggest major errors in design have been made or that significant design changes appear necessary. It is not my intent however, to suggest that all is well. ASRS and other sources of data indicate that there are situations where the modern cockpit is less than optimally utilized. Part of the reason the benefits of the modern cockpit are not fully realized is obviously related to its design. Therefore, we at Boeing are very much aware that continuous design improvement is indeed appropriate.

I, for one, however, believe that the most significant opportunities for improvement lie in the way that we operate modern cockpit airplanes and in the way that we train to them. However, before discussing opportunities for improvement in the way airplanes are operated and trained to it may be appropriate to first understand how the designs came to be.

When Boeing or other manufacturers design airliners they first develop candidate design for flight deck features and then expose those design features to customers. For example, the 747-400 during its design development was exposed to a large number of flight crew personnel. During this period over 400 flight crew personnel reviewed the proposed design concepts. Most of these flight crew personnel were from airlines and many of them were typical line pilots. Boeing's forthcoming new airliner, the 777, due in 1995, has also had its proposed designs reviewed by many flight crew personnel, as of March, 1993, over 400. In fact a total of 1,200 people, including pilots, have conducted such 777 design reviews. Remember this is an airplane that is still well over two years from entry into revenue service.

I do not, however, wish to suggest we simply listen to airline pilots and provide whatever it is they want. While this might initially satisfy the customer, it may also result in unwise decisions. Therefore, candidate designs offered by Boeing, and design changes made in response to pilot inputs must be consistent with good flight deck design philosophies and objectives. Nonetheless, design features are strongly influenced by users (pilots).

We at Boeing, among other design philosophies, strive for simplification, redundancy and fault tolerant system design. Error tolerant designs are important and we must be always cognizant of the workload imposed on the pilots. Most important of all, is that we appropriately design automation to meet the needs of the human pilot. It is our objective to achieve automation in flight deck designs that allows pilots to choose a level of automation appropriate to the task. Other objectives are to assure pilot awareness of the situation is preserved or enhanced and that appropriate feedback is present with regard to pilot inputs or action.

With such philosophies in mind, let us briefly look at changes that are typical in modern cockpit design. Horizontal Situation Indicators (HSI's) have long been the primary instrument by which pilots maintain the desired course or lateral flight path of the airplane. In modern cockpits like the 757/767, the HSI was replaced by an Electronic Horizontal Situation Indicator (EHSI). As we thought it important to preserve familiar instrumentation for the pilot, an EHSI display was made available that looked very much like the earlier generation electro-mechanical HSI's.

Modern electronic displays, however, offer us the ability to display optional information in the same display space. For example, while preserving much of the course related information found on early HSI's, the electronic displays allowed us to superimpose weather information on the same display, so that the pilot could see the weather information without the necessity to look at a separate indicator. Perhaps most importantly, it allowed us to display the literal equivalent of a pilot's navigation chart directly on the EHSI. So instead of simply displaying information, regarding whether one was left or right of a desired course, one could show a moving map of the ground based route and displacement of the airplane from that desired route. It was possible, at the touch of a button, to selectively display other information such as ground based navigation stations, airports, and optional routes. I believe the moving map display is one of the most powerful features in the modern cockpit. It has significantly increased pilot awareness of their position and may be the single most important factor in reducing controlled flight into terrain accidents.

Another feature of the modern cockpit that has significantly changed the way pilots do their job is the Flight Management Computer (FMC) characterized by an FMC Control Display Unit (CDU) provided for each pilot. These CDU's allow the pilots to access a number of different displays and to view or insert certain information. The FMC CDU puts incredible computing power into the hands of the pilots and allows them to manage the flight path of the airplane in a manner that is much more highly accurate than was achievable in previous generation airplanes. Further, it allows the flight to be flown in a manner that is much more optimal from an economic perspective than was previously achievable.

Other features associated with the modern cockpit are very sophisticated crew alerting systems (messages), as well as messages of high technology engine indications which alert the pilot when a parameter is beyond a desired limit. The very latest flight deck designs, such as the 747-400, have also integrated a great many flight deck displays into a single Primary Flight Display (PFD). This display integrates airspeed, airplane attitude, altitude, vertical speed, and heading information that, in previous designs, were all found in separate indicators. Putting such information on a single display is believed to enhance the ability of the pilot to easily and accurately monitor the information.

Another feature of modern cockpit designs are synoptic displays which provide system related information in a user friendly format. For example, a simplified schematic of the fuel system is provided which shows position of the valves and resulting flow of fuel from tanks to engines. While such information is generally available from other sources on the flight deck, these displays allow a great deal of information to be derived from a single glance.

In summary, the modern cockpit airplanes have significantly improved navigation capability and accuracy. Awareness of airplane position and its progress are obvious at a glance and route or tracking errors become much more obvious. We see improved system status and monitoring information available to the pilot, along with improved alerting and annunciation of airplane health. So with all these wonderful features is there a reason for concern? When users voice concerns the answer can only be yes, and I, too, admit there are areas of concern. However, I characterize the concerns in a slightly different manner and put them into three general areas.

My first concern is with the proliferation of information, the added capability. A great deal of information has been provided to pilots operating the modern cockpit. While this information adds capability, it also increases the amount of knowledge required to operate and monitor the equipment.

An example which illustrates my first concern is holding information provided on FMC's. Holding patterns have been with us for many years, long before modern cockpits were available, and have always presented a complicated and difficult maneuver for a pilot. Because of their complexity many pilots felt holding patterns were prime candidates for automation and were included in FMC's.

Such an automated feature looks like a tremendous advantage to pilots, and indeed it is. But, the automated feature itself is fairly complicated, as many options are available in order to respond to the many variables in an actual holding pattern. The holding page of the FMC can present a challenge to a pilot who has not utilized it in some time. Many such features are provided in FMC's and a number may be infrequently used. Therefore, a pilot who does not occasionally review such information to maintain proficiency may find it difficult to use the features. However, one alternative is to enter a holding pattern without the use of the FMC as was done on previous generation airplanes.

The second area of concern is the complexity of some automated features, such as those that accomplish highly sophisticated calculations which cannot be done by pilots.

An example of complexity that the pilot has difficulty understanding, is descent planning. During descent in an FMC a series of waypoints or fixes can be entered. At each waypoint or fix, the pilot has the option of selecting altitudes or airspeeds one wants the airplane to achieve. The FMC will then calculate an optional profile between each waypoint to achieve the best economy. A pilot can monitor the system to assure the desired altitudes and speeds are achieved, but the actual profile flown may be different than a pilot would choose. Such differences tend to frustrate pilots because they do not fully understand the choices the computer is making.

And a final concern with the modern cockpit is its accuracy and reliability. That's right, I said a concern is its high degree of accuracy and reliability. When something is highly accurate and highly reliable there is always the risk of complacency. In other words the pilot finds that it performs so well day in, day out, that they begin to expect it will always perform perfectly; they relax their vigilance and potentially fail to adequately monitor.

When designs offer incredible additional flexibility, capability, accuracy and reliability, one must be concerned about the adequacy of training and strategies for operation of the equipment. A number of concerns arise with regard to how successful we have been in these areas.

First of all with the modern cockpit, we sometimes find inadequate training has been provided with regard to focus on actual job accomplishment. Training has focused on repetitious accomplishment of individual procedures to achieve a high degree of proficiency but rarely are such procedures practiced in a realistic environment. Although some training programs include Line Oriented Flight Training (LOFT) or Line Oriented Simulations (LOS) using training scenarios designed to replicate the real world, such efforts are still relatively infrequent.

A second concern with training and operation is that we as an industry have been remiss in terms of defining strategies for the use of automation. Automation in many cases, has offered many optional methods of job accomplishment and only rarely have we indicated to pilots which methods are preferred. One pilot may, therefore, choose one method, while another pilot may make a different choice. When two pilots are flying together they may not reach the same conclusion regarding which method is optimal. In some cases the non-flying pilot has no idea which method the flying pilot will choose, and is therefore poorly prepared to monitor and backup the flying pilot.

Another area of significant concern is that we rarely tell pilots when not to use automation. In fact, we often use the automation in an inappropriate manner during training to achieve the desired degree of proficiency. For example, we have both pilots heads down using the FMC on final approach; a method we would never advocate in revenue service where one pilot should be heads up, looking out the window and monitoring traffic. Additionally, we may create the impression that problems or challenges are always to be solved through highly automated means, even when simpler means would be preferable.

Another area of concern in training and operations is little attention is directed to managing the Man/Man/Machine relationship. In this context the Man/Man/Machine is the captain and first officer and FMC. In previous airplanes, the flight path could only be managed by a high degree of communication by the captain and the first officer. Maps had to be viewed, radios had to be tuned, courses had to be selected, and both pilots had to work together to accomplish these activities. Further, due to the intracockpit communication necessary to accomplish the tasks, it was obvious to both pilots what actions were being accomplished. With an FMC, however, the captain can very easily manage the flight path of the airplane without the aid of the other pilot. Conversely, the first officer can do the same. In fact, a first officer who is highly proficient with the use of the FMC may usurp the authority of a captain who is less proficient or somewhat hesitant to use automation. Under other circumstances, one pilot may be managing the flight path of the airplane through the FMC without intending to exclude the other pilot, but fails to communicate what is being accomplished. The other pilot only finds out what is being accomplished after the fact by monitoring the FMC display.

We have always had a concern with regard to pilots working together in an optimal manner as a team to accomplish challenges present on the flight deck. The FMC allows improvement with regard to this human resource problem, or inappropriately managed, it offers the opportunity to isolate the two crew members on the flight deck in a manner that was not achievable before.

A final concern is inadequate mentoring during initial in-service operation. With previous generation airliners, the way pilots were trained to truly accomplish the job was for a more experienced pilot to supervise them or assist them during the initial stages of operation of the airplane in revenue service. While this principle or practice still exists, it has become much more challenging. Remember, many more choices and options are available to pilots and the challenge of teaching job accomplishment is heightened. The pilot who is supervising the new pilot during their entry into revenue service may also focus excessively on the use of automation to assure the newly qualified pilot is capable of utilizing it effectively. This again may lead to the perception that it is desirable to operate the airplane in the most highly automated way. Further, the pilot doing the supervision may have also not been properly trained in optimal use of automation and may offer little guidance in terms of preferred methods.

It is my belief that we as manufacturers have significant responsibility for the methods of operation of modern cockpit airliners and for the adequacy of training programs. The airplane design has significant influence on training programs and operational techniques. Additionally, the manufacturer offer airlines a set of recommended operating procedures and structures a recommended training program. Therefore, the manufacturer has a unique opportunity to influence the ways in which modern cockpit airplanes are operated.

Concerns also exist with regard to the influence of users of airplanes, principally pilots; who, at times, seem to have an insatiable appetite for more automation. On one hand, pilots say that they are concerned that automation is taking over, while on the other hand they ask for more and more features and more and more capability in the modern cockpit. We all know that users may be inadequate monitors of performance of highly automated systems, especially those that operate reliably and accurately day in, day out. But that in itself does little to inhibit some pilots from asking for more automation. Pilots also, at times seem to have an apparent and almost obsessive need to solve challenges through highly automated means, even when less sophisticated means would be preferable. It is difficult to understand why pilots make such choices, but it may be to prove to themselves that they are indeed in charge of, and capable of mastering the automation.

A final area of concern is related to human factors research. While such research is essential to future improvement, the potential for benefit is, at times, not achieved. Perhaps we are not as capable in the use of such data as we think we are, or perhaps we simply have a disconnect or failure to communicate between human factors researchers and those of us who must understand what they have to say.

We must be careful when viewing results of human factors research or human factors data to be sure it is indeed telling us what we think it is. At times a researcher may examine a problem without full awareness of outside influences. Or they may be only examining a sub-element of a problem and the entire problem must be examined before conclusions can be drawn. Also, problems may not be considered in the context of total system influences. This is not necessarily a deficiency on the part of human factors research, it is simply the result of much of such research being done in segmented fashion, attacking one challenge at a time. Human factors researchers may also identify a problem, but not determine its significance. Solving insignificant problems, through use of greater automation could add complexity without any real benefit. Not all problems deserve to be solved. We, as recipients of human factors research, may also mistakenly conclude that the human factors researcher is calling for us to solve a problem when the problem is only beginning to be understood.

It is also necessary to be aware that problem related data often relates to perceptions of problems. Surveys of pilots may be susceptible to such perception problems. If the question is worded in a manner that is vague, general, or non-specific, then the answers that one receives may be less than adequate to fully understand the problem. While perception of problems is important and often is the first step in understanding real problems, one must be careful to differentiate when perceived problems and real problems differ.

As previously indicated, I believe we have, in general, provided great benefit with the modern cockpit. Yet there are clearly opportunities for improvement and we must continue to seek optimal solutions to modern cockpit human interface problems.

There are cases where the equipment is not as user friendly as it could be, and there are cases where further optimization of designs is indeed readily achievable. But we must be very cautious to assure continued expansion of automation is consistent with actual human needs; that we are indeed solving problems in a way that results in benefit. We must be cautious to not add complexity, which has potential benefit that cannot be realized as a result of associated challenges of understanding or operating the automation.

With regard to human factors related data, we as a community must work harder to assure data which portrays problems is not vulnerable to misconceptions regarding its significance, the degree to which it is conclusive, or the extent to which it is applicable to solutions.

Without any changes to airplane designs, training programs offer potential for significant and near term benefit in managing the Man/Man/Machine relationship. We must assure flight crews understand appropriate practices for use of automation. Embedding human factors in training is one element that is absolutely essential to achieving this objective. We must structure training programs which cause the kinds of decisions, choices and activity which are appropriate to actual job accomplishment. We must create awareness of when or why tasks or operations are to be accomplished, create understanding of when non-use or limited use of automation is preferable. We should embed in our training programs scenarios that have outcomes which make it obvious to the crew how well they have performed as a team and how appropriate their choices or actions were. Often times the best lesson learned is one which you discover yourself.

The modern cockpit may not be perfect, but by any measure can only be termed a remarkable success. While there are opportunities for improvement in design that are appropriate to pursue, it is my position that there are far greater and more immediate benefits in us collectively focusing on operational and training strategies for managing the Man/Man/Machine relationship.

Indeed, we have unleashed the power and choices of the Genie and it is up to us to assure we are in charge!

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ФУНДАМЕНТАЛЬНАЯ ИНЖЕНЕРНАЯ ПОДГОТОВКА ЛЕТНОГО СОСТАВА, КАК СРЕДСТВО АКТИВИЗАЦИИ ЧЕЛОВЕЧЕСКОГО ФАКТОРА В АВИАЦИИ

Развитие современной авиационной техники и всей авиационно-транспортной системы существенным образом изменило содержание труда летного состава при подготовке и выполнении полета. Новые средства автоматизации управления самолетом, навигации и контроля работы функциональных систем берут на себя исполнение многих рутинных операций в пилотировании самолета и как отмечал доктор Котайт на предыдущем симпозиуме по человеческому фактору в Ленинграде, что "Современный линейный пилот является инженером по эксплуатации сложных авиационных комплексов". Высокотехнологичные кабины экипажа требуют меньшей физической рабочей нагрузки, однако предъявляют повышенные требования к проявлению познавательных способностей человека, умению вести контроль и принимать решения в нестандартных условиях полета. Сокращение состава экипажа до двух пилотов без бортинженера и штурмана существенно изменило технологию его работы и требования к уровню первоначальной подготовки пилотов современных транспортных самолетов.

Вместе с тем наблюдается стремление к сокращению сроков обучения и затрат на подготовку пилотов, упрощенный подход к обучению профессиональной регламентированной деятельности по инструкции, т.е. по принципу "знаю, что делаю", а не по принципу "знаю почему и зачем".

Ошибочно представление, что в руководствах, инструкциях, сборниках исчерпывающе описана регламентация деятельности по действиям в ожидаемых условиях эксплуатации и при возникновении особых ситуаций. Реальная эксплуатация самолетов протекает в различных условиях полета и настолько разнообразно влияние многих факторов на безопасность полета, что невозможно дать исчерпывающие рецепты на каждый случай.

Анализ авиационных происшествий и серьезных инцидентов показывает, что отсутствие глубокого понимания законов аэродинамики, принципов построения и работы функциональных систем зачастую создают затруднения в распознавании ситуации и принятию адекватных решений по парированию особых ситуаций в полете.

В качестве классического примера здесь можно привести катастрофу самолета Ил-62, происшедшую пятнадцать лет назад, в аэропорту Шереметьево, когда на продолженном взлете произошло ложное срабатывание сигнализации о пожаре двух двигателей почти одновременно. После появления первого сигнала бортинженер по команде командира выключил двигатель, затем через несколько секунд появился ложный сигнал о пожаре второго двигателя. Несмотря на то, что взлет производился ночью при максимально допустимой взлетной массе, а самолет еще не набрал безопасную скорость полета, командир принимает решение выключить второй двигатель, а бортинженер бездумно ее выполняет. В результате таких безрассудных действий произошло сваливание самолета. В данной ситуации экипаж не распознал ложного срабатывания системы сигнализации о пожаре (возникновение одновременно двух крайне редких независимых событий, как пожар одного и второго двигателя являются практически невероятным событием), а также не учел при принятии решения о выключении второго двигателя скорость самолета. Экипаж, состоящий из двух опытных пилотов, бортинженера и штурмана действовал только по инструкции: "Сигнал пожара - выключай двигатель" без анализа конкретной обстановки. Только незнанием программы и ограничений системы управления можно объяснить катастрофу самолетов А-320 и Ту-144 во время демонстрационных полетов во Франции.

Пилоту современного транспортного пассажирского широкофюзеляжного самолета вверяются жизни большого количества пассажиров и огромные материальные ценности, поэтому система первоначальной подготовки должна обеспечивать целенаправленное фундаментальное высшее авиационное образование, обеспечивающее развитие профессиональных мыслительных способностей, адаптацию выпускника к научно техническому прогрессу в авиации. При обучении пилотов основные затраты связаны с летной подготовкой, поэтому усиление фундаментального образования ненамного увеличивает общую стоимоть подготовки (слайд № I).

Важное значение в системе образования имеет ее гуманитаризация и гуманизация. Высшая школа должна не только давать узконаправленную подготовку, но и сформировать личность, воспитывать гражданские качества, научить современным формам межличностного общения, умению жить в быстроменяющемся мире, развивать способность осваивать новую информацию и принимать эффективные решения. Гуманистические идеалы в сознании молодого специалиста должны утвердиться как безусловные моральные нормы поведения, исключающие принятие безнравственного решения на любом этапе жизненного пути и прежде всего в профессиональной деятельности. В своем предсмертном письме физик-ядерщик академик Легасов вину за трагедию Чернобыля возложил на высшую инженерную школу, которая подготовила специалистов с технократическим замкнутым мировоззрением, с низким уровнем нравственной, общей и технической культуры.

Этим также можно объяснить те сознательные нарушения правил полетов, неоправданный риск в принятии решений, которые создают непосредственную угрозу безопасности полетов ни в чем неповинных пассажиров. Трагедии с самолетом Ил-62 в Гаване из-за безрассудного решения взлетать в условиях тропического ураганного ливня, с самолетом Ту-154 в аэропорту Тбилиси из-за заведомо превышенной взлетной массы и запредельно-передней центровки, пренебрежение предупредительной сигнализацией опасного сближения с землей при посадке в сложных метеоусловиях и другие авиационные происшествия заставляют нас пересмотреть отношения к воспитанию летного состава.

В отличие от существовавшей на протяжении десятилетий в летных училищах профессионально-прикладной подготовки летного состава в Киевском институте инженеров гражданской авиации внедрена новая система обучения летного состава, сочетающая гуманитарную, фундаментальную общенаучную, инженерную и профессиональную подготовку. Система была отработана в течение 15-летнего опыта подготовки бортинженеров на самолеты первого класса и сейчас трансформирована в систему подготовки пилотов-инженеров для воздушных судов нового поколения.

Новая система обеспечивает направленное на будущую летную профессию высшее авиационное образование специалиста. Научный потенциал Киевского института инженеров ГА, насчитывающий свыше 100 докторов технических наук, профессоров и около 500 кандидатов технических наук, доцентов обеспечивает фундаментальную инженерную подготовку, ориентированную на перспективу развития авиации. Уникальная учебно-лабораторная база института и летных учебных заведений Украины создает возможности глубокого познания авиационной техники, сочетать теоретическую и профессионально-прикладную подготовку студентов. Так, например, при подготовке бортинженеров на заключительном этапе обучения отработка операторских навыков осуществляется в течение семидесяти часов на функциональных и комплексных тренажерах. Затем приобретенные навыки и умения закрепляются в производственных условиях в процессе наземной и летной практик.

Эффективность разработанной системы убедительно подтверждена успешной деятельностью свыше 500 выпускников института, подтвердивших высокий уровень теоретической и практической подготовки, умении принимать правильные решения в экстремальных ситуациях, связанных с отказами авиационной техники в полете.

Приведу лишь один пример. Москва, аэропорт Внуково, 1990 год. Пожар второго двигателя при взлете самолета Ту-154. Диспетчер дает неправильную информацию "У вас горит третий двигатель". Бортинженер, выполняющий всего лишь третий самостоятельный полет, правильно оценивает ситуацию и действует в соответствии со сложившимися обстоятельствами.

Приведенный нами анализ деятельности выпускников института позволяет однозначно констатировать значительное повышение уровня безопасности полетов, не было ни одного серьезного инцидента, связанного с неправильными действиями наших выпускников.

В соответствии с принятым в Украине Законом об образовании в настоящее время у нас внедряется многоуровневая подготовка (слайд №2). На всех уровнях обучения обеспечивается целенаправленная авиационная подготовка, в том числе и в области влияния человеческого фактора на безопасность полетов. Первый уровень образования в течение двух лет обеспечивает общенаучную, гуманитарную и общеинженерную подготовку. На этом этапе формируются необходимые навыки самостоятельной учебной работы, обеспечивается развитие интеллектуальных способностей обучаемых.

По результатам конкурсного отбора на втором уровне продолжается гуманитарная и инженерная подготовка, а также профессиональная, в том числе летная, подготовка, обеспечивающая получение диплома бакалавра по эксплуатации воздушного транспорта и свидетельство младшего специалиста (пилота, бортмеханика). На этом уровне обеспечивается фундаментальное инженерное образование по профилю специалиста.

Третий уровень представляет возможность углубленной профессиональной подготовки и квалификации дипломированного специалиста (пилот-инженер, бортинженер).

При построении дидактической системы подготовки специалистов в основу была положена концепция деятельностного подхода к обучению и воспитанию будущего специалиста и личности, способной к самосовершенствованию. При этом приоритет дается принципам обучения, позволяющим развить профессиональные мыслительные способности и умения действовать в нестандартных ситуациях. С этой целью в дополнение к традиционным дисциплинам введены такие как логика, теория принятия решений, практическая психология и валеология, летная эксплуатация и безопасность полетов. Предусмотрена система диагностики профессионально важных и опасных качеств будущих специалистов и их коррекции в процессе профессиональной подготовки. Разрабатываются специализированные тренажеры, способствующие формированию профессиональных мыслительных способностей и навыков принятию решений в особых ситуациях полета.

Формирование учебных планов и программ производилось на основании модели специалиста с учетом требований прогноза развития авиации и квалификационной характеристики специалиста.

В настоящее время институт готовит на восьми факультетах (слайд № 3) инженеров по 35 специальностям и специализациям для более чем 80 стран. Имеются резервы для подготовки авиационных специалистов различного профиля на достаточно льготных условиях (1500 - 3000 долларов в год за теоретическое обучение).

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The other side of automation - A challenge for pilot training

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1. SITUATION

Before we can answer the question, how to train pilots for modern cockpits, we have to look into the technical specialities of the advanced technology flight deck, and its effect on the crew.

What we first notice in a modern cockpit, are the flight data display and arrangement, the refined simplicity of the control panels and the high degree of automation. This has given the crew better situational awareness and a reduction in the workload.

2. THE NEW RISK FACTORS

2.1. The complexity and interdependability of the cockpit systems

With the help of automation, faults are generally easier to deal with. Some examples here are synoptic displays, ECAM, flight warning computers and dark cockpit philosophy. Due to the high degree of integration, however, we're beginning to see previously unknown faults, which lead to unexpected combinations of warnings. This actually makes it more difficult to analyse what has occurred. It's not easy to say what effect this has on flight safety, the complexity tends to muddy, or black out completely the clarity of system status.

Faults in complex systems can have more serious results than in simple systems, and they're more difficult to track down. Paradoxically there's an old aviation adage which sums it up: 'The higher you go - the further you fall!'

2.2. Extreme variations in work load

The increase in automation has led to the pilot no longer playing an active role in the system. On longrange flights especially, the problems of boredom and monotony have increased. The obvious human reaction is carelessness and premature fatigue. (When I look around the hall here... I can see you're getting my message!).

If, on the other hand, events depart from programme, peaks of workload occur, which are difficult for the crew to deal with. This is directly attributable to the mass of automatic actions happening in a modern cockpit, thousands of potential faults, waiting to be dealt with.

2.3. The shortcomings of softwaredriven systems

On softwaredriven systems, we're getting isolated, non reproduceable faults. They are often caused by electromagnetic interference, and aren't the type of defect we've been used to. They're not irreparable faults - we're seeing unique appearances, which then repair themselves. These defects are inherent in the systems, and the crews often give up when faced with them, and never do find out what caused them.

Faults in software, even when discovered, aren't so easy to repair. Changes in the software are often accompanied by new faults. The data banks - basis of the digital technology, have become so huge, that it is almost impossible, to keep them free of faults. By all this, we can see that all the precision which we believed to be inherent in digital systems, is in fact based upon blurred, faultridden information.

The built in software dictates more and more the operation. If the crew wants to fly something other than what is programmed, they either have to forgo any support from the automatics, or they have to do some very clever juggling, to get the system to play along.

2.4. The erosion of good airmanship

The introduction of fly by wire has made it possible to define a flight envelope, which the pilot is unable to exceed. This... well..'wing clipping' together with the fact that the control inputs of the pilot are refined by a computer, raise the question of the influence of the pilot in a system such as this. The user friendly panels allow the pilots to push buttons according to the rules of play; they won't let people get any closer to the system 'though. It's this sort of thing, which makes a pilot begin to think that 'maybe someone else is in charge here!' There's a distinct danger that he'll, at least in part, abdicate his responsibility for the operation of the flight. It's important, in this connection, that not only the manufacturers, but the operators too, are clear in their minds, that the responsibility for having a function carried out correctly is met by the man, irrespective of whether the man or the machine carries the action out. (Here I should point out, perhaps, that I am using the term 'man' in the generic sense, to mean what these days in Washington, is called a 'person').

Actually, it can be proved, that pilots let automatics get away with actions, which they would not have accepted from humans - including themselves.

Having such a large amount of systems, it's necessary - and the general dependability reinforces this attitude - that the pilot must place a lot of trust in them. This fact undermines his natural healthy mistrust. It's getting more difficult for Joe Pilot to know where he can place his trust and where not. As technology gets closer to perfection, we notice a certain carelessness creeping in, which we certainly don't want in aviation.

Largely as a result of cockpit layout, there is a danger of too much headdown flying, with a consequent deterioration in lookout.

It's long been proved, that the increase in automation discourages hand flying. One's confidence in one's own flying skill is reduced. If we switch off the automatics, especially if they have been operating at a high level, we lose some of the picture. This has tended to lead to a reluctance to switch off the autopilot, autothrottle, or whatever, although a difficult situation could have been more easily mastered in this way.

3. POSSIBLE SOLUTIONS

There really are some useful areas where we can try to eliminate the negative manifestations of the trend outlined. Here they are:

- By improving the contact between man and machine with a human orientated bias.
- By changing traditional operating policies, to adapt to the technology at hand.
- By improving the communication between maintenance and flight operations (a 'whizz kid' is not necessarily the best Technical Pilot - a straight soldier may see a fleet problem earlier).
- By solving software problems more quickly.
- By adapting the ATC system to the cockpit technology, in order to make the most of its potential.
- By training the crews and engineers in a more suitable way.

4. TRAINING CONSEQUENCES

The problems we have seen can't be solved solely by improving the man machine interface, although human orientated development philosophy is gaining in importance. Right now, however, I intend to concentrate on cockpit crew training, which is all the more important, since there's no immediate improvement to be expected from the technical sector. We must learn to accept the disadvantages, which presently go hand in hand with the new technology, and to deal with them.

4.1. The Extent of Training Needed

Flight training will have to be carried out as it always has been. In addition, every new automatic system created to ease the pilot's job, must be fully understood by him; if it goes unserviceable, the man has to take over the function of the machine. The consequence is more extensive training. The training quality must improve, if the time required isn't to increase.

Lets's now see, what top quality instruction entails.

4.2. Instructional Methods

Traditional training methods are no longer suitable for teaching modern aircraft systems-handling. What we used to do, was give the trainee a picture of the whole, by teaching him about each individual part, like making a jigsaw puzzle. This method is too demanding for a student, faced with modern complex systems. You see, in the dynamic state, there are so many different ways in which the subsystems interact with each other, that it isn't possible to achieve a general view, from the standpoint of the individual components.

A much better way of going about it, is total immersion introduction. In this method, the aircraft is presented as a whole. From the very beginning the aircraft is flown and operated by the student. The operational experience he brings with him, is continually added to, and as the logical relationships between the systems are understood a solid base of knowledge is achieved, which remains in the memory (the learning by doing approach).

Typical for a course based on this method are:

- The intensive use of simulators from the earliest stage (full flight or fix-base simulators may be used here).

- CBT or computer-based training, which is especially suitable apart from other reasons, due to the obvious possibilities for animation in the graphics.

- LOFT or line orientated flight training, in which the connection is made to daily operations, so that crews can use their line experience to assist their personal learning curve.

4.3. Complexity

In the future, computer technology as a pilot's subject is going to be imperative. The assembly, functioning, then data transfer conformity of software driven systems must be understood. It's also important, to know about system redundancy, the effect on behaviour, of bugs in the system and to understand all about available computer modes.

Integration of systems, has become a science of its own.

4.4. Resource Management / Human Aspect Development

The most efficient use of all the resources available (more of them all the time) has increased in importance in the modern cockpit. The best method to train resource management (and here we mean not only the systems, but the combined brain power of the crew) is in LOFT training in the simulator.

Good crew teamwork is the irrevocable prerequisite for safe operation. A modern cockpit offers many different ways of solving a problem, which requires optimum crew cooperation and communication. (What's he going to do? What does he want me to do?). Here people are involved, with all their strength and weaknesses, who have to get along together. If we look at the man as an integral part of the system, we see that CRM-Training or HAD-Training (human aspect development as we call it) has become a necessity. Technical training is no longer enough.

4.5. Self confidence

Recurrent training courses must be set in a way, that every pilot has confidence in his flying ability. The manual option has to become a genuine one, under any condition.

For longrange crews flying enlarged crew missions, extra simulator training may well have to be offered.

If pilots are not to feel defeated by the advanced technology flight deck, a high degree of self discipline is required. Only those who refuse to be intimidated into working in the same way as a machine themselves (which today's cockpit technology makes the pilot do) can make use of the strength of the human in the system. There will only be genuine redundancy, when the pilot behaves as an intuitive decision maker in the man/machine system. He can only do this, when his level of knowledge is high enough, and when he is well trained. We can stop the erosion of good airmanship by bolstering our pilot's confidence in their ability.

TRAINING FOR COMPUTER ASSISTED FLYING (CAF)

Captain Matti Sorsa
IFALPA

1. Training in the systems context

Training is an integral part of the life and career of any airline pilot. Unlike many other professional people airline pilots regularly go through various training sessions practically until they retire.

Computers is another essential element in the everyday working environment of the airline pilots whether we like it or not.

It is thus more than natural that the International Federation of this aviation community is very interested in the combination of these two crucial issues: computers in the aircraft and training for their use.

IFALPA is very grateful to have the opportunity to present the views of professional airmen in this ICAO Symposium of greatest importance.

It is necessary to understand that training has no independent value as such. Training is a part of the system well described by Dr. James Reason. In this system earlier decisions concerning hardware and software design of equipment, procedures and company policies behind them as well as overall socio-economic climate will dictate most of the end-result, the flight safety.

Training during this process is indispensable, of course. But it has definite limits. It should not be misused as a cover-up of wrong decisions. Pilots are by definition extremely adaptable. They will probably learn to fly anything that has some sort of wings. But human adaptability should not be used against humans. What does it really prove that pilots have passed conversion courses to advanced technology airplanes? Not much. Perhaps that with strong motivation you can pass almost any course. It certainly does not prove that these aircraft have been designed in a manner suitable for human operators or that the training system is optimal.

Training is too important to be used as a trash-box. It is irresponsible and intellectually lazy to argue: well, training can handle this or that when decisions are immature or simply wrong. In addition, if the training sub-system in itself is badly designed the unfortunate trainee shall then carry the burden of the sins of all involved, from the ignorant to the nonchalant.

2. CAF and its specific demands for training

Computer Assisted Flying (CAF) is a term we in IFALPA prefer for automation. The basic function of the pilot has not changed too much. The pilot is still the human tasked to be responsible for the safe and economic execution of the flight. Just think about the 100% freedom of the pilot not to do so.

Technical assistance to the piloting task has changed a lot during years, of course. At the moment the order of the day is the assistance provided by the computers. We think that the CAF is an accurate term to describe the relationship between the pilot and the automated technology.

When components change in any technological system, training should reflect that change. But it would be simplistic to approach this requirement by concluding that training should aim at these new components only, in this case computers and their direct effect on the autopilot. And yet, this has been the case in many instances.

> Back in 1981 a major U.S. carrier started their B767 conversion courses with the idea that the students should program the FMS from the first training period. The first periods were 90% of time concentrated attempting to learn the FMS and 10% learning to fly the simulator. Only after a couple of years the established B757/767 pilots managed to convince the training department that the first few simulator periods should be devoted to manual flying. When this conceptual change was executed an immediate lower rate of failures - and happier students - resulted.

The CAF is a major conceptual change in the over-all operation of the aircraft. It is a new way of thinking having wide implications from the flight planning phase to all aspects of the actual flight operation. Our B767 example is a reminder of the way the conceptuality of the CAF was underestimated in the beginning. Either the conversion course was handled with the same old syllabus plus some isolated facts about these new gadgets. Or even worse, the conversion course handled the basic airplane as a kind of a secondary system and concentrated on teaching these new magic things. The result was a lot of rather horrid flying along the infamous magenta line.

The CAF demands a new way of thinking. Due to its inherently totalistic nature it is essential that the training takes the operation of the aircraft into account very early in the instruction of the hardware and software. In practice the training for the CAF should integrate this level of technology to the decision-making, communication and leadership concepts.

Computers have a profound effect on the workload distribution and time-sharing, long and short term. If these elements are not made clear from the beginning the students will get a twisted and over-optimistic picture regarding the role of this equipment. Incidentally, this aspect has another implication. Only the real-world operator can competently teach these skills of the new technology to the future operators.

3. Learning to use the computers

Training upwards along these lines requires that the training system uses intelligently and economically the CBT (Computer Based Training) and FTD (Flight Training Device) opportunities. The fact that these devices are not airplane look-alikes should not make us think that the operational aspects can be left aside. Quite on the contrary. The computer used without operational emphasis is a fairly worthless thing for an airline pilot.

Next aspect of this CAF training is that it should be aimed at crews not individual pilots. Typically the errors in the use of computers are crew errors or mistakes. All traditional CRM concepts should be present when learning how to fly effectively assisted by computerized systems. The instructors should be line pilots specifically trained at the questions of the human interaction in the flight deck. The computer system specific problems related to the cockpit communication and workload distribution should become clear before even approaching the very expensive FFS (Full Flight Simulator). In the FFS the most effective way of teaching and honing these skills is the LOFT (Line Oriented Flight Training). It should appear very early in the syllabus and carry the main burden of that phase of training.

Perhaps the most important phase of the CAF training is, however, flying the line with the route instructor. This practical familiarization phase requires that the right people are carefully selected for this task of route instructors. Their training is worth of a major investment, because their deep understanding of the system implications in the CAF determines how the new pilots learn to use the computers in an optimal manner. As the very nature of the computers implies abundant degrees of freedom to the conduct of the flight it is essential to learn early which applications are safe and efficient and which not. Otherwise the risk-analysis of the new pilots may not be based on realistic presumptions. The freedom of choices is not a negative factor as such. It can enhance the performance of the pilots by making the work more creative and satisfying. The only problem is that as there are so many alternatives and as you do not really know all the software combinations it is very hard to learn by trial and error what you can do and what you should not even try.

4. Learning to live without computers

When especially aircraft manufacturers train pilots their natural emphasis is on the positive aspects of the new technology. It is however equally important to learn how to fly without these new aspects of controlling the airplane. In fact, redundancy is one of the key words of flight safety, now perhaps more than ever. In the CAF there are two distinct kinds of redundancy, voluntary and involuntary.

Voluntary redundancy is the basis for the intelligent operation of the aircraft. From the Human Factors point of view the issue is the control of the cockpit workload. As all line pilots well know the computers create their own particular kind of a workload pattern. Sometimes it is painfully far from the optimum. Thus for instance the computers have a well-recognized tendency of setting the workload level ultra low during cruise phase of the flight. Equally, during approach these modern wonders can demand so much attention that pilots have too little mental energy left to the rest of the operation.

This is where the voluntary redundancy can really save the day. We should never forget that computers are there to help the pilots to fly the aircraft. Learning from the beginning when to switch off totally or partially is a major component in the ability to operate the aircraft in a professional manner. In this kind of a learning the LOFT is probably the most effective training tool. Living through situations where it makes sense to revert to manual functions in order to optimize the workload is a major learning experience. Training should give the pilots mental models and preparedness to reduce the level of automation when needed. Desperate clinging to the automated devices is not a sign of professionalism.

The age-old cross-checking concept is another form of the voluntary redundancy in action. There are too many examples of Standard Instrument Departures (SID) flown by the computer and never independently checked by the pilots.

> The famous Bombay SID confusion was reported by one of our senior members: In Bombay there is a departure called SUGID 1. Now, if you try to find that in your FMS page you quickly run into something abbreviated SG1. The next page would give you SUGID1 if you ever got that far. You should. SG 1 is quite another SID called SONGADH 1. The consequences of this situation when actually flown without redundant cross-checking are obvious to this audience.

Involuntary redundancy is another training issue. When the computers gracefully leave you when you most needed them the training really should have given you ample amount of mental models in order to cope with the situation. We should tell the new pilots that these devices may not always work as advertized. The surprise is most unpleasant if the training has always emphasized the maximum use of automation. That kind of a training concept is totally unfair to the pilots. This requirement for preparing pilots to operate with different levels of automation is nothing more or nothing less that the good old back-to-basics training principle. The issues of cockpit communication and workload control are particularly relevant here.

5. Summary: Training operational wholes

We pilots feel that flying advanced airplanes, flying assisted by computers requires a truly integrated training approach. Operational implications of the various levels of automation chosen or available for use should be made clear from the start.

Mental models are learned in realistic training scenarios (LOFT).

The use of the modern training technology (CBT,FTD) combined with the experience of real-world line operators as instructors is a basic requirement.

The CAF can bring a lot of enjoyment to the work of the pilot and thus raise the level of his performance if all the available degrees of freedom are utilized. Training should make this utilization possible.

Redundancy training back-to-basics is another aspect too easily forgotten.

All in all we think in IFALPA that good training will create positive attitudes to the good old flying - this time assisted by not only your fellow airmen but also by the computers.

Совершенствование процесса отбора и подготовки диспетчеров автоматизированных систем управления воздушным движением (АСУ ВД)

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В последнее десятилетие наметилось отчетливое усложнение задач, решаемых диспетчерами УВД. Труд авиадиспетчеров становится небезопасным для них самих. Значительно учащаются и омолаживаются многообразные проявления церебро-висцеральной патологии. Это не может не сказаться на эффективности и надежности "человеко-машинных" систем. Нет сомнений в целесообразности проведения комплексных, динамических, многофакторных исследований роли человеческого фактора (ЧФ) в безопасности воздушного движение (ВД).

Высокая психоэмоциональная напряженность и сложность труда авиадиспетчеров определяется большим количеством факторов. К ним относятся такие , как выраженная неравномерность рабочей нагрузки, необычайно высокая ответственность за безопасность пассажиров и воздушных судов, крайне выраженная стохастичность ВД и метеообстановки, дефицит времени для принятия решений, гиподинамия, нарушения циркадного ритма и др. Это является обоснованием необходимости пристального внимания к здоровью авиадиспетчеров, улучшение условий их труда и жизни со стороны руководства и медицинской службы.

Для объективного доказательства того, что работа по управлению воздушным движением (УВД) инициирует выраженное напряжение психической сферы и основных физиологических систем организма, нами были разработаны стратегия и тактика оценки функционального состояния и уровня здоровья авиадиспетчеров. Сущность ее заключается в комплексном динамическом психологическом, психофизиологическом, физиологическом, гематологическом и биохимическом обследовании диспетчеров в двух фазах деятельности - в свободный от работы день и в разные периоды реальной деятельности по УВД с регистрацией более 70 переменных с применением тестирующих нагрузок. Это позволило объективно подтвердить развитие достоверных признаков почти постоянного выраженного интеллектуального и эмоционального напряжения под влиянием профессиональной деятельности по УВД.

Для обеспечения высокой эффективности труда диспетчеров, сохранения в течение длительного времени на высоком уровне их работоспособности и здоровья, а следовательно и надежности и безопасности УВД, потребовалось проведение углубленных систематических междисциплинарных исследований деятельности авиадиспетчеров в составе автоматизированных систем УВД, в которых именно на авиадиспетчеров ложится основная нагрузка по принятию решений. Вместе с тем возможности ЧФ в системах УВД не безграничны и необходимо иметь адекватные критерии оценки уровня работоспособности и толерантности человека к особым условиям труда и иметь средства управления ими. Сделать это возможно лишь при системном исследовании качества выполняемой работы, психофизиологической и физиологической "стоимости" ее с целью своевременной коррекции возникающих нарушений. Под "стоимостью" здесь мы понимаем различные затраты организма на обеспечение профессиональной деятельности.

Многолетние комплексные исследования большой популяции (более 500 человек) авиадиспетчеров и курсантов авиатехнических учебных заведений в разные фазы и смены реальной деятельности по УВД и вне ее, а также в процессе обучения этой профессии, показал, что диагностический процесс надо начинать с обследования вне рабочей деятельности и привычной обстановки, т.е. в выходной день. Это позволяет получить "базовые", исходные данные функционального состояния обследуемого,т.н. "точку отсчета" для последующей оценки влияния самой профессиональной деятельности на организм. Используя эту тактику исследования, нами было установлено, что уже перед началом рабочей смены, после предсменного инструктажа обнаруживаются статистически достоверные признаки "предстартового" интеллектуального и эмоционального напряжения, в основе которого лежит условно-рефлекторный механизм. "Предстартовое" напряжение удалось выявить лишь при сопоставлении показателей до начала смены с таковыми в выходной день при "базовом" обследовании. Далее, истинные сдвиги в психической сфере, в физиологических и биохимических системах, зафиксированные после окончания смены, выявляются при сопоставлении их как с исходными до смены, так и особенно с "базовыми" данными. Только такой двухфазный подход к диагностическому процессу позволяет объективно зафиксировать наличие у диспетчеров выраженного интеллектуального и эмоционального напряжения, инициируемого профессиональной деятельностью по УВД.

Нами было отмечено,что характер изменений на разных уровнях целостного организма, обусловленных профессиональным напряжением, был неодинаковым в различных возрастных группах диспетчеров. В сравнении со старшей возрастной группой, у молодых (до 30 лет) в меньшей степени ухудшались показатели функционального состояния сердца, существенно выше были показатели сократительной функции сердца (по данным УОС и МОК). В группе диспетчеров "успешных" по показателям профессиональной деятельности предсменные изменения были выражены в меньшей степени, нежели у "неуспешных". С помощью разработанной нами методики все обследованные диспетчеры были разделены на 3 группы по качеству профессиональной деятельности:успешные, средне успешные и неуспешные.

Был проведен анализ изменений в анализируемых системах во всех трех сменах работы. Оказалось, что как в "предстартовой" фазе, т.е. до начала смены, так и под влиянием работы по УВД наибольшие сдвиги отмечены в случае работы в ночную смену. Это, очевидно, связано и с резким нарушением биоритма, и со снижением активации защитно-приспособительных механизмов. Именно по завершении ночной смены зафиксированы наибольшие изменения показателей центральной гемодинамики (функции сердца) и периферической (мозгового кровообращения). Уже перед началом ночной смены у 60 % обследованных диспетчеров систолическое (максимальное) артериальное давление достигало 130-175 мм рт.ст., а диастолическое (минимальное) было в пределах 90-100 мм рт.ст. Одновременно отмечены наивысшие среднегрупповые значения МОК и УОС, а также наихудшее состояние мозгового кровообращения. Установленный факт привлек наше внимание, и нами были разработаны специальные методы и средства коррекции функционального состояния и работоспособности при работе в ночную смену.

Детальный анализ статистически обработанных результатов комплексного обследования большой выборки диспетчеров позволил нам выделить и подробно описать два альтернативных исхода адаптационных реакций организма на профессиональное интеллектуально-эмоциональное напряжение. Это эффективный и неэффективный типы адаптации, влияющие на успешность, надежность работы в системах УВД и здоровье диспетчеров. Ведущим фактором, лимитирующим процесс адаптации, является уровень резервов толерантности к профессиональному хроническому интеллектуальному и психоэмоциональному напряжению. Последнее наиболее отчетливо выявлялось при применении специфических и неспецифических нагрузочных тестов до начала смены, по ее завершении и в свободный от работы день.

Эффективная адаптация к профессиональному напряжению имела место лишь у 25-30 % обследованных диспетчеров и проявлялась в устойчивости психологических, психофизиологических, физиологических и обменных процессов под влиянием работы по УВД. У этой популяции диспетчеров сдвиги в анализируемых системах к концу рабочей смены имели кратковременный обратимый характер и, что очень важно, отсутствовали признаки "последействия" в свободный от работы день. Все это указывало на высокую толерантность (устойчивость) у эффективно адаптированных диспетчеров к профессиональным факторам напряжения, что и обеспечивало успешность операторской деятельности, сохранение психического и соматического здоровья.

Иначе обстоит дело в группе диспетчеров (их 30-45%), неэффективно адаптирующихся к профессиональному фактору напряжения вследствие низких резервов толерантности к нему. Важно и то, что у этой группы диспетчеров низкой была толерантность и к мышечной нагрузке (например, это выявилось при велоэргометрической пробе). Признаки неэффективной адаптации проявлялись как в фазе достаточно выраженной предсменной активации психологического статуса и физиологических систем организма, так и по завершении смены. Крайне неблагоприятным фактом является состояние "последействия" в свободный от работы день. У неэффективно адаптированных диспетчеров во время работы отмечались ложные срабатывания, ошибки типа "пропуск", снижение внимания и его распределения между наблюдаемыми объектами, неоптимальное проявление функций мышления и памяти, снижение успешности профессиональной деятельности и работоспособности. Наиболее закономерно эти отклонения выявлялись при экстремальных ситуациях, при высокой интенсивности ВД или при монотонной работе (например, в ночную смену).

Следует особо подчеркнуть, что неэффективный тип адаптации к особенностям профессиональной деятельности по УВД наряду с нарушениями в психической сфере сопровождался многообразными нарушениями функционального состояния сердечно-сосудистой системы в виде учащения сердцебиений, повышения артериального давления при одновременном значительном снижении сократительной функции сердца, в ослаблении процесса стабилизации ритма сердца, что зафиксировано при телеметрической регистрации ЧСС в течение всей рабочей смены. Перепады частоты сердечных сокращений при этом находились в диапазоне 50-160 ударов в минуту и более даже при невысокой интенсивности ВД. Имелись и признаки нарушения регионарного мозгового кровообращения. Все эти сдвиги приводили к формированию артериальной гипертензии или нейроциркуляторной дистонии. У ряда диспетчеров этой группы повышалась свертывающая активность крови, концентрация адреналина и атерогенных липидов. Недостаточная толерантность к интеллектуальному и эмоциональному напряжению приводит к формированию широкого "набора" факторов риска развития заболеваний и, в первую очередь, сердечно-сосудистой системы (преимущественно к гипертонической болезни), нарушению психического здоровья с признаками нервно-психической неустойчивости, к снижению надежности деятельности и сокращению профессионального долголетия.

Многолетняя работа сотрудников нашего коллектива под руководством и при постоянном участии профессора, доктора мед. наук КАНА Г.С. по оценке состояния диспетчеров, работающих на неавтоматизированных системах УВД и в разные сроки адаптации к АС УВД после их внедрения в наши аэропорты позволили получить объективные доказательства облегчения многих сторон деятельности при работе на АС УВД и улучшения условий труда после введения автоматизации. При этом зафиксировано снижение уровня нагрузки на многие психические и физиологические процессы. Вместе с тем обнаружены и некоторые негативные последствия работы на АС УВД. Это особенно касается высших психических и эмоциональных функций и системы кровообращения. Диспетчерам, работающим на АС УВД, должны быть предъявлены повышенные требования к профессионально важным качествам (ПВК). Они должны обладать способностью обеспечивать необходимую актуализацию психофизиологической, метаболической и защитной сфер, высоким уровнем успешности деятельности, наличием хорошего уровня функционирования регуляторных механизмов организма. На хорошую успешность работы по УВД в автоматизированных системах можно надеяться лишь при наличии у диспетчера необходимого набора и должного уровня развития ПВК. Под профессионально важными качествами при этом мы понимаем качества человека, без определенного уровня развития которых невозможно успешное выполнение профессиональных обязанностей специалиста УВД в плане обеспечения безопасности полетов.

Роль этой составляющей в надежности диспетчеров в контуре УВД чрезвычайно велика. Психофизиологические и медицинские обследования диспетчеров в лабораторном эксперименте с помощью технических устройств, моделирующих отдельные элементы и фрагменты деятельности по УВД, и в полевых условиях при непосредственном выполнении функциональных обязанностей по УВД позволил нам выделить 3 группы необходимых ПВК - морально-организаторские, психологические и психофизиологические, медико-биологические.

1. Морально-организаторские. Это глубокое понимание своего профессионального долга и ответственности, честности, принципиальности, дисциплинированности, самокритичности и выдержки.

2. Психологические и психофизиологические. Это хороший уровень развития интеллектуальных качеств, оперативность, т.е.

способность к быстрому принятию решений в сложной и часто меняющейся обстановке, оперативная и долговременная память, эвристическое мышление, развитое пространственное представление, развитый объем внимания, способность к его концентрации и переключению, эмоциональная устойчивость, помехоустойчивость.

3. В качестве самостоятельной составляющей ПВК на основании наших теоретических и практических разработок выделена третья группа - медико-биологических ПВК. К ним относится общее состояние здоровья и физического развития. Важными являются и достаточно выраженные подвижность, сила и уравновешенность основных нервных процессов в системах регуляции висцеральных функций. К этой группе ПВК мы отнесли и отсутствие в выходной от работы день достоверных психофизиологических и висцеро-метаболических признаков остаточного профессионального интеллектуально-эмоционального напряжения и тем более доклинических признаков заболеваний сердечно-сосудистой системы и функциональной психо-неврологической патологии, достаточно высокий уровень толерантности основных психологических и физиологических показателей к профессиональному и моделируемому интеллектуальному и эмоциональному напряжению и к дозированной субмаксимальной физической нагрузке. К этой же группе ПВК относится средний по интенсивности и адекватный по направленности характер предсменной активации наиболее информативных показателей основных физиологических систем и психологического статуса, отсутствие сразу по окончании рабочей смены чрезмерных (превышающих 10 % к предсменному уровню), затянутых, инвертированных изменений ЧСС, ЧД, АД, показателей гемодинамики, ЭКГ и метаболизма, нормальное проявление суточной биоритмики важнейших обменных процессов.

Ввиду необычайно высокой медико-биологической "платы" за успешную деятельность в нештатных, экстремальных ситуациях, необходимые навыки в плане психологической подготовки должны быть отработаны и по возможности доведены до автоматизма в процессе обучения с помощью тренажеров. Этот путь совершенствования ПВК должен служить весомым вкладом как в процессе обучения, так и у работающих диспетчеров, особенно в АС УВД. При этом необходимо индивидуализировать прохождение стажировки и начальной адаптации к профессиональной деятельности в сфере УВД. Своевременное выявление недостаточного развития ПВК и нарушения функционального состояния позволит проводить оздоровительные и восстановительные мероприятия. Это: психологическая поддержка, психотерапевтические и лекарственные средства. Нами разработаны соответствующие схемы воздействия, апробированные в лабораторных и полевых условиях.

Из изложенного очевидно сколь велики требования к комплексу ПВК специалиста по УВД. Наличие и достаточный уровень развития ПВК является залогом высокой надежности профессиональной деятельности диспетчера, а следовательно и безопасности ВД.

Ввиду большой значимости исходного уровня развития комплекса ПВК особо важное значение приобретает проблема первичного профотбора. Обучать специальности "диспетчер УВД" целесообразно лишь тех абитуриентов, которые изначально обладают необходимым набором ПВК, даже при неудовлетворительном уровне их развития. Отсюда следует, что очень важно проводить тщательный первичный отбор среди абитуриентов и отсеивать на этой стадии совсем непригодных для дальнейшей работы по УВД, не поддающихся тренажу и обучению в требуемом объеме. При первичном профотборе допускается неполный или несовершенный набор ПВК. На этом профотбор не заканчивается. На разных стадиях формирования молодого специалиста следует продолжать первичный профотбор, пролонгируя его вплоть до момента завершения стажировки и начала выпускником самостоятельной профессиональной деятельности по УВД. При повторной проверке уровня развития ПВК в случае обнаружения изъянов необходимо с помощью специальных технических средств и программ подтягивать, совершенствовать некоторые недостаточно развитые ПВК. Мы в своей работе использовали разработанный Кутуевым А.Б. имитатор рабочей нагрузки, моделирующий отдельные элементы и фрагменты деятельности по УВД. Для этих же целей нами использованы батарея психологических компьютеризированных диагностических тестов, набор игровых приемов, тренажеры и разработанный нами совместно с конструкторами автоматизированный психодиагностический комплекс, прошедший уже опытную проверку в нашем коллективе.

Повторные профотборы и тренаж ПВК мы рекомендуем проводить в процессе обучения, по его завершении и в начальный период самостоятельной работы по УВД. Такая система отбора и подготовки диспетчеров получила наименование "пролонгированный профотбор".

По нашему мнению, только такая тактика проведения профотбора позволит постоянно иметь обратную связь, оценивать и при необходимости совершенствовать процесс формирования профессиональных навыков и умений, совершенствовать технологию и технические средства обучения специальности "диспетчер УВД". Все эти мероприятия позволят выдавать сертификат специалиста по УВД – действительно надежного профессионала, что несомненно повысит надежность ЧФ в системе АС УВД и безопасность ВД, а также сохранит здоровье и профессиональное долголетие этих ценных специалистов.

Coordination des pilotes dans les glass-cockpits
quelques effets de l'expertise et de la culture[1]

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Résumé :

La coordination d'équipage comporte deux composantes de synchronisation : temporelle dans les actions et cognitive dans le partage d'un référentiel commun. La communication homme-homme et homme-machine est l'outil essentiel de ces deux types de synchronisation. On retrouve parmi les facteurs contribuant à ces synchronisations des facteurs psychologiques non techniques particulièrement étudiés dans les cours de CRM: attitudes des pilotes, aussi bien vis à vis des autres membres d'équipage que vers l'avion et des facteurs plus techniques, moins souvent évoqués mais tout aussi important surtout sur les glasscockpits: connaissance des systèmes et des procédures de communication, briefings, annonces et checklists. Cet article se centre sur ces facteurs techniques en les mettant en relation avec des facteurs culturels tels que le niveau de maîrise de l'anglais ou la familiarisation aux nouvelles technologies. On utilise deux types de résultats: le premier provient de la base de données COSYNUS-Aéroformation sur les performances des stagiaires A320 en cours de transformation à Toulouse (1148 dossiers), le second provient d'une étude commandée par la DGAC, portant sur les stratégies de communications verbales et extra-verbales utilisées par les équipages en cours de transformation sur A320. Les difficultés de reconversion sur glasscockpits, particulièrement dans les aspects communicatoires sont remarquablement liées à l'age et au dernier avion piloté. On montre également que les difficultés de maitrise de l'anglais ralentissent l'apprentissage technique des systèmes et se soldent par un handicap dans toutes les sphères de la coordination homme-homme et homme-machine. Les équipages des pays non anglophones pallient partiellement à cet handicap linguistique en utilisant plus intensément la communication extra-verbale, particulièrement gestuelle et visuelle (regards), en mélangeant aussi dans les procédures leur langue maternelle pour les problèmes difficiles et la langue anglaise pour les mots et phrases clés, et dans tous les cas avec des variations culturelles non négligeables dans la manière d'effectuer les contrôles mutuels. Il en résulte des façons assez différentes de se synchroniser dans les cockpits, y compris pour les SOPS; ces façons sont construites pour pallier aux difficultés spécifiques de chacun, et semblent toutes pouvoir être efficaces. Toutefois ces voies alternatives sont dans l'ensemble plus longues à mettre en place par les équipages et peuvent parfois expliquer un certain retard dans la qualification par rapport à des équipages anglophones, mais encore une fois sans nécessaire préjudice sur la qualité finale des pilotes.

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[1] L'étude de la coordination des équipages en cours de transformation sur A320 présentée en deuxième partie de l'article est financée par la DGAC Française. Il s'agit d'une longue étude réalisée conjointement par le CNRS (J.Rogalski et R. Samurcay), le CNAM (P. Falzon), le CENA (S. Figarol) et bien sûr le CERMA (R. Amalberti) et Aéroformation-Airbus (C. Pelegrin & E. Racca). Le pilotage DGAC est assuré par G. Molinier et F. Wibaux (également participante dans l'étude aux cotés de P. Falzon). Nous remercions vivement tous ces chercheurs et la DGAC qui ont accepté que soit présenté en primeur à l'OACI, alors que l'étude n'est pas encore terminée, le cadre méthodologique et une première série de résultats.

1-La coordination d'équipage sur glasscockpit : une évolution des idées

1-1 les différents modes de coordination d'équipage

La coordination d'équipage est un point crucial de la conduite des avions de lignes modernes, particulièrement depuis que les équipages se sont réduits à deux. Le travail doit être parfaitement partagé entre les deux pilotes et le résultat global doit être synergique, supérieur aux résultats des individus pris séparément.

Les modes de coordination sont de deux ordres :

>La stricte duplication des actions à la recherche d'une somme du résultat est exceptionnelle. Dans ce cas, CdB et copilote réalisent le même but à court terme avec les mêmes actions, cas par exemple d'actions simultanées sur un manche de vol pour éviter un obstacle.

> Dans la plupart des cas, il y a dissociation partielle entre CdB et copilote pour mieux développer la synergie et la gestion des ressources; ces situations s'inscrivent dans le cadre plus général des situations de coopération: CdB, copilote se sont partagés le travail et les objectifs à court terme; ils se synchronisent par contre régulièrement. Cette synchronisation désigne, d'une part, la synchronisation cognitive et, d'autre part, la synchronisation temporelle.

>>La synchronisation cognitive concerne la construction d'un référentiel commun, d'une conscience commune de la situation et d'une logique d'action complémentaire orientée vers ce même référentiel. Ce but est particulièrement important pour le suivi de toute modification des modes de conduite, de paramètres de vol et pour le déroulement d'actions planifiées.

>>La synchronisation temporelle concerne aussi bien le déclenchement simultané d'actions (mettre le chrono en route au décollage en pleine puissance), que le déclenchement d'actions successives (mettre l'avion dans une configuration donnée) ou le respect de conditions d'actions (e.i: attendre 400' avant d'engager les ECAM actions suite à un feu moteur au décollage).

1-2 le rôle des communications dans la coordination

La communication entre pilotes, quelle soit directe-ou par le biais des ordinateurs- est l'outil essentiel de la régulation de ces activités synergiques.

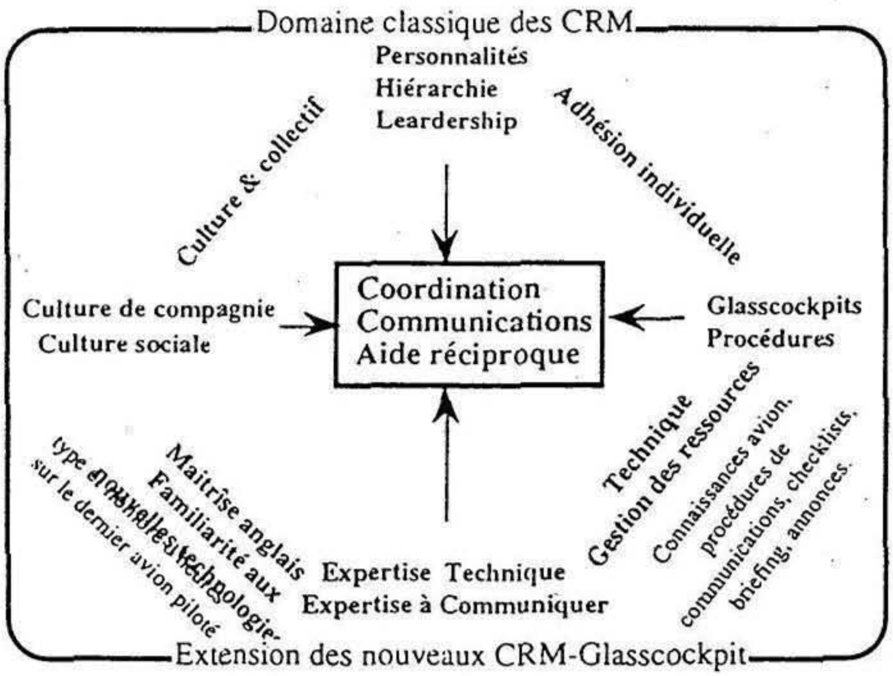
Ces communications ont été, sous l'influence Américaine, largement traitées dans une perspective de psychologie sociale et de communications exclusivement verbales (voir par exemple Foushee, 1984; Foushee & Helmreich, 1988) : les facteurs étudiées ont été principalement les personnalités et attitudes des membres d'équipages dans le cockpit, le style de leadership et la construction d'une conscience de la situation effectivement partagée entre les deux pilotes par une dialogue actif. Un autre pan de recherches a concerné le risque d'interuptions et d'abandon de la tâche en cours dans les communications verbales (voir par exemple l'étude historique de Ruffel-Smith, 1979).

Proche de cette perspective, des études plus récentes ont analysé l'influence de la culture de compagnie, mais aussi de la culture au sens ethnologique du terme, sur les relations entre membres d'équipage. Johnston (sous presse) dans un très complète revue des aspects culturels en aéronautique souligne que les écarts entre pilotes appartenant à des cultures ethnographiques différentes sont peu liés aux connaissances techniques mais sont surtout liées aux communications, à la résolution de conflit et aux relations interpersonnelles; partout les bons équipages font preuves des mêmes qualités : ce sont ceux qui savent se coordonner et être orientés en permanence vers la tâche et les mêmes objectifs du vol; mais la manière d'y parvenir varie largement, même dans le cadre des SOPs (Standard Operating Procedures). Ce point avait déjà été noté dans le cadre plus limité de l'usage des checklists dans les compagnies Américaines (culture de compagnie, Degani & Wiener, 1991).

Toutes ces études sur la communication ont finalement mis fortement l'accent sur la nécessité d'une formation des pilotes plus centrée sur le facteur humain, complémentaire à la formation technique. On retrouve cette volonté dans le développement des cours de Cockpit Resource Management (CRM) et du Line Oriented Flight Training (LOFT) (Orlady and Foushee, 1987; Helmreich, 1988; Wiener, Kanki and Helmreich, 1993). L'accent est mis dans ces approches sur trois thèmes : partage de la représentation (conscience de la situation), style de leardership et barrière à la communication entre membres d' équipage.

Figure 1

Facteurs contribuant à la coordination d'équipage. On retrouve en haut du schéma les facteurs non techniques : attitudes des pilotes, aussi bien vis à vis des autres membres d'équipage que vers l'avion et en bas les facteurs techniques et sociaux techniques : familiarisation à l'informatique, connaissance de l'anglais, connaissance de la répartition des tâches à 2 et des procédures de coordination.



Mais à coté de cette approche non technique (figure 1), l'automatisation des cockpits a récemment restitué un interêt non négligeable à l'étude des communications dans leur aspects techniques, que ce soit sur la forme ou sur le fond.

L'architecture et la technologie des glasscockpits a beaucoup apporté en matière de facilité de représentation du monde externe mais elle a diminué les possibilités de synchronisation non verbales, qu'il s'agisse de vision périphérique (le copilote bouge moins, les informations sont précises (alpha numérique) et la mobilité des systèmes de commandes -manches et manettes -est réduite) ou de conduite "aux sensations " (niveaux de bruit et mises en attitudes lissés par l'informatique).

Les nouvelles architectures permettent également aux pilote un accès individuel à des bases de données de taille sans cesse croissante, et surtout un accès aux commandes quasi-individuel. Cette grande richesse et souplesse d'utilisation peut se transformer ponctuellement en piège si les deux pilotes ne font pas d'efforts particuliers pour se coordonner systèmatiquement et annoncer mutuellement leurs intentions et leurs actions sur le système (Amalberti, 1992a).

Cette évolution s'est donc accompagnée, pour compenser les pertes en coordination non verbale, pour gérer la confiance dans les systèmes et dans le partenaire, et pour réaligner en permanence les projets d'actions -donc la conscience de la situation-, par une augmentation des contrôles visuels en vision centrale de son équipier et du système (la vision périphérique ne suffit plus) et une augmentation des échanges verbaux réglementaires (particulièrement annonces, mais aussi briefings et check-lists).

Dans dous les cas, ces communications sont beaucoup plus dépendantes des connaissances techniques que les attitudes précedemment étudiées.

Une nouvelle série d'études dans l'aéronautique et dans les situations coopératives au sens large se développe ainsi, plus orientée vers les interactions entre connaissances techniques sur le système et niveaux de communication. Ces travaux relèvent plus de la psychologie ergonomique cognitive que la psychologie sociale (Navarro, 1987; Falzon, 1991; Rogalski, 1989; Degani & Wiener, 1991; Sarter & Woods, 1992, Wibaux, 1992).

On notera d'ailleurs que les derniers développement sur le concept de CRM (e.i. CRM Air France) prennent en compte cette évolution centrée sur la compréhension mutuelle de la situation, rehabilitant au coté de l'étude classique des attitudes, les différents aspects techniques de la compréhension mutuelle, de la confiance et de la communication sur glass cockpit.

Les résultats présentés dans cet article se place dans ce courant en essayant de restaurer une vision plus globale de l'interactions des differents facteurs techniques et non techniques dans la coodination d'équipage.

2- Cadre(s) d'étude

2-1 l'utilisation de la base de données COSYNUS sur A320

Aéroformation-Airbus s'est doté d'une base de données intelligente sur les performances des pilotes en cours de transformation sur A320 (Amalberti, Pelegrin, Racca, 1991). Cette base de donnée, appellée COSYNUS, recense toutes les notes et appréciations obtenues par les stagiaires à chaque séance de simulation (FBS et FFS). Son développement a nécessité une revision substantielle de l'ensemble de la notation des instructeurs (notation à cinq niveaux) avec l'introduction d'une notation complémentaire utilisant des valeurs qualitatives et non quantitatives. La base de données contient plus de 1000 dossiers de stagiaires A320 (1148 pour les résultats présentés) et est maintenant étendue aux autres avions de la famille Airbus. Sa conception permet de pratiquer des statistiques multibases (différents types d'avion) afin de réperer des spécificités d'apprentissage communes à la famille airbus ou au contraire plus liées à un type donné d'avion. COSYNUS est utilisée à Aéroformation-Airbus comme tableau de bord pour les instructeurs (suivi-qualité de l'instruction, adaptation optimale de la formation au profil des stagiaires).

2-2 l'étude des communications dans le cockpit en situation de formation sur A320

Une étude systématique des communications verbales et extra-verbales des équipages en cours de qualification sur A320 a été entreprise en 1992 sous l'impulsion de la DGAC.

Aéroformation-Airbus founit l'accès et les facilités de ses simulateurs (dispositif de monitoring vidéo dans les simulateurs à trois prises de vues combinées) ainsi que le contact et l'autorisation de travailler avec de vrais équipages en cours de formation. Ce dernier point est particulièrement important, car il assure une validité écologique parfaite à l'étude (il s'agit de vrais stagiaires, motivés, observés dans le cadre de leur transformation sur A320)[2].

Les compagnies auxquelles appartiennent ces pilotes, et les pilotes eux-mêmes ont donnés leur accord pour être filmés dans le cadre de l'étude.

Les séances enregistrées sont les FFS3 (Full-Flight Simulation n°3) et FFS6 (séance de LOFT -Line Oriented Flight Training). La formation sur A320 compte sept séances de FFS. Les séances enregistrées sont donc au milieu et à la fin de la progression, juste avant la séance de qualification (FFS7).

On étudie un décollage avec feu moteur à V1 suivi d'une approche monomoteur avec atterrrisage en surcharge (durée moyenne 20 minutes) et une approche VOR-DME avec remise de gaz (durée moyenne 10 minutes) .

Le codage de chaque bande vidéo analyse systématiquement les comportements des deux pilotes : position des mains, position de tête, direction du regard, zones consultées, texte des communications verbales y compris relations avec l'instructeur.

3-Résultats

3-1 Résultats de la base de données Cosynus : expertise, niveau d'anglais, culture et difficultés en coordination

Les résultats présentés portent sur 1148 stagiaires A320 passés au centre de Toulouse depuis 3 ans. Ces équipages se répartissent en équipages Nord-Européens (n=306), Sud-Européens (n=313), Moyen-Orient (n=199), Asie du Sud-est (n=187), Europe de l'est (70), Amérique hispanisante (n=56) et divers (17).

Une première série de résultats rappelle les principaux facteurs en lien avec les difficultés de progression dans la transition sur A320.

L'age du pilote stagiaire est de façon surprenante le critère de cette base de données le mieux corrélé à la réussite à la formation sur A320. Ce résultat est relativement stable pour les pilotes de plus de 45 ans comparé aux résultats obtenus sur A310 en 1987 alors que les jeunes pilotes semblent au contraire avoir plus de facilité à se former sur des machines très modernes (sans doute une prime à la familiarisation précoce à l'informatique) (figure 3)

L'handicap de l'age pour les plus agés peut partiellement se comprendre par la classique résistance aux changements, mais il dépend aussi de deux variables communicatoires : la maitrise de l'anglais et la famliairisation aux nouvelles technologies informatiques. La maitrise de l'anglais est (en moyenne) une fonction linéaire de l'age pour les pilotes non anglophones (les jeunes maitrisent très bien, les plus agés moins bien); elle s'avère plus que jamais indispensable sur des glasscockpits où l'information est écrite en anglais (de moins en moins de cadrans, de plus en plus de textes et labels), et ou les procédures verbales doivent reprendre

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[2] Nous remercions vivement les compagnies et pilotes clients d'Aéroformation qui ont accepté de participer à cette expérimentation. La validité écologique du résultat en est infiniment plus grande que s'il s'agissait de pilotes se déplaçant pour participer à "une expérimentation sur la coordination d'équipage". En bref, le jeu des pilotes observés n'est pas "forcé", ni "biaisé par l'expérimentation", il est simplement naturel et les résultats ont beaucoup plus de portée.

sans cesse des expressions anglaises (Voir Amalberti et Racca, 1989 pour des résultats détaillés sur les difficultés en anglais en fonction de l'age des pilotes).

Figure 2

Percentage of pilots failing at FFS7 during A320 transition course as a function of age, N=1148

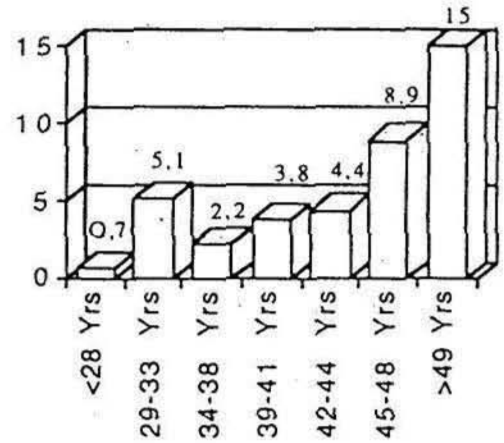
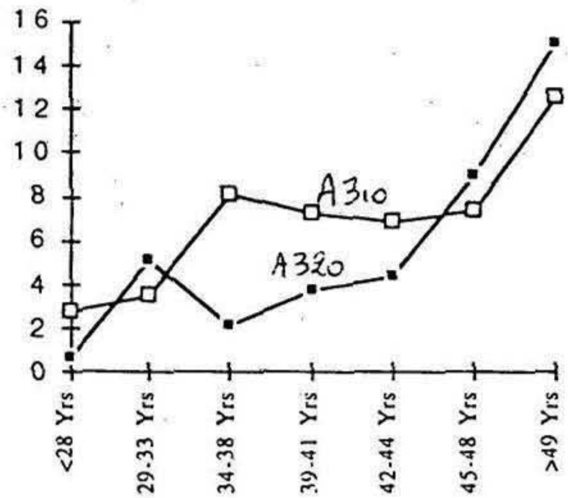


Figure 3

Comparison between A310 trainees failing at the FFS exam and A320 trainees failing at the same exam. A310 results come from Amalberti & Racca, 1989.



Il convient de noter que l'échec au premier contrôle de FFS7 sanctionne une progression insuffisante du stagiaire mais ne doit en aucun cas être interprété comme un échec définitif à la formation sur A320. Les stagiaires ayant échoué au premier contrôle sont généralement admis à l'occasion d'un second contrôle effectué après une ou plusieurs séances supplémentaires de simulateur.

Le deuxième critère le mieux correlé à la réussite est le dernier type d'avion piloté et le nombre d'heures de vol effectué sur ce type (figure 4 et 5).

De façon générale, le fait d'avoir déjà une expérience sur glass-cockpit ou d'être jeune (cas de la plupart des pilotes de turbo-prop) est une aide très conséquente à la transformation sur glasscockpit.

Figure 4

Percentage of pilots failing at FFS7 during A320 transition course as a function of the last a/c flown

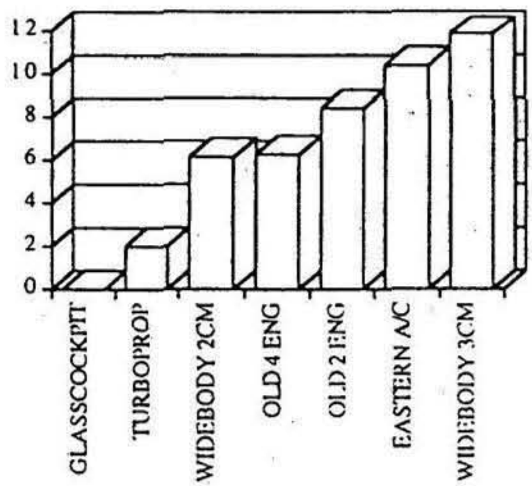
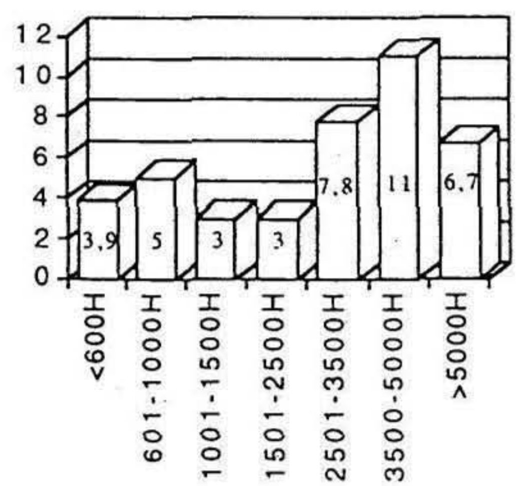


Figure 5

Percentage of pilots failing at FFS7 during A320 transition course as a function of fligh-time hours on the last a/c flown, N= 1148



Le lien très fort avec le nombre d'heures sur le dernier avion piloté peut s' expliquer par les exigences plus "intellectuelles" des stages de qualifications sur les machines modernes. L'effort de compréhension est considérable comparé à ce qu'il était sur les machines plus anciennes où la part de l'apprentissage par l'action était dominant. Ce nouvel état de fait est sans doute plus difficile à satisfaire pour les pilotes formés depuis longtemps à leur ancienne machine et déshabitués des qualifications de type. On peut aussi penser que dans le cas ou les pilotes sont restés longtemps sur un avion d'ancienne génération, leur schéma de coordination, different de celui qu'il faut appliquer sur glasscockpit, est plus difficile à modifier et devient un handicap pour se qualifier sur les nouvelles machines.

Une deuxième série de résultats analyse plus particulièrement les effets de culture (origines géographiques des stagiaires) en fonctions de 6 thèmes en relation avec la communication Homme-Homme et la communication Homme-Machine. L'analyse porte sur les thèmes suivant : la communication H/M mesurée par (1) la maitrise du FMS et (2) des Ecams, la communication H/H mesurée (3) globalement), (4) lors des approches et atterrissages, (5) en situation de panne, enfin (6) une indication générale sur la vitesse des progrès du stagiaire pendant le stage de qualification.

Tableau 4

Rang relatif par thèmes liés à la communication H/H et H/M des difficultés rencontrés par les stagiaires pendant leur qualification de type sur A320 (du plus mauvais résultat coté 1 au meilleur coté 6) N=1148.

	1	2	3	4	5	6
Northen Europ	Use of FMGS	Master Failure Coping	Use of ECAMs	Approach and Landing	Progress	Crew-Coordinat
Southern Europ	Use of FMGS	Master Failure Coping	Approach and Landing	Use of ECAMs	Progress	Crew-Coordinat
Oriental countries	Use of FMGS	Master Failure Coping	Progress	Use of ECAMs	Crew-Coordinat	Approach and Landing
Eastern Europ	Crew-Coordinat	Progress	Use of FMGS	Master Failure Coping	Use of ECAMs	Approach and Landing
Southern & Central America	Progress	Crew-Coordinat	Use of FMGS	Master Failure Coping	Approach and Landing	Use of ECAMs
Middle east Countries	Use of FMGS	Master Failure Coping	Progress	Approach and Landing	Crew-Coordinat	Use of ECAMs

Le tableau 4 résume les difficultés des stagiaires sur ces 6 thèmes en les présentant sous forme d'une statistique de rang (du plus difficile de valeur 1 au plus facile de valeur 6). On retrouve le FMGS comme difficulté principale (voir d'autres résultats dans ce sens : Amalberti, 1992; Sarter et Woods, 1992) mais avec des nuances importantes :

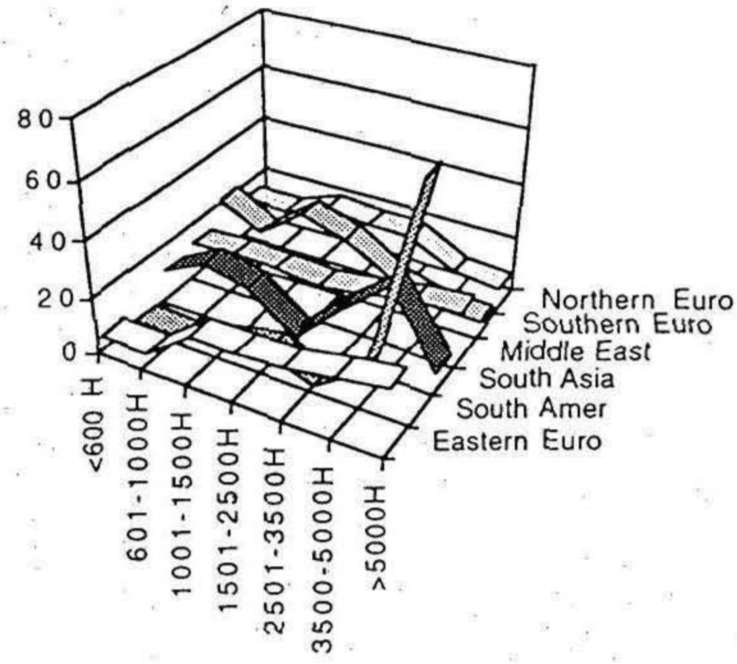
-pour les équipages des pays anglophones et les équipages ayant peu d'heures sur leur dernier avion piloté (la figure 6 indique ce nombre d'heures), la maitrise du FMGS apparait effectivement comme la première difficulté des stagiaires; la coordination d'équipage est bien maitrisée et les progrès dans la qualification ne posent pas de problème particulier par rapport aux standards de la qualification sur le type.

-Ce n'est pas le cas des équipages provenant de pays non anglophones et dont le temps passé sur le dernier avion piloté est de surcroit élevé (on a vu en figure 5 le lien négatif entre le nombre d'heures passés sur le dernier avion et la résussite au premier contrôle de FFS7). Pour ces équipages, la première difficulté est bien d'ordre communicatoire (poids très important de l'item *crew-coordination*) avec une incidence assez forte sur le rythme des progrés des acquisitions qui est ralenti. Les difficultés avec le FMS ne viennent alors qu'en deuxième plan.

On notera aussi que de façon globale, les difficultés sont d'autant plus fortes que la distance entre la langue maternelle et la langue d'apprentissage est grande, que la culture des stagiaires est éloignée de la culture des instructeurs et plus globalement de celle du cours proprement dit.

Figure 6

Pilots' flight hours spent on the last a/c flown as a function of geographical origin



Notons bien ici que l'effet de l'anglais est double : procédural dans l'usage des systèmes, leur compréhension et la reprise de leur nom pour les désigner, mais aussi langue d'enseignement, donc vecteur plus ou moins facile de l'apprentissage et de culture.

A cet égard, il est important de noter que tous *les instructeurs Aéroformation sont* au moins bilingues (anglais-français) et parfois trilingues avec l'allemand, ce qui favorise considérablement les stagiaires pratiquant mieux le français et l'allemand que l'anglais et gomme pour ces stagiaires les effets de distance de langue d'apprentissage.

L'ensemble de ces résultats de la base de données Cosynus sert évidemment Aéroformation-Airbus pour mieux cibler les difficultés des stagiaires et ajuster l'enseignement en conséquence en gommant autant que possibles les effets de culture qui viendraient à défavoriser certains de ces stagiaires.

3-1 Résultats de l'étude DGAC sur les processus de communication dans les glasscockpits

L'enregistrement et l'analyse fine des processus de communications dans les équipages en cours de transformation sur A320 se poursuit actuellement. Les résultats présentés ci-dessous sont donc extrêmement partiels et ne sauraient représenter des résultats définitifs.

Les équipages enregistrés à ce jour en FFS 3 et FFS 6 se répartissent comme suit :

4 équipages Sud-Européens pour lesquels l'enseignement a été pratiqué avec un mélange de français et en anglais

4 équipages de l'Amérique hispanisante, avec un enseignement, sauf cas ponctuel, réalisé exclusivement en anglais

2 équipages à très bon niveau d'Anglais (langue anglaise quasi-native).

Rappellons ici que le dépouillement des communications verbales et extra-verbales d'une demi-heure de vidéo est très long et que de ce fait l'étude progresse lentement. L'objectif final est une vingtaine d'équipages répartis en trois groupes : anglophone natif ou quasi-natif (deuxième langue officielle), non anglophone avec un culture relativement proche du constructeur, et non anglophone avec une culture différente.

Premiers résultats

Les résultats présentés ci-après sont limités à l'analyse de quelques équipages lors de l'exercice de take-off avec feu moteur à VR.

Les analyses portent sur les déviations et écarts entre équipage d'origine différentes en fonction du type de communication réglementaire mise en jeu.

Rappellons que l'on distingue trois niveaux de communications réglementaires qui sont plus ou moins spécifiés dans les SOPs (Wibaux, 1992):

Un niveau peu spécifié qui correspond à des consignes générales et permanentes. On retrouve par exemple dans cette catégorie :les "Aknowledgements " ou l'encouragement à proposer des solutions et à critiquer les solutions choisis" ou encore le crosscheck des informations utilisées ou insérées par l'autre membre d'équipage.

Un niveau spécifié dans ses grands thèmes mais pas dans son contenu précis ni dans sa position temporelle lors du vol: l'exemple type en est le briefing. L'équipage doit le faire; le cadre est spécifié: le CdB est chargé de le construire et de lire, le copilote doit prendre des notes et répéter ce qu'il a compris. Mais la façon de le rédiger et le moment de le dire sont laissés, dans une large mesure, au bon jugement de l'équipage.

Un niveau très spécifié dans son contenu et dans son exécution temporelle C'est le cas typique des annonces et des checklists (encore que l'exécution temporelle puisse être quelque peu flexible) et également des procédures ECAMs (là encore, procédures temporelles pouvant être interprétées avec un degré de liberté relatif).

3-1-1 Variation des communications très spécifiées

La lecture des annonces et des checklists ne pose pas de problème spécifique de compréhension aux équipages mais se trouve particulièrement sensible à la pression temporelle. Tous les équipages ont fait sans gêne apparente ces communications en anglais. Il s'agit de communications essentiellement verbales, médiées par l'interface, sans regard vers l'autre partenaire.

Les écarts observés portent sur des annonces oubliées (i.e: les modes FMA, le train sur rentré) et sur des crosschecks qui ne sont pas effectués par l'autre pilote quand la checklist est enoncée. La déviation par rapport aux actes réglementaires de dialogue s'explique par l'interprétation technique en fonction du contexte; dans ce cas l'explication tient manifestement à une interprétation multimodale de la procédure : si le coéquipier a vu ce que vous faites, que vous le savez, et que la situation est risquée, il semble qu'il soit préferé ne pas occcuper inutilement le canal verbal avec une information peu informative (gestion des ressources de communications).

Extrait de protocole:

FO: V1
FO: rotate, Klaxon de master warning
FO: positive climb : le FO entre le train mais personne ne prononce gear up, le Captain regarde le train et pose ses mains sur les manettes.

La lecture des Ecams donne lieu à des différences plus importantes entre équipages. Les difficultés sont en effet de deux ordres, comprendre soi-même et communiquer avec son partenaire. Les erreurs relevées sont multiples; certaines sont arrivées à des équipages avec des jeunes copilotes ou des pilotes peu habitués aux nouvelles technologies et aux procédures de dialogue:

absence de synchronie temporelle : précipitation, avec lecture trop précoce ou trop complète en fonction de la situation,

absence de synchronie cognitive : lecture sans prendre en compte la disponibilité de son partenaire qui ne peut de se fait intégrer la nouvelle situation et les nouveaux statuts et qui nécessite une nouvelle lecture.

Dans d'autres cas, il s'agit plus typiquement d'une communication rendue difficile par la mauvaise maitrise de l'anglais. Le passage à la langue maternelle est l'attitude la plus fréquente, et la communication devient redondante avec les regards des deux pilotes qui suivent les gestes de celui qui actionne les systèmes. Certains mots-clés de l'ECAM sont traduits dans ce cas dans la langue maternelle des pilotes (probablement pour oter toute ambiguïté).

Extrait de protocole

CdB : Vamos a la lista
FO: continue con ECAM actions
CdB: baisse intensité de la voix : Continue ECAM
FO : (très lent et très doucement) AirPack 1+2 faults, ...when differential pressure below one percent
Instructor: Why do you have this message
FO : baisse intensité de voix, retour en langue maternelle

3-1-2 Variations des briefings

Les briefings ont representé le type de communications où les pilotes se regardent le plus, mais là encore avec des variations selon les pilotes et suivant leur charge de travail.

Les briefings les plus courts sont des briefings en anglais réalisés par des pilotes non anglophones; pour les quelques équipages qui ont recommencé leur briefing en le réalisant en langue maternelle suite à une intervention de l' instructeur, le contenu est devenu nettement plus conséquent montrant que la formulation en anglais est effectivement un handicap communicatoire (situations d'instruction).

3-1-3 Variations des autres actes de coordination

Le style général de communication est extrêmement variable d'un équipage à l'autre même dans le cadre d'une situation de formation à priori très standardisante.

Le volume de parole varie de 1 à 4 et le nombre d'interactions visuelles ou gestuelles varie dans des proportions encore plus grandes.

On relève de nombreuses actions impropres (enclenchement trop tôt de "open climb") qui correspondent à des shémas de communications désynchonisés (un des deux pilotes anticipe sur les déroulements du schéma de communication, des manques de contrôles mutuels ou de protection mutuelle (extinction moteur).

On relève également de nombreux débriefings informels en langue maternelle avec le regard porté sur son partenaire. Ces communications, qui suivent ou précèdent des briefings ou des checklists, fonctionnent comme des alarmes sur des points réputés difficiles. Elles augmentent la conscience du risque encourru.

Enfin, plus globalement, l'interaction simultanée avec parole, geste et vision du partenaire est relativement rare; le taux de signes dédiés à l'autre pilote pour le même exercice est de respectivement 12 et 15 pour les équipages sud-américains analysés, 8 pour les équipages sud-européens et moins de 4 pour les équipage anglophones alors que l'on retrouve également un volume de parole plus important chez les équipages d'Amérique hispanisante et sud-européens par rapport aux équipages anglophones. Ces communications gestuelles ont à l'évidence une double fonction, de suppléance quand à l'anglais et au canal verbal, et de synchronisation cognitive en sécurisant l'autre co-équipier sur la compréhension des informations clés. De même les regards sont distribués différemment entre équipages de cultures différentes, plutôt orientés vers les objets du discours verbal (nord européen), plutôt orientés vers l'équipier dans les cultures plus méridionales.

En conditions d'opérations maitrisées (conformes à la procédures même si elles sont dans un cadre de situations incidentelles), le canal verbal est utilisé de façon dominante pat tous les équipages. Les gestes sont utilisés pour les actions individuelles (sans intention de communiquer au partenaire de l'information) et le regard sert surtout à faire des contrôles d'objets sans synchonie temporelle avec son équipier. En bref, la communication sur glasscockpit est médiée par l'interface qui transformé beaucoup d'échanges jadis synchrones sur avion classiques en échanges asynchrones rythmés par les informations en retour de la machine (un agit, et l'autre ne contrôle pas l'action, mais le retour de l'action sur son interface). A noter que les équipages anglophones semblent plus sensibles à ces changements car ils utilisent moins les communications extra-verbales que les équipages non anglophones (gestes mutuels et regards dirigés vers l'autre).

En conditions d'opérations non maitrisées (i.e.:erreurs d'un des membres d'équipage, situation trop évolutive, etc), tous les équipages changent presque systématiquement leur mode de communication; on voit alors apparaitre

-un retour à la langue natale, en tout cas à un niveau de langue peu structuré, avec une augmentation du volume global des communications et de la longueur des interventions (effet du stress, mais aussi facilitation de la communication)

-une redondance du langage par geste pointant les objets ou données fautifs, et guidant l'autre opérateur

-une synchronie des regards qui se portent sur des objets communs objets des signes gestuels ou de la conversation verbale (voir l'exemple suivant) :

Extrait de protocole

FO : fire is out

FO : we discharged...both agents

FO : clear it?

Instructeur : NO clear NO NO NO!

CdB longue intervention en langue natale + geste touchant le bras du coéquipier et le panneau plafond + regard sur plafond en synchonie avec FO (dialogue de récupération typique en langue naturelle)

CdB: shut down...fuel crossfeed is on? (la situation semble récupérée, retour à un mode de communication standard, FO regardele fuel bleed. CdB revient à ECAMS)

FO (hésitant) is on...?

CdB repart en langue native, regards des deux pilotes portés sur Ecams et sur fuel bleed et gestes accompagnant l'explication et la levée de doute

Au bilan, ces premiers résultats confirment l'existence de différentes façons de se coordonner. Aucune de ces façons n'est totalement exempte de défauts. Les communications des équipages anglophones souffrent parfois d'un manque de synchonie temporelle parce que les pilotes se regardent peu et priviligient la communication verbale et le contrôle mutuel par l'intermédiaire du système. Les communications très redondantes visuo-verbales et gestuelles des équipages sud-européens et surtout d'Amérique hispanisante assurent une assez bonne synchronie cognitive mais consomment beaucoup de ressources au détriment de la conduite du vol et parfois de la synchronie temporelle avec la situation. Dans ce cas, les réglages s'installent progressivement en se familiatisant avec les textes des ECAMs et le maniement du FMGS, provoquant parfois un certain retard dans la progression globale du stage de qualification, mais sans pour autant qu'il y ait un lien avec le niveau de compétence final du stagiaire. Dans tous les cas, le style global de communication ne disparait pas mais évolue plutôt vers une adaptation, un compromis qui prend en compte les facteurs techniques, les propres compétences en anglais du stagiaire, ses craintes vis à vis du système et ses habitudes culturelles à communiquer dans un petit groupe avec des marqueurs propres hiérarchiques de ré-asssurance mutuelle et de régulation du stress.

Conclusion

La coordination d'équipage sur les glasscockpits fait appel à des facteurs non techniques (attitudes, compétence à communiquer) et à des facteurs techniques (maîtrise de l'anglais, connaissance des systèmes, connaissances des procédures de coordination réglementaire).

Les résultats présentés dans cet article, bien que partiels, confirment qu'il existe de nombreuses différences dans la manière de mettre en jeu cette coordination. L'âge des pilotes et le dernier type d'avion piloté sont des facteurs très influents sur la facilité ou la difficulté de la qualification sur avion automatisé. La maitrîse de l'anglais, sous-jacente à ces facteurs, joue un rôle important en ce sens qu'elle facilite l'apprentissage (enseignement en anglais) et une communication homogène avec les exigences du système (ECAMs, FMGS). Les équipages moins anglophones compensent cet handicap en développant des stratégies de communications non-verbales qui paraissent peut-être plus lentes à stabiliser et à adapter aux exigences des glasscockpits (effet sur l'apprentissage) mais tout aussi performantes en fin de qualification. Inversement, les équipages anglophones, particulièrement les jeunes, utilisent peu les communications extra-verbales, et peuvent, malgré un apprentissage rapide, souffrir dans certaines situations de ce manque de redondance.

De fait, cette étude confirme après les analyses de Degani et Wiener (1991) sur les checklists, de Johnston sur les effets culturels (1992), qu'il n'existe pas de référence absolue à la coordination d'équipage. Les régles prescrites et enseignées sont bien sûr nécessaires pour une standardisation minimale mais elles restent relativement générales. Au delà, leur mise en application dépend des individus et laisse suffisamment de degrés de liberté pour que chacun les interprète afin d' obtenir la meilleure performance possible en fonction de ses propres difficultés.

Enfin, on notera que l'étude DGAC, en cours d'exploitation devrait permettre, en association à d'autres études en cours à Aéroformation sur la direction du regard dans les glass cockpits, de souligner l'importance des communications non verbales, trop souvent négligées. Ces dernières servent de sécurisation, de redondance, de prise en compte de l'autre, d'adaptation à l'autre et au rythme de l'autre, autant de rôles non techniques mais particulièrement sollicités sur l'apprentissage d'une nouvelle machine qui est une période d' adaptation importante.

Références

Amalberti R. (1992a) Automatisation et facteur humain: le meilleur et le pire, *Bulletin de Sécurité des Vols d'AirFrance*, 28, 52-64

Amalberti R. Racca E. (1989) Cosynus: the data base system for trainees, 1st Airbus training symposium, paper 24, Airbus: Toulouse.

Amalberti R. Pelegrin C. Racca E.(1991) Cosynus : a new data acquisition system for aiding pilot training on modern aircraft, Proceedings WEAAP 91, Dentan MC & Lardennois P. (eds), AirFrance publisher, Paris, 71-83.

Amalberti R. Falzon P. Figarol S. Pelegrin C. Racca E. Rogalski J. Samurcay R.

Wibaux F. (1992) Communication et coordination dans les cockpits automatisés Rapport scientifique intermédiaire DGAC-2-92

Degani A. Wiener E. (1990) Human factors of flight-desk checklists : the normal checklist, *NASA report CR 177549*, Moffet-Field

Falzon P. (1991) Cooperative dialogues, in J.Rasmussen, B.Brehmer & J.Leplat (Eds) *Distributed Decision Making : Cognitive Models for Cooperative Work*, London : Wiley and sons, 145 192.

Foushee H. Helmreich B. (1988) Group interaction and flight crew performance, in Wiener E. Nagel D. (eds) *Human factors in aviation*, San Diego: Academic Press.

Foushee C. (1984) Dyads and tryads at 35,000 feet, Factors affecting group process and aircrew performance, American Psychologist, 39 (8)

Helmreich R. (1987) Theory underlying CRM training, psychological issues in flight crew performance and crew coordination, NASA conference publication 2455, 15-22.

Johnston N. (in press) Cross cultural perpectives, in Wiener E. Kanki B. Helmreich R. (eds) Cockpit Resource Management, Academic Press Inc, NY

Navarro C. (1987) Communications fonctionnelles et complexité des tâches dans le pilotage d'un avion de ligne, *Le travail Humain*, 50,4, 289-304.

Orlady H. Foushee C.(1987) Cockpit resource management, CRM training proceedings of NASA/MAC workshop, NASA conference publication 2455, San Francisco, May 6-8.

Rogalski J. (1989) Cooperative work in emergency management : analysis of verbal communications in distributed decision making, *Second European Meeting on Cognitive Science Approaches to Process Control*, CEC-JCR Ispra-University of Siena, Siena, 183-193.

Ruffel-Smith H. (1979) A simulator study off the interaction of pilot workload with errors, vigilance and decisions, *NASA technical memorandum 78482*, Moffet-Field

Sarter N. Woods D. (1992) Pilot interaction with cockpit automation : operational experiences with the flight management system, Int. Journ. Aviat. Psychol., 2(4), 303-321

Wibaux F. (1992) L'implicite dans la prescripion : le cas de la formation au pilotage de l'A320, mémoire de DEA d'ergonomie, CNAM, 1992.

Wiener E. Kanki B. Helmreich R. (eds) (1993) *Cockpit Resource Management*, Academic Press Inc,NY

Wiener E. Nagel D. (eds) (1988) Human Factors in Aviation, Academic Press: NY

Computer-Based Approaches for Enhancing Human Performance in Aviation Maintenance

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ABSTRACT

Advanced technology computer hardware and software provides opportunities to enhance the performance of aviation maintenance technicians. Maintenance tasks require that the technician be properly trained and have access to technical information appropriate for each aircraft. Therefore, improved training and information access is likely to enhance human maintenance performance.

This paper describes systems that capitalize on expert-system software technology to deliver simulation-based training and real time job-aiding for troubleshooting. The systems operate on small desktop and portable computer hardware. In addition, the systems are being designed to use "Pen" computers, that require no keyboard and use a pen stylus to write on the computer screen. The pen technology permits easy access to technical documentation as well as a convenient means for the technician and/or inspector to complete required documentation of maintenance.

Background: Human Factors and Maintenance Performance Enhancement

The U.S. FAA Office of Aviation Medicine has an extensive ongoing research program related to human factors in aviation maintenance. That research program has been described at all of the ICAO Regional Seminars (Johnson & Shepherd, 1991, Shepherd & Johnson, 1991, Shepherd, 1992 & 1993). Further, the research program has conducted seven conferences on human factors in maintenance as shown in **Table 1**. All of the conference proceedings are published in hard copy and on CD-ROM (Galaxy, 1993). The CD-ROM is available from the FAA Office of Aviation Medicine or from Galaxy Scientific.

The human factors in aviation maintenance research program uses the model shown in **Figure 1**. The aviation maintenance technician (AMT) is at the center of the system. The input to the aviation maintenance system are aircraft, shown to the left of the human. System outputs are safe and available aircraft. It is important to note that the safe and available aircraft must be affordable for the passengers and profitable to the operator. Therefore each activity of the human factors research maintains a consciousness toward improving human performance to enhance work efficiency and, thus, lower overall maintenance costs.

Surrounding the human are a variety of factors that are likely to affect human performance. While the research program is addressing each of the factors in **Figure 1**, this paper concentrates on two, training and data sources.

1st	"Human Factors Issues in Aircraft Maintenance and Inspection"	October 1989
2nd	"Information Exchange and Communication"	December 1989
3rd	"Training Issues"	June 1990
4th	"The Aviation Maintenance Technician"	December 1990
5th	"The Work Environment in Aviation Maintenance"	June 1991
6th	"Maintenance 2000"	January 1992
7th	"Science, Technology, and Management: A Program Review"	August 1992

Table 1. Human Factors in Maintenance and Inspection Workshops since 1989

Training

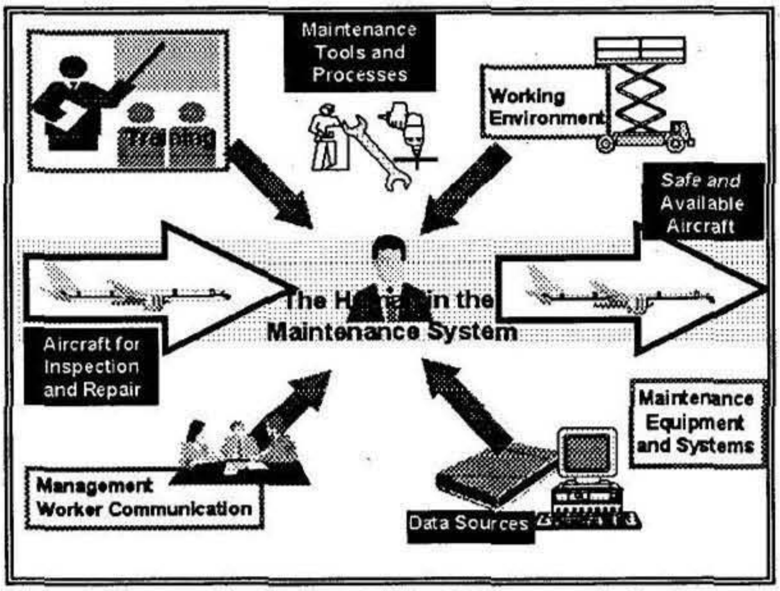

Figure 1 The Human in the Maintenance System

Concerns for effective and efficient maintenance training are shared by all the airlines of the world. There is continuing management attention to provide sufficient training for maintenance personnel to ensure safe practices. At the same time management must schedule training so that it is not an overwhelming cost burden due to such factors as travel or time off the job. Improved training practices are a potential solution in that such training may be able to provide more and better instruction for less money. Advanced technologies, like computer-based training (CBT), are one such solution. Therefore, the Office of Aviation Medicine embarked on a research and development plan to demonstrate and evaluate state-of- the-art CBT. The resultant software has been distributed to most of the world's airlines, via the Air Transport Association (ATA) Maintenance Training Committee. Like the CD-ROM, mentioned above, the CBT is available from the FAA Office of Aviation Medicine and Galaxy Scientific.

The training system is designed to demonstrate the concept of "intelligent tutoring." The training system has software to model the performance of a system expert, an instructional expert, and the student. It is beyond the scope of this paper to describe intelligent tutoring. However there are numerous detailed descriptions elsewhere (Johnson, 1990, Johnson & Norton, 1991, Johnson, Norton, & Utsman, 1992).

The training system is for a Boeing 767-300 environmental control system (ECS). Due to the generic nature of the ECS many airlines suggested that it would be a good exemplary system. The training design capitalizes on simulation of the system to provide diagnostic training and practice. Training for troubleshooting has the best potential for training adults to be prepared to perform the maintenance job. The system permits the learner to access all appropriate cockpit and maintenance bay controls for the environmental control system. In addition, the learner can access interactive pages from the Boeing fault isolation manual (FIM) as shown in **Figure 2**.

The training was designed to exemplify what can be done with CBT. The system avoided the use of non-interactive "page-turning" computer screens that characterize early CBT for maintenance training. The ECS training has demonstrated that today's software and hardware can provide robust simulation in a rich, advice- and feedback-oriented environment.

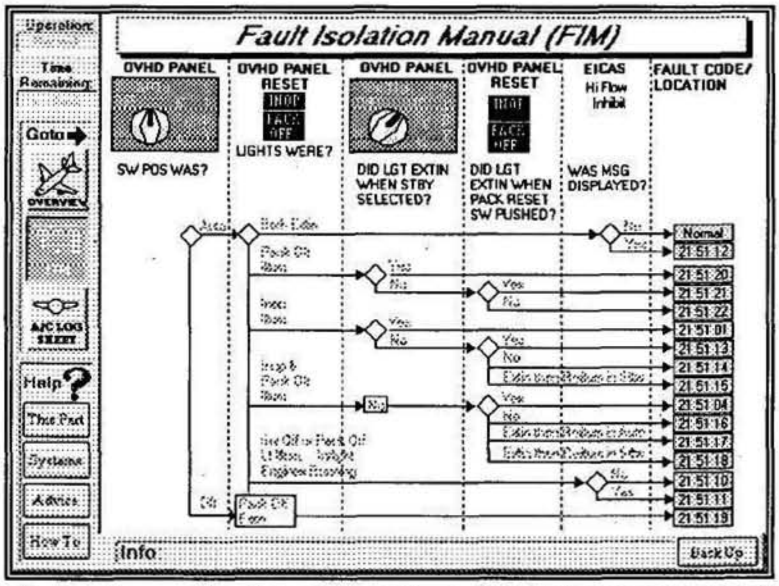

Figure 2 An Interactive Page from the Boeing Fault Isolation Manual

The ECS training system was evaluated at a large US carrier. At the suggestion of the ATA and the participating carrier the training evaluation study was designed to compare student-controlled CBT to instructor-led CBT. A group of 20 students were trained for approximately six hours using one of the two methods. Using a written post-test, it was shown that post-training knowledge was the same for both groups. Students, however, expressed a preference for the combination of CBT and a human instructor. It is reasonable to expect that learners desire an enlightened human as well as the CBT. However, the student-controlled CBT group had no requirement for scheduled group training, for a human instructor, for a projection computer, or for a classroom. Since post-training knowledge was the same for both groups the research favors the cost effectiveness of the student-controlled training. Extensive reporting of the ECS evaluation is contained elsewhere (Galaxy Scientific, 1993).

Data Sources

Aviation maintenance has extensive data requirements. Mechanics have estimated that 40-50% of a day can be spent on finding technical data and completing required "paper work." Therefore the Human Factors in Maintenance research program explores ways to provide better access to technical data and better ways to record, store, and analyze data collected in the field and shop, or on the hangar floor or flightline. This section describes two such projects: the CD-ROM and the Performance Enhancement System (PENS)

CD-ROM

This project has the goal of designing large digital documents that are easy to develop and use. While this goal appears to be straight-forward it is a challenge in today's ever changing hardware and software environment.

Current CD-ROM hardware exists on a 5 1/2" disc media that stores about 640 Megabytes of data. The storage technology is not complex. Conceptually, it can be considered as a large hard disk with "read-only" capability, in most cases. The challenge, therefore, is to design interfaces to make it easy for a novice user to find the information that is desired. Even more significant is the task of developing software to facilitate easy development of the digital data.

The interface to the FAA Office of Aviation Medicine CD-ROM is shown in **Figure 3**. As shown, the CD-ROM contains six major programs as demonstration of the technology. The first program, at the top left of **Figure 3**, is the Hypermedia Information System. It contains about 1800 pages of proceedings from the conferences listed in **Table 1**. The software permits a variety of ways to search the information from these meetings.

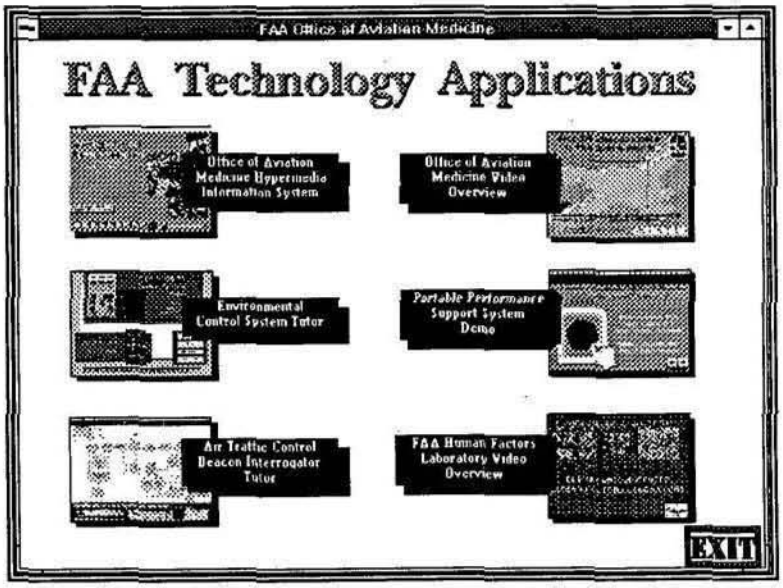

Figure 3 Main Interface for Aviation Medicine CD-ROM

In addition to the conference proceedings the CD-ROM contains two complete CBT programs. One of the CBT programs is the ECS tutor, described above. The second program demonstrates a CBT system used by the FAA for training of Airway Facilities electronic technicians. That program, named ATCBI-4, shows the combination of intelligent tutoring, electronic simulation, and retrieval of technical documentation for maintenance.

The CD-ROM contains two multimedia presentations with audio and video. The first showcases the FAA Office of Aviation Medicine. The second program shows the Human Factors Laboratory at the FAA Technical Center in Atlantic City, NJ. Both programs were designed to be stand-alone programs for kiosks at various convention exhibits.

A demonstration of the PENS software is also included on the CD-ROM. This demonstration is useful to describe the need for the PENS research and development. Of course, the PENS project has been rapidly evolving. Therefore, the PENS version on the CD-ROM is not the very best example of current capability. Current PENS capability is described below.

Performance ENhancement System (PENS)

The research program is working with the FAA Flight Standards Service to develop a Performance ENhancement System (PENS) for Aviation Safety Inspectors. PENS is designed to provide aviation safety inspectors with portable, easy-to-use, hardware and software to enhance on-the-job performance. PENS helps inspectors to collect, store and analyze safety data in real-time. PENS uses hand writing recognition, and smart software to reduce error and expedite data collection. **Figure 4** shows an example of the on-line PTRS form and pull-down menus for access to other data sources.

Aviation Safety Inspectors perform a variety of tasks, including: accident and incident investigation, certificate management, avionics inspection, and aircraft inspection. They document their activities on a Program Tracking and Reporting Subsystem (PTRS) form. PENS permits the inspectors to record the PTRS and other data in a format that can be directly entered into the National database.

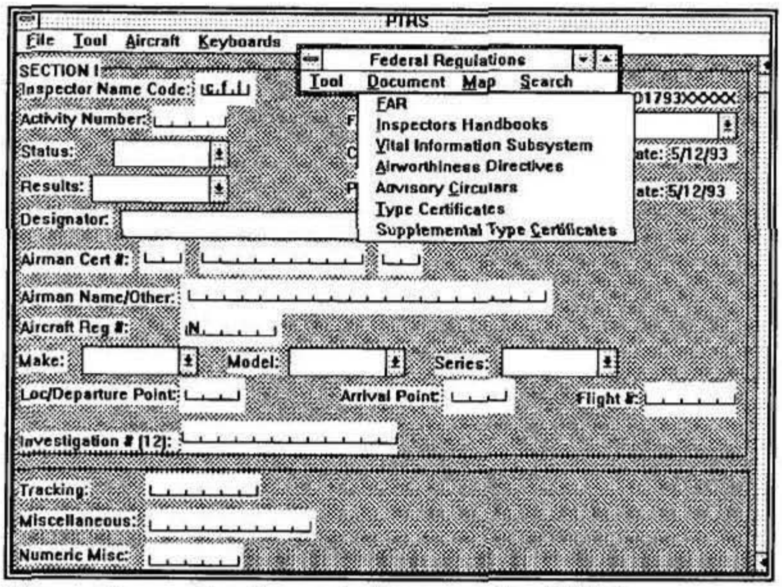

Figure 4 An Example Form on the PENS

Another aspect of the inspector's job is information retrieval; the inspectors must not only maintain records of their activities, they must have access to the large amounts of information relevant to their jobs. Such information, as shown in **Figure 4** includes: Federal Aviation Regulations, Airworthiness Directives, Advisory Circulars, Inspector's Handbooks, and more. Again, PENS provides ready access to such information. The software technology from the CD-ROM hypermedia project permitted a rapid technology transfer to the PENS project. This same technology is applicable for a variety of additional aviation maintenance work environments.

Conclusions

Advanced technology is a means to enhance human performance in maintenance. Technology is not an end. As research and development on human factors in aviation maintenance and inspection continues, the team of scientists and engineers will explore technology and match it to appropriate applications. Experience has shown that hardware capability most often exceeds the design of quality software and development of good intuitive interfaces. The research program has a scientific responsibility not only to develop new advanced technology but also to test it and be sure that it is integrated properly into the maintenance system.

Development, implementation, and evaluation will remain the highest priority for the research program. In order to ensure success the research team will continue to interact with government personnel, airline management, and aircraft maintenance job incumbents. The research end products and reports shall be designed for immediate transfer and useful acceptance by the aviation maintenance community.

References

Galaxy Scientific Corporation (1993). *Human Factors Issues in Aircraft Maintenance and Inspection: CD-ROM* {Compact Disc Read Only Memory}. Atlanta, GA: Galaxy Scientific Corporation (Distributor).

Galaxy Scientific Corporation (1993). *Human Factors in Aviation Maintenance Phase 3, Volume 1: Progress Report.* Washington, DC: U.S. Department of Transportation, Federal Aviation Administration.

Johnson, W.B. (1990). Advanced technology for aviation maintenance training: an industry status report and development plan. *Proceedings of the 34th Annual Meeting of the Human Factors Society.* Orlando, FL: The Human Factors Society, 1171-1175.

Johnson, W.B. & Norton, J.E. (1991). Using intelligent simulation to enhance human performance in aircraft maintenance. *Proceedings of the 1991 International Conference on Aging Aircraft and Structural Airworthiness* (NASA Conference Publication 3160). Washington, DC: Federal Aviation Administration and National Aeronautics and Space Administration, 305-313.

Johnson, W.B., Norton J.E., and Utsman L.G. (1992). New technology for the schoolhouse and flightline maintenance environments. Proceedings of the 7th FAA Conference on Human Factors in Aircraft Maintenance and Inspection. Washington, DC: FAA Office of Aviation Medicine. NTIS No. PB93-146975.

Johnson, W.B. & Shepherd, W.T. (1991). Human factors in aviation maintenance: research and development in the USA. *Proceedings of the ICAO Flight Safety and Human Factors Seminar.* Douala, Cameroon, B-192 - B-228.

Shepherd, W.T. (1993). Issues in aviation maintenance human factors. *Proceedings of the ICAO Flight Safety and Human Factors Seminar.* Cairo, Egypt.

Shepherd, W.T. (1992). Aircraft maintenance challenges and human factors solutions. *Proceedings of the ICAO Flight Safety and Human Factors Seminar.* Mexico City, Mexico, 167 - 183.

Shepherd, W.T. & Johnson, W.B. (1991). Aircraft maintenance challenges and human factors solutions. *Proceedings of the ICAO Flight Safety and Human Factors Seminar.* Bangkok, Thailand, 204-220.

ОБУЧАЮЩИЕ КАЧЕСТВА ТРЕНАЖЕРА КАК МЕРА ЕГО ВОЗДЕЙСТВИЯ НА ЧЕЛОВЕЧЕСКИЙ ФАКТОР

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1. Безопасность полетов и человеческий фактор

В настоящей работе излагаются результаты исследований, выполненных в Летно-исследовательском институте и посвященных анализу взаимосвязи между критериями совершенства авиационных тренажеров и снижением в результате обучения на них отрицательного воздействия человеческого фактора. Рассматриваются, в основном, комплексные тренажеры. В широком смысле для тренажеров этого типа можно указать следующие цели (рис. 1):

1. переучивание пилотов на определенный тип самолета;
2. тренировка экипажей как единого целого;
3. периодические тренировки.

Все эти цели должны интегрировать задачу обеспечения высокого уровня безопасности полетов.

Использование самолета в качестве основного средства для обучения и переучивания пилотов в настоящее время не может рассматриваться. Это обусловлено высокой стоимостью полетов, большим расходом топлива и ресурса, а также опасностью. Поэтому центральной проблемой является обеспечение т.н. Transfer'a, т.е. полной адекватности наземной подготовки тем результатам, которые имели бы место при подготовке в полете. Только это гарантирует обоснованный перенос в летную практику знаний, навыков и умений, сформированных с помощью тренажеров и других обучающих средств.

Если говорить укрупненно, то безопасность полетов определяется тремя составляющими: материальной частью летательного аппарата, внешними условиями и той совокупностью параметров, которую принято обозначать как человеческий фактор (рис. 2). Человеческий фактор в свою очередь можно условно разделить на регулярную и нерегулярную составляющие. Первая определяется профессиональным мастерством; вторая носит неопределенный характер: она проявляется в виде неверных, спонтанных решений и грубых промахов. Человеческий фактор проявляется не только как индивидуальная характеристика, но и во взаимодействии между членами экипажа.

Потенциальный уровень безопасности ЛА, определяемый летной годностью, оценивается при сертификации. Заметим, что летная годность охватывает не только конструкцию самолета и его оборудование, но и внешние условия и некоторую часть регулярной составляющей человеческого фактора. На практике уровень безопасности снижается на порядок и даже больше из-за влияния неучтенных элементов человеческого фактора - ошибок пилотов, эксплуатационного персонала и диспетчеров УВД.

Уменьшить указанное расхождение между потенциальным и фактическим уровнем безопасности можно с помощью хорошо организованных тренировок, которые позволяют существенно снизить вероятность ошибок летных экипажей и даже исключить многие из них. Здесь должен рассматриваться широкий спектр обучения. Собственно переучивание влияет в полной мере на регулярную составляющую. На нерегулярную составляющую оно сказывается значительно меньше. Периодические же тренировки и контрольные проверки, а также предполетная поддержка могут оказать существенное влияние на нерегулярную составляющую ЧФ.

Однако для того, чтобы тренировки были эффективными, необходимы эффективные средства, обладающие высокими обучающими качествами.

С позиций безопасности полетов можно значительно интенсифицировать тренировки, если уделить достаточно большое внимание ошибкам пилотов, приведшим в процессе эксплуатации к серьезным летным происшествиям. Практика показывает, что ошибки повторяются. Не менее важно выявить и все ошибки, допущенные конкретным курсантом в процессе обучения. Эффективность такого процесса значительно повысится, если ошибки будут продемонстрированы курсанту непосредственно после "полета" на тренажере.

2. Направления совершенствования тренажеров и ТСО

При практическом решении задач, указанных выше, возникает множество проблем. Здесь сложилось несколько направлений (рис. 3).

Одно из направлений, являющееся первым в историческом плане, стремится усовершенствовать сам тренажер, наращивая и развивая отдельные компоненты. Однако нет четкой ясности, *обеспечивает ли более сложный тренажер лучшее решение задач обучения?*

Второе направление ставит целью повышение характеристик тренажера и его компонентов для того, чтобы добиться большей адекватности с полетом реального самолета. На этом принципе построены все национальные стандарты и тренажеры, а также недавно разработанный Международный стандарт. Исходная посылка заключается в том, что на адекватном тренажере можно сформировать адекватные навыки. Однако высокая адекватность прямо не обуславливает высокие обучающие качества. кроме того, полной адекватности между тренажером и самолетом добиться никогда не удастся. Ограничением здесь является резкий рост сложности и стоимости. Рост этот имеет нелинейный характер: в зоне "насыщения", в которой находятся сейчас тренажеры высший классов, небольшой прирост адекватности требует очень больших затрат и увеличения стоимости. Поэтому, в частности, получило интенсивное развитие направление создания тренажеров низкой стоимости, но сравнительно высокой эффективности.

Третье направление стремится расширить обучающую базу, подключив к комплексному тренажеру компьютерные классы и процедурные тренажеры.

Отличительной особенностью всех перечисленных направлений является то, что их реализация влияет на обучающие качества не прямо, а косвенно. В то же время необходимо рассмотреть пути совершенствования именно обучающих качеств тренажеров. К удивлению, это направление разработано мало. Восполнить указанный пробел должно *направление, которому посвящена настоящая работа. Задача заключается в достижении* адекватности не по отдельным характеристикам тренажера, а по результатам обучения в целом.

3. Условия, учитываемые при оценке обучающих качеств тренажеров

Понятие "обучающие качества", хотя в принципе понятно, до последнего времени не имело четкого определения. Поэтому прежде всего следует конкретизировать именно его.

Поскольку нет возможности провести сравнение тренажерной и летной подготовки и на этой основе сформулировать оценки тренажера, примем в качестве исходной базы результаты сертификации самолета или материалы специальных летных испытаний. Это позволит установить некие эталонные характеристики пилотирования, которые должны являться опорными при обучении. Именно возможность воспроизведения на тренажере установленной совокупности эталонных характеристик пилотирования должно являться главным критерием его обучающих качеств.

Предполагается, что в сертификационных испытаниях определены режимы и фазы полета, в которых при "правильном или эталонном пилотировании" нет угрозы безопасности. Термин "правильное пилотирование" введен потому, что неправильное пилотирование, заметно отличающееся от эталона, может привести к последствиям, существенно отличающимся от тех, которые были определены при сертификации; в наиболее неблагоприятном случае - это аварийная или катастрофическая ситуации.

Для того, чтобы осуществить обучение, следует, с одной стороны, обеспечить пилотам возможность выполнить на тренажере все манипуляции и процедуры, с другой стороны, динамическая модель тренажера должна реализовывать последствия этих процедур как при правильном, так и при неправильном пилотировании. Более того, обучающиеся должны четко видеть как эти последствия, так и свои ошибки.

На слайде 4 указаны условия, которые должны выполняться для реализации высоких обучающих качеств тренажера:

- курсанту должно быть продемонстрировано "правильное" пилотирование;

- должна быть обеспечена возможность выполнения этого "правильного" пилотирования; это означает, что должны быть все управляющие органы, адекватные модели и вся необходимая информация;

- должны быть организованы все условия для обучения правильному пилотированию;

- должен быть обеспечен строгий, точный и безошибочный контроль за процессом обучения;

- все ошибки, допущенные пилотами, должны быть идентифицированы и затем продемонстрированы.

Сегодня выполнение большинства условий полностью ложится на инструктора, который сам подвержен воздействию человеческого фактора и может ошибаться. Наши специальные исследования показали, что при визуальном контроле за деятельностью курсантов даже опытный инструктор допускает большое число ошибок. Остаются незамеченными от 10 до 50% ошибок; более того, в 10-25% случаев инструктор указывал курсантам ложные ошибки, которые те не допускали (слайд 5). Поэтому мы считаем, что для достижения высоких обучающих качеств тренажер должен быть снабжен автоматизированной экспертной системой.

Для того чтобы достичь высоких обучающих качеств, необходимо выполнить комплекс требований, показанных на слайде 7. Эти требования разбиты на пять групп. В первую входят требования к конструкции тренажера и его характеристикам. Вторая группа объединяет требования к адекватности. пилотирования. Третья группа определяется совершенством пульта инструктора, возможностью автоматизировать контроль и управление тренировкой; четвертая группа охватывает элементы, образующие содержательно-методическую базу обучения. Сюда можно отнести также сценарии обучения и эталоны пилотирования. Наконец, пятую группу образуют методы испытаний и тестирования тренажера.

Если эти требования выполнены в полном объеме и одновременно, то будут созданы все предпосылки для формирования с помощью тренажера устойчивых навыков и умений правильного пилотирования адекватных тем, которые могли бы формироваться в полете. Если одно или несколько требований не выполняются или выполняются частично, то соответственно снижаются обучающие качества.

4. Эталоны пилотирования

Неоднократно упоминавшиеся выше опорные характеристики могут быть формализованы в виде регламентированного множества характеристик, названного нами "эталоны пилотирования" (ЭП). Исследования, проводившиеся Летно-исследовательским институтом в течение нескольких лет, позволили выбрать рациональный состав этих характеристик и разработать методику их определения.

Под ЭП понимается полученная экспериментально из летных испытаний область допустимого управления, обеспечивающего достижение в каждом режиме - нормальном или отказном - тех же результатов или последствий, которые были установлены в процессе сертификации. Пилотирование понимается достаточно широко и охватывает не только характеристики движения самолета, отклонения управляющих органов и изменения других управляющих параметров; сюда включены также параметры решений и функции взаимодействия. Пилотирование должно осуществляться в точном соответствии с указаниями Руководства по летной эксплуатации (РЛЭ).

Поскольку ЭП представляет собой некую область изменения параметров, различают номинальные характеристики (рис. 9) и границы допусков. В штатных условиях допуски определяются из статистики; в ОС выход параметра на границу допуска чреват возникновением угрозы безопасности, изменением классификации ситуации по отношению к той, которая была сформирована при сертификации.

Для примера на рис. 10 показана номинальная эталонная программа продольного пилотирования при взлете и наборе высоты самолета Ту-154В. Там же указаны дискретные процедуры: подъем передней стойки, уборка шасси, уборка механизации. Для полного формирования эталона пилотирования эту программу необходимо дополнить, указав:

- эталонную зависимость параметров, контролируемых пилотами;

- допустимую область разброса каждого параметра.

Частично указанные данные иллюстрируются графиками на рис. 11. Границы допусков определялись в летных испытаниях и из моделирования, исходя из уже высказанного принципа - соблюдения последствий ситуаций, определенных в процессе сертификации.

На слайде 12 показан пример эталона взаимодействия. Эталон взаимодействия определяет дискретные и непрерывные процедуры управления, выполняемые конкретным "членом" экипажа, речевые команды, процедуры контроля. При этом устанавливаются также процедуры взаимодействия между членами экипажа, которые также подлежат контролю.

Выделены интервалы времени между прохождением команд и соответствующей реакцией другого пилота.

Каждый эталон должен относиться к определенному режиму полета. Здесь весьма плодотворным оказался перенос в практику тренажеростроения принципа "Расчетных случаев", хорошо зарекомендовавшего себя при сертификации самолетов. Суть его заключается в том, что вместо исключительно большого "размытого" множества комбинаций и условий и режимов, в том числе отказных, использовать относительно небольшой набор типовых сюжетов - около 150-200. Эти сюжеты должны являться статистически значимыми для всей области ОУЭ, которую они должны полностью покрывать.

Так же, как реальная полная программа полета, эталон пилотирования не является "жестким". Он содержит постоянную и переменную составляющие. Даже для штатных программ возможны переменные составляющие, которые изменяются из-за варьирования эксплуатационных условий, например изменения массы или центровки. Навыком введения этих составляющих и их выполнения должен овладеть обучающийся на тренажере.

При возникновении отказа должна изменяться постоянная часть программы: должен быть осуществлен переход к новому эталону. Алгоритм такой перестройки схематически показан на рис. 13. Пилоты должны на основании сигнализации и естественных признаков отказа распознать возникшую ситуацию, точно идентифицировать ее, принять решение по выбору новой программы, безошибочно и быстро осуществить переход на эту программу и далее четко реализовывать ее для безопасного завершения полета. На все эти частные операции можно установить эталоны, поскольку в процессе сертификации "правильное" пилотирование должно быть четко продемонстрировано.

5. Типовые ошибки пилотирования

Детальный анализ многочисленный полетов, большого числа летных происшествий и предпосылок к ним показывает, что огромное разнообразие допущенные ошибок можно свести к сравнительно небольшому числу типов. Провести такую классификацию помогают введенные нами эталоны.

Слайд 14 иллюстрирует указанную классификацию. Отдельно рассматриваются ошибки, допущенные в штатных режимах и в особых ситуациях, вызванных отказами. Для штатных режимов ошибки сводятся к:

- большим отклонениям от эталонных параметров;
- значительному запаздыванию в выполнении дискретных процедур;
- перепутыванию или пропуску процедур, предписанных РЛЭ;
- выполнению заведомо неверных процедур, которых нет в РЛЭ.

Отмечено также нечеткое или неправильное взаимодействие между членами экипажа. Существенно, что в полете встречается не одна, а несколько или даже серия ошибок. Характерно, что в большинстве случаев эти ошибки взаимосвязаны; толчком являлась первая ошибка. Обычно пилот, заметив эту ошибку, начинал исправлять ее чрезмерно интенсивно, вследствие чего допускал новую, еще более опасную ошибку.

Отклонения от эталона взаимодействия заключаются в пропуске исполнительной или контрольной команды, неосуществления контроля, чрезмерном запаздывании выполнения процедуры как реакции на команду.

В ОС, вызванных отказами, к перечисленным ошибкам добавляются:

- нераспознавание ситуации, т.е. продолжение полета по старой программе;
- неверная идентификация ситуации и, как следствие, неверный выбор программы;
- значительное запаздывание перехода к новой программе.

Помимо указанных выше ошибок часто допускаются выходы за ограничения, поскольку в сложной и аварийной ситуации допустимая зона параметров сужается.

Указанным ошибкам, их устранению и парированию должно уделяться при обучении на тренажере особое внимание. Именно в этом лежит одна из важнейших возможностей повышения безопасности полетов за счет снижения влияния человеческого фактора и повышения профессионального мастерства пилотов.

6. Пути повышения обучающих качеств

До последнего времени главное внимание уделялось первой группе требований к тренажеру, указанной на слайде 7. Не отрицая ни в коей мере их важности, мы в нашем подходе исходим из того, что требования третьей группы позволяют обеспечить более высокие обучающие качества при более слабых требованиях к адекватности.

В нашей работе особое внимание было обращено на коренное усовершенствование пульта инструктора и улучшение за этот счет обучающих свойств тренажера. Это достигнуто созданием нового информационного поля; по существу в пульт инструктора введена экспертная система.

На цветном дисплее графстанции или персонального компьютера в наглядном виде демонстрируются фактические параметры движения и управления, реализованные курсантом в процессе тренировки на тренажере. Индицируются непрерывные параметры, траектория полета, дискретные процедуры. Эти данные сопоставляются с эталонами пилотирования.

Все это позволяет инструктору быстро и безошибочно оценивать качество пилотирования, выявлять допущенные ошибки.

Курсанты могут использовать систему и для самообучения. Эталоны позволяют овладеть правильными действиями, в том числе по принятию решений и взаимодействия членов экипажа друг с другом. Особое значение имеет демонстрация ошибок и последствий неверных действий.

Последним аспектом, на котором мы хотим остановиться, это тестирование. Задача тестирования - получение ответа на базовый вопрос: способен ли тренажер формировать навыки, полностью адекватные тем, которые вырабатываются в реальном полете и соответствуют эталонному пилотированию? Признано, что экспертные оценки (хорошо, плохо, удовлетворительно) совершенно недостаточны, хотя, безусловно, необходимы.

По нашему мнению, испытания тренажера должны проводиться в три этапа. На первом испытываются основные компоненты. На втором испытывается тренажер в режиме автоматического пилотирования. При этом задаются эталонные управляющие воздействия (дискретные и непрерывные). На третьем этапе тренажер по специальной методике оценивают высококвалифицированные летчики-испытатели. Летчик, ранее не работавший на тренажере, но летавший на самолете, должен за короткое время научиться правильно пилотировать тренажер.

Для оценки обучающих качеств используется следующая процедура. Тренажер предъявляется группе пилотов, имеющих достаточный опыт полетов на реальном самолете, но не "летавших" на тренажере. Обучающие качества тренажера считаются высокими, если каждый пилот реализует через 2-3 попытки на тренажере характеристики пилотирования, близкие к эталонным. Если это не удается, необходимо выяснить причину этого явления, а обучающие качества считаются недостаточными.

Таким образом, мы изложили все составляющие направления совершенствования обучающих качеств комплексных тренажеров. По нашему мнению, обучающие качества могут и должны являться мерой совершенства тренажеров.

TAXONOMY AND MODELS FOR HUMAN FACTORS ANALYSIS OF INTERACTIVE SYSTEMS: AN APPLICATION TO FLIGHT SAFETY

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ABSTRACT

This paper discusses how the problem of analyzing human erroneous behaviour can be appropriately tackled by a framework that comprises four phases, namely: 1) the consideration for a paradigm of human behaviour; 2) the development of a taxonomy of human erroneous actions; 3) the evaluation of appropriate tables of data and 4) a methodology of analysis at different levels of complexity. An application of the proposed method has been focused on the accident of the flight AZ-404 Milan-Zurich. The study has been performed from two different hypotheses concerning the human erroneous behavior. The results, in terms of root causes and manifestations, have been compared.

INTRODUCTION

Nowadays, the vastly improved reliability of mechanical and electronic components has further contributed to the increased human implication, as the "causal factor", up to approximately 70% of the accidents for air carriers (Nagel, 1988). Moreover, the advent of "glass cockpit", which has enhanced the role of the pilot as "supervisor" rather than actor in the flight control process, and the extensive use of Information Technology (IT) for the design of the Cockpit Resources Management, have induced additional perspectives in human factors analysis (Speyer, 1990). These can be summarized in the need to study in detail the cognitive/decisional processes as well as the dynamic interaction within the loop pilot-aircraft-control system. Consequently, the improvement of human factors methods calls for the consideration of the "interactive system" represented by the pilot(s), their mental processes and the dynamic, IT governed, environment in which they operates.

The main objective of this paper is to propose a method which couples a classification (taxonomy) of human erroneous behavior with the dynamics of the working domain in which the human skill is operating, i.e., the pilot-airplane-control system interaction. The proposed analysis of human erroneous behaviour is based on four phases:

1. The availability of a model or paradigm of human behaviour.
2. The development of a taxonomy (classification) for human erroneous behaviour.
3. The existence of tables of data between the actual working domain and the taxonomy.

4. The presence of a method of analysis.

While the availability of an adequate model of cognition and the systematic classification of human erroneous behavior are theoretical issues, the drawing of data from actual situations and the application of the technique to design and/or evaluation of real airplane control and management are topics of practical consideration. In this paper, we will describe the proposed methodology focusing on the model of the pilot and on the taxonomy of erroneous behavior. We will then apply the methodology to a retrospective study of the accident of the AZ flight 404 Milan-Zurich on November 1990. We will show how the root causes of the accident, as far as the human factors are concerned, can be searched and analysed in a "systematic" way using the proposed taxonomy framework and the data collected from the flight voice recorder.

DESCRIPTION OF METHODOLOGY

A Model of cognition and a Taxonomy of erroneous behavior

The availability of a paradigm (model) of behavior of cognition is the necessary initial condition for the construction of a taxonomy of erroneous actions. More specifically, the model must be able to emulate and control at least the following categories of operator functions: *perception/observation (OBS)*, *memory* (recall of information), *interpretation (INT)* (identification/diagnosis), *planning/choice (PLAN)* (decision making), and *action/execution (ACT)* of a plan. These categories can be formalized (Hollnagel, 1993) in terms of a Simple Model of Cognition (SMoC) (fig. 1).

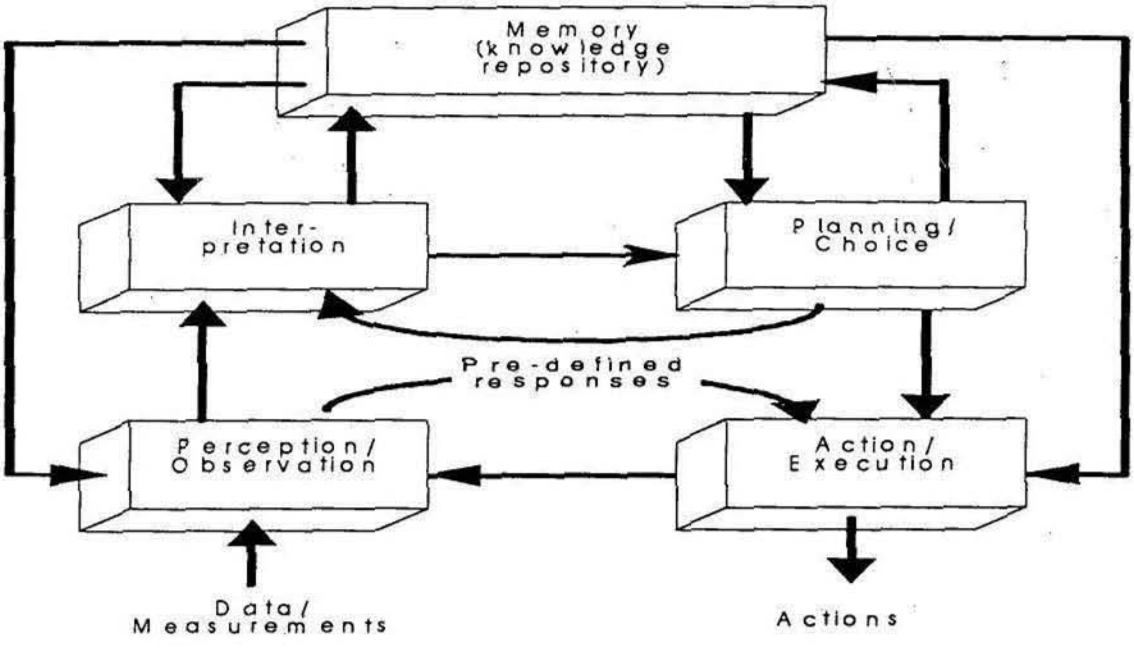

Figure 1 A Simple Model of Cognition

In the context of human factors analysis, the cognitive model needs to be included in a taxonomy framework in order to identify categories of erroneously performed actions. We will refer in our methodology to a taxonomy, developed since some years, which is being adjusted to fit the SMoC paradigm and is based on the principle to maintain, at all levels, a clear distinction between *causes, manifestations* and *consequences* of erroneous behavior. The causes of erroneous behaviour are the reasons which determine the occurrence of a certain "inappropriate" behaviour. The manifestations are the forms or modes in which the "inappropriate" behavior takes place. The causes can be further subdivided in internal or "person related" and external or "system related", but the latter play a role only as possible triggering conditions, able to set-off or modify a person related cause or even a random event. It is up to the safety analyst to perform the appropriate evaluation of the working environment in order to identify and quantify these external, system related factors affecting the human behavior.

The incidental sequences due to erroneous behavior can originate at anyone of the four levels of the SMoC. In order to apply the taxonomy to the working environment, four tables can be developed for the detailed analysis of causes and manifestations of erroneous behavior corresponding to the 4 functions of the SMoC. In each table the causes and the manifestations (effects) are further subdivided in general (cause/effect) and specific (cause/effect), according to whether they represent a generic situation or a more specific case. In the tables each *General Effect (GE)* and its related *Specific Effects (SE)* are liked to a *General Cause (GC)*, which is the manifestation of an erroneous behavior at the level immediately preceding; and/or to a *Specific Cause (SC)*, depending also on a system related event or on a random occurrence. Tables 1-4 report the taxonomy with reference to the four phases of SMoC, i.e. Action (*ACT*), Planning (*PLAN*), Observation (*OBS*) and Interpretation (*INT*). For brevity, only no detailed comments on these tables are reported here, while a better description can be found elsewhere (Pedrali, 1993). This way of analysing the human behavior can be proceduralised.

A Framework of Application

In figure 2 the procedure is depicted for analysing an existing sequence of events, starting from the manifestations (effects) and searching, in a retrospective way, for the causes at all levels of the SMoC. The starting point is thus the manifestation of the erroneous behavior, i.e. the inappropriate action (*ACT*), which is also called "*phenotype*" and it is described as a *SE* and a correspondent *GE*. From this initial condition, the steps to be followed by the analyst are:

1. Search for the *GC*(s), using the taxonomy tables (tab. 1). If only Random Events are identified, then the search is finished. Else continue.
2. Identify the *GE* and *SE* at the level immediately above (tab. 2), namely *PLAN*. Note that the *GCs* at any level are equal to the *GEs* of the level immediately above! Search for the *GCs* and/or *SCs* at this level. If *SCs* are found, one branch of the analysis is terminated .
   If *GCs* exist, then the search for more (other) root causes at the above level *(INT)*.
3. At *INT* level the same procedure is applied in order to reach the level of *OBS*. At this level only *SCs* are to be recognized from the taxonomy and the search process terminates.

The analysis performed in this way, leads to the identification of the level at which the initiating human event has occurred, to the system related causes and to any other *Specific* (root) *Cause*.

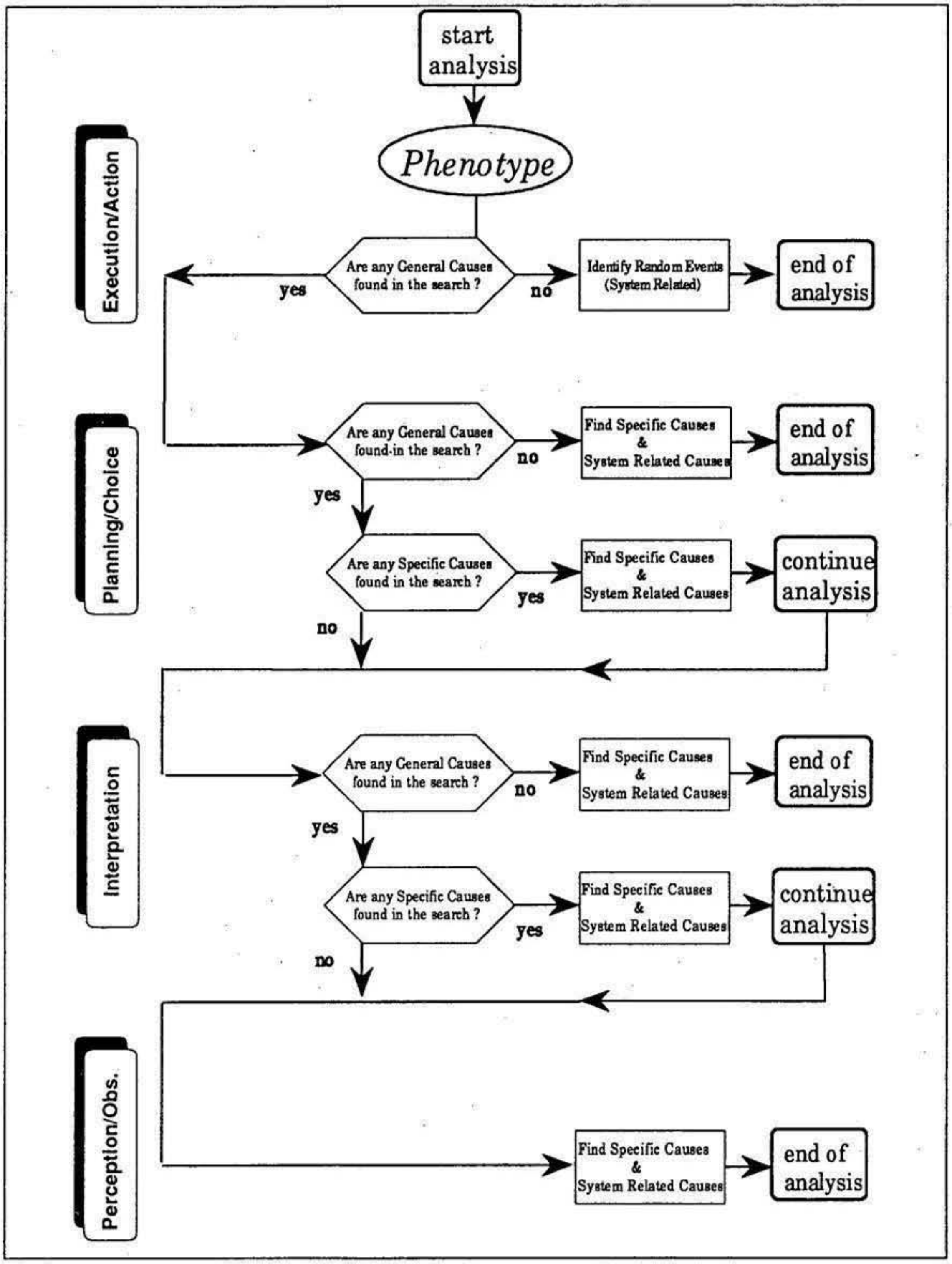

Figure 2. The procedure for a retro-spective application of the taxonomy.

<table>
<tr><th>General Effect</th><th>Specific Effect</th><th>General Cause</th><th>Specific Cause</th></tr>
<tr><td>Incorrectly timed action</td><td>Delay
Omission
Premature</td><td>Incorrect choice of alternative (PLAN)
No choice made (PLAN)</td><td rowspan="9"></td></tr>
<tr><td rowspan="2">Action out of sequence</td><td>Jump forward
Jump backward
Repetition
Reversal</td><td>Random Event
(System Related)</td></tr>
<tr><td>Continue beyond end point
Failure to complete</td><td rowspan="2">Incorrect choice of alternative (PLAN)</td></tr>
<tr><td>Incorrect Action</td><td>Branching
Capture
Intrusion
Side tracking</td></tr>
<tr><td>Incorrect Force</td><td>Too much
Too little</td><td rowspan="3">Random Event
(System Related)</td></tr>
<tr><td>Incorrect Duration</td><td>Too long
Too short</td></tr>
<tr><td>Incorrect Direction</td><td>Too far
Too short
Wrong movement type
Wrong direction</td></tr>
<tr><td>Incorrect Object</td><td>Neighbour
Similar object
Unrelated object</td><td>Incorrect choice of alternative (PLAN)</td></tr>
</table>

Table 1. Error modes realted to the *Action/Execution* part of SMoC

<table>
<tr><th>General Effect</th><th>Specific Effect</th><th>General Cause</th><th>SpecificCause</th></tr>
<tr><td>No choice made</td><td>Decision paralysis
(Chock, Fear, ...)
Incomplete matching of alternatives

Pre-condition not considered
Side-effect not considered
Sub-goal not considered</td><td></td><td>General functions</td></tr>
<tr><td>Incorrect choice of alternative</td><td>Planning horizon too short

Satisficing
Recognition primed choice
Wrong criteria used
Use of wrong decision rule</td><td>Incorrect/incomplete recognition of state (INT)

Incorrect identification (INT)

Incorrect diagnosis (INT)</td><td></td></tr>
</table>

Table 2. Error Causes realted to the *Planning/Choice* part of SMoC

General Effect	Specific Effect	General Cause	Specific Cause
Incorrect identification	Incomplete or partial recall Incorrect recall (of wrong knowledge) Incorrect reconstruction Recalled knowledge is wrong		**General functions:** Absent from place Attention failure Memory failure Operation mode misjudged Phisiological needs Recent failures Time compression Work overload Deduction failure Inadeguate knowledge Induction failure Lack of training Long interval since learning Over-generalization
	Premature identification		
Incorrect diagnosis	Misinterpreted symptoms Symptoms confused Unfamiliar situation Frequency gambling Similarity matching Subjectively ambigous information Incorrect assumptions		
Incorrect Incomplete recognition of state		Failure to notice signal/alarm (OBS) Incorrect/Incomplete recognition of value (OBS)	

Table 3. Error Causes realted to the *Interpretation* part of SMoC.

General Effect	Specific Effect	General Cause	Specific Cause
Failure to notice signal/alarm			General functions
Incorrect/Incomplete recognition of value	Reading wrong value Reading wrong indicator		

Table 4. Error Causes realted to the *Perception/Observation* part of SMoC

THE ACCIDENT OF ZURICH

The study of a real accident has been performed applying the taxonomy in a retrospective way aiming at the identification of the root causes of the human erroneous or inappropriate behavior. The accident examined is the crash of the DC 9-30, Alitalia flight 404 Milan-Zurich, against the hill of Stadelberg on November 14th, 1990. On that day, the Alitalia flight 404 was approaching the Zurich airport and at 20:06:20 hours the aircraft was authorized to descend to 4000 ft, the altitude at which the final approach starts. At this point, a number of flight control operations were carried out in order to capture the glide slope ("from below"), within few seconds. At a distance of 11 NM the airplane was flying too low (~1000 ft), with reference to the glide, however, neither the crew nor the ATC detected this state. The aircraft followed the localizer (LOC-14) precisely, but descended constantly below the glide path, as if it was established on the glide, until the crash on the ground at 20:11:17 hours.

This accidents has been the object of many inquires made primarily by the Swiss authorities, under the coordination of the Office of investigation of the aeronautical accidents, and also by the Accident Investigation Group of the ANPAC ("Associazione Piloti Aviazione Commerciale") and by the Accident Analysis Committee (AAC) of the IFALPA ("International Federation of Airline Pilot Association"). The aim of this analysis is to show how the proposed *methodology could serve the purpose to search for the root causes of human behavior*, given certain environmental and cognitive conditions which may have strongly affected the pilots believes, decisions and actions during the course of the accident evolution.

The study of the human factor

The analysis of the accident, carried out on the basis of the voice recorder and by making a number of logical and plausible considerations, has clearly shown that the crash was the result of the *combination* of several concurrent system (components) malfunctions/failures and human factors as well as environmental conditions. We will not discuss further the system malfunctions identified by the official inquiry, but we will focus on the analysis of the human *factors developed during the accidental evolution from two possible perspectives. Indeed, with* reference to the **findings** of the official commission of the inquiry, we will apply the taxonomy in two different ways:

1. to study the **causes** related to the human factors identified by the official commission;
2. to evaluate a different hypothesis relative to the initiating human cause.

According to the results of the official commission of the investigation, the safety measures, which should have prevented the airplane crash, failed at all three levels, namely:

1. *The flight navigation system* (the VHF NAV unit No 1) was malfunctioning, giving the false indication "on glide", whereas the airplane was flying 1000 ft below the glide path.
2. *The crew flight management* showed inadequate system failure analysis, non-compliance with basic procedures and poor cooperation between pilots.
3. *The air traffic control* did not monitor the adherence to the clear altitude of 4000 ft before the Final Approach Point and the airplane's vertical alignment on the ILS.

Focusing on *the crew flight management*, the commission of inquires concluded that, despite the VHF NAV malfunction, there was a number of erroneous actions made by the pilots:

1. the crew omitted to report "established" on the ILS;
2. they omitted to perform the briefing of "CAT I", following the failure of the NAV system;
3. they omitted the regulation of the Decision Height (DH) at 200 ft.

Moreover, these errors must have been coupled to a continuous misreading of the "drum pointer" altimeter by the Captain, which led to a series of related inappropriate actions, namely:

4. the interrupted "go around" and the subsequent
5. "leveling" prior to the crash.

We identified these 5 events as the *phenotypes* of the human behavior and we have applied the taxonomy in a retrospective way, for the evaluation of their root causes.

The first analysis

The application of the taxonomy, according to the procedure described above (figure 2), revealed that the phenotypes 1, 2 and 3 were *Omissions* while phenotypes 4 and 5 have shown a more complex nature. For sake of brevity we will describe here only the analysis of phenotype 1 and we will only sketch the others, making some observation on the findings.

Phenotype 1. The *Omission (SE-ACT)* to report "established" on the ILS by the crew has been considered as an *Incorrect choice of alternative (GC-ACT => GE-PLAN)*,more specifically a *Use of wrong decision rule (SE-PLAN)*, since they noticed that all four NAV indications gave an "On Glide" indication without a warning flag appearing. This *Specific Effect* was due only to a *Specific Cause - work overload -* triggered by two System Related Causes, namely *conflicting priorities*, since the pilots had to follow the approach to landing procedure at the same time as to maintain the separation from preceding airplane, and *inadequate functioning*, of the Automatic Flight Control System.

Phenotype 2 and 3. The *Omissions (SE-ACT)* relative to phenotypes 2 and 3 can schematically be described as follows: *No choice made (GC-ACT => GE-PLAN), Planning horizon too short (SE-PLAN), Work overload (SC-PLAN)* and *Time compression (SC-PLAN), Conflicting priorities* (System Related Cause).

Phenotypes 4 and 5. In order to define the root causes of phenotypes 4 and 5, it has been necessary to backtrack through the taxonomy up to the level of Perception/Observation. For example, the interrupted "go around" has been recognized as a *Failure to complete (SE-ACT)*, due to an *Incorrect choice of alternative (GC-ACT => GE-PLAN)*, more specifically a *Wrong criteria used (SE-PLAN)*, caused by *Lack of training (SC-PLAN)* of the co-pilot unable to overcome the decision of the Captain to stop the "go-around", and by an *Incorrect recognition of state (GC-PLAN => GE-INT)*. This inappropriate interpretation was due to an *Incorrect recognition of value (GC-INT => GE-OBS)*, provoked by the *ambiguous labeling* of the indicator (System Related Cause), and more specifically by the Captain *Reading the wrong value (SE-OBS)* on the drum pointer altimeter because of *Failure of attention (SC-OBS)*.

A similar type of analysis, performed for the "leveling", has led to the same root cause, *Failure of attention (SC-OBS)*, even if a different path has been followed through the taxonomy.

From the analysis of these erroneous behaviors it results that, while errors 1-3 are very clearly identified and explained, the underlying reasons of phenotypes 4 and 5 are much more complex to enhance. Indeed, they are both dependent on a common fundamental specific cause, which resides at the first level of the cognitive process, i.e., the erroneous reading (observation) of the altimeter due to failure of attention, and they are both sustained by a number of other causes related to the socio-technical environment of the crew. The phenotypes 4 and 5 are thus quite different in nature and causes than the phenotypes 1-3, which are based on much simpler and immediate representation of the situation.

The second analysis

These particular remarks relative to phenotypes 4 and 5, coupled with a very important feature of the findings, namely the fact that the altimeter of the Captain was never found, have led us to attempt the analysis of the accident, with particular focus on these last two errors, from a different perspective. We have postulated a much simpler error of the Captain: the miscalibration of the altimeter. We have, then, performed the analysis of the accident from the instant of the miscalibration onward, applying the taxonomy in a prospective manner. Here are the results.

The instant of the calibration of the Altimeter of the Captain, who was acting as the Associate-Pilot, from the QNH (1019, in this case) to the QFE value (970), should have occurred at a height of about 5000 ft approximately. The wrong calibration of the instrument could be classified as a *Wrong movement type (SE-ACT)*, or more in general as a phenotype of *Incorrect direction (GE-ACT)*. From table 1, this type of error is only linked to a system related random event, with no connection to the other levels of the taxonomy and only general function of the working domain can be analysed as the triggering conditions of this error. For example, interference of communication within the crew or conflicting priority with another request of the Co-pilot could be seen as the external factors triggering the random error of miscalibration. So this error could be very simply classified.

From this point onward, if we assume that the altimeter of the Captain was calibrated at a pressure somewhere in between 1019 and 970, the altitude reported would have resulted higher than the actual one in a QFE-ATL mode: this miscalibration could have approximately compensated for the low altitude at which the airplane was flying. With this scenario in mind, the prospective analysis of the interrupted go-around and the subsequent leveling (phenotypes 4 and 5 above) can be carried out assuming that the Captain did not misread the altimeter but, quite on the contrary, always read correctly an inadequate functioning instrument. In this case, using the tables of the taxonomy and following the procedure of application (fig. 2) in the direction of the prospective analysis, there would be: an *Incorrect/incomplete recognition of state (GE-INT => GC-PLAN)* ("altitude too low"); this would lead to a *Recognition primed choice (SE-PLAN)* ("no-need to increase level of flight") and more in general to an *Incorrect choice of alternative (GE-PLAN => GC-ACT)*, represented by the *Failure to complete (SE-ACT)*, ("the interrupted go-around"), and by the *Unrelated object (SE-ACT)*, ("the leveling").

This analysis, although based on a speculation concerning a possible error of calibration of the altimeter, carries to two relevant features in contrast with the previous study:

1. A simpler construction of the sequence of the accident is obtained, as far as the errors of go-around and leveling are concerned. This is more coherent with the reconstruction of the other events of error of omission made by the crew during the ATL phase. In other words, the inappropriate behavior shown by the crew during the various phases of the accident remains, as in the previous cases of omissions, at the level of errors of planning or of random errors, which are very common in everyday life and do not call for a complex cognitive analysis.
2. The repetitive erroneous reading of the altimeter is not identified as one of the root causes of the accident. Indeed, this continuous error can be considered as a rather unlikely event, given that the Captain was a very experienced pilot with more than 10000 hours of flight and thus very well used to capture at once the information from the altimeter reading.

CONCLUSIONS AND FUTURE PERSPECTIVES

This paper has described a methodology for studying the human factor in man-machine interactive systems. Its potentialities have been shown in an application to a real accident situation applied to the avionics domain.

The results obtained have demonstrated that it is possible to use the reports on accidents to analyse in detail and derive the root causes of human behavior. In most cases, the lessons learned from such analyses can be used for improving further the design of control systems and specially the training of personnel. This could be exactly the case of the accident of Zurich, in which the *work overload* and the *time pressure* have been identified as the root causes of a number of crucial errors, while the misreading of the altimeter (case 1) or the miscalibration of the same instrument (case 2) have played an additional role in the accident evolution. These two main causes are becoming predominant in accidents of modern technological systems and they must be handled by appropriate design features as well as by ad-hoc training.

The overall methodology has not yet been fully formalized in an instrument able to sustain the safety analyst and the designer of control procedures. However, the results obtained in the application to the case of the Zurich accident have been very promising and are encouraging for the remaining work of development still to be carried out.

REFERENCES

Hollnagel E., (1993). *Reliability of Cognition: Foundations of Human Reliability Analysis*. Academic Press, London

Nagel D.C., (1988). Human Error in Aviation Operations. In Wiener E. L. and Nagel D.C. (Eds), *Human Factors in Aviation*, Academic Press, San Diego, CA, pp. 263-303

Pedrali M., (1993). Modelli e tassonomie di errori umani per l'analisi di sicurezza nell'aviazione civile. Il caso studio delll'incidente di Zurigo: ricerca delle cause e indagine prospettica. Tesi di Laurea in Ingegneria Aeronautica. Politecnico dii Milano. 1993

Speyer J.J., (1990). Towards design-induced error tollerance, Proceedings of the ICAO Human Factors Seminar, Leningrad, April 1990, ICAO, Montreal, Canada, pp.A-393-414

VERBAL PRESENTATION

Dr. Thomas McCloy and Dr. Mark Hofmann (USA)

Overcoming Obstacles in the Application of Research to Practice in the Aviation Environment

Good afternoon. It is a pleasure to be with you to speak about a topic of great interest to all of us--Overcoming Obstacles in the Application of Research to Practice. I might add that the movement of research to practice which has been evident throughout this symposium, reflects that I am speaking to a knowledgeable group with regard to this topic.

In the final analysis, it is the objective of all research to get into practice either directly or indirectly by supporting other research that ends up in practice. Therefore, understanding and removing obstacles that may impede meeting this objective is an important topic. Though I will not have many visual aids today, this particular quote

VG-1

I believe contains great meaning for the topic at hand. Introducing anything new, which research to practice inevitably does, has never been easy, a point that Machiavelli succintly pointed out nearly 500 years ago. I humbly submit that things have changed very little since that time. Some, like John Gilman in his 1991 article in Physics Today, entitled Research

Management Today, may say the problems have become worse "because of muddled language to describe research, counter-productive management policies, and unfavorable financial conditions." However, one way to combat the resistance to change which Machiavelli captures in his note is to first and foremost build a constituency or customer base. For the case at hand, this means developing a base for human factors research and the products it produces. If there is not a constituency or customer base, the chance of moving from research to practice diminishes greatly and eventually the support which exists for the research will erode.

There are many strategies to build this customer base, but one effective way is to actively involve the potential customer in the planning and execution of the research.

This technique of active involvement of customers or potential customers in the research process helps focus the research. It facilitates shaping and maturing the research product into a form that best solves customer problems, enhances the likelihood the product will have value added and assist in making the product customer acceptable. It must also be remembered, that customers should not be narrowly defined. For example, in the aviation environment, customers can include pilots, air traffic controllers, maintenance personnel, flight attendants, and so forth. They can also include management personnel, unions, professional groups, engineers, regulators, inspectors, etc. Anyone of the above-mentioned customers or more likely some combination of the above, will be involved if research is to enter practice.

Customer acceptance or overcoming the obstacle Machiavelli so eloquently pointed out should not be taken lightly. How many research products and technologies struggle for introduction and application because of the significant resistance to change which must first be overcome. Often this situation is independent from the overall objective value of the product. Customer acceptance is so important that technologies may be derated to minimize the changes which are required for introduction.

For example, insistence on keeping boiler guages on CRT's or advanced display mediums - do not develop better ways to present information - use the same old presentation or interface mode that was required by the old technology even if it is not required by the new. Then maybe you can gradually improve the presentation mode over time so resistance to acceptance is minimized. Problems in reducing resistance can be magnified many times and become increasingly complex when one moves from this simple example to expanded customer bases and larger systems with their inherent cultures and procedures. For example, consider the introduction of collision avoidance advisory systems on onboard aircraft which can cause pilots to take evasive actions that otherwise would not occur without air traffic direction and when they do, occur can have a direct impact on air traffic controllers' ability to manage traffic.

Clearly not all resistance will be dissapated by customer involvement or all problems solved, but in most cases, if handled correctly, it will not hurt. This customer participation demand oriented model is in no way meant to infer that all research must be focused on solving the here and now today problems of aviation customers at the expense of technology push or longer-range research. A continuum of research is needed for research program staying power and staying ahead of the power curve.

A second area where obstacles can be found in getting human factors research products to practice is developmental policies and processes or lack thereof. It is essential that human factors research products be considered for applicability and value in all developments, be they hardware, training, organizational, or other. Further, they must be considered in a systematic manner with emphasis on the early stages of the development. This obstacle, if it exists, is best overcome by policy that requires and rewards their consideration. These policies must come from higher-level management who must be sold on the value added of the research products in a lexicon they understand. It might be added, this marketing can be immeasurably helped by having customer support.

Last but not least, in overcoming obstacles in going from research to practice is the trained human factors specialist. It is these folk who often must take the product forward to application by working with intermediate as well as end customers. These persons must have knowledge of human factors research products as well as developmental processes. To be effective, they must be able to interact and communicate with persons of other disciplines. They must be able to operate in the real world in real time with all the tradeoffs this environment imposes. They must also be strategically placed in the organization in sufficient numbers to do the job.

In conclusion, for overcoming obstacles in the application of research to practice in the aviation environment one needs to:

VG-2

a. Have research products that provide value added.

b. Have processes whereby the products can be introduced.

c. Have skilled persons to introduce the products.

To accomplish this:

VG-3

a. Establish a program of research which is balanced in terms of longer and shorter term research that is focused by active customer participation and matured through the process of analysis, simulation, and field validation.

b. Establish via high-level policy the requirement and process to consider human factors in all developments.

c. Establish a cadre of trained human factor specialists and strategically place them in adequate numbers inin the organization.

I believe from what we have heard at this symposium, the aviation community is effectively overcoming many of the obstacles found in application of research to practice.

Thank you for your kind attention.

Major Obstacle

"It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage, than the creation of a new system, for the initiator has the enmity of all who would profit by the preservation of the old institution and merely luke warm defenders in those who would gain by the new one..."

Machiavelli, 1513

Establishing Elements

- Balanced programs of research established with active customer participation.

- Policies and rewards to consider Human Factors products in all developments.

- Cadre of trained Human Factors specialists strategically placed in the organization.

Elements for Successful Transitions

- Research products which provide value added.

- Processes whereby products can be introduced.

- Skilled persons to introduce products.

Appendix B

EVALUATION OF THE SYMPOSIUM

The participants, keynote speakers and panel chairpersons were asked to assess the symposium. The following evaluation reflects their assessment as submitted to the secretariat at the end of the Symposium.

The Second Flight Safety and Human Factors Global Symposium, organized jointly by the United States Government and ICAO, constituted an important step in the ICAO Flight Safety and Human Factors programme.

The Symposium underlined the importance of consolidating the experience and knowledge gained by States, airlines, and international organizations in the area of Human Factors. The excellent attendance attests to the need for future events to update the level of knowledge and most importantly, to share that knowledge among States and institutions. In this way, the improvement of safety in aviation through better understanding of Human Factors will become a reality.

Responses through Symposium assessment forms were received from the majority of the participants. The assessment questionnaire contained four questions designed to obtain feedback and to make recommendations for future Symposia.

In response to the question: *What is your overall opinion of the Symposium?* 34 percent of respondents graded it Excellent, 47 percent Very Good, 12 percent Good and 07 percent Appropriate. The majority of comments received highlighted the need to have similar Symposia at regular intervals. This can be best summarised through the words of one respondent: *"As excellent as the papers presented were, is the action of bringing the world experts together to share their experience and information".* Participation from developing States was felt to be missing. The wish of such representation through ICAO fellowships in the future was expressed. All respondents expressed admiration on the top quality of the interpretation services.

The second question consisted of three parts. In response to question number 2(a): *Were there topics irrelevant to the work programme?* All respondents said that all topics were relevant. In response to question number 2(b): *Were there topics other than those presented which should have been included in the work programme?* Respondents included a long list of topics (20 all in all) which they felt should have been addressed. 65 percent felt that a topic on Human Factors Awareness for Management Personnel should have been included. In response to question number 2(c): *Please rate the relevance of the lectures presented to your operational/training requirements,* 70 percent found them to be relevant to their requirements while 20 percent indicated that, though the presentations as a whole were relevant, some presentations seemed to aim at "what we have done" rather than " what we have discovered or achieved". They said that "additional depth would have been appreciated".

The third question asked participants to rate *the technical work programme as a whole.* 90 percent of the respondents agreed that, overall, the technical work programme was very good. Quality of interpretation was rated excellent.

Question Number 4 asked the participants: *What should be the* ***theme*** *of the next Flight Safety and Human Factors Global Symposium, planned for 1996?* In response to this question the majority (75 percent) agreed that the theme of the next Symposium should address Human Factors and Management. It was felt that this theme augmented by presentations on "Human Factors and International Cooperation" would go a long way to achieve ICAO Human Factors objectives as declared in all Human Factors Digests. Other Symposium themes suggested by participants included: Safety in Complex Systems and Integration of Human Factors in Airline Operations.

Eighty five percent of respondents recommended that ICAO should continue to organize Regional Seminars designed to address the particular requirements of the regions were they are held. Many of the representatives considered such regional seminars as the preparatory ground for an effective participation by regional experts, especially from the developing States, in the Global Symposium. Many suggested that ICAO take steps to assure that the developing States fully participate in future regional and global seminars, to update the knowledge and commitment to Human Factors throughout the industry.

The ICAO initiative which led to the holding of this Symposium and the four regional seminars since the First Global Symposium in Leningrad conforms a deep commitment to solving the Human Factors issues which confront the air transport industry. Participants of the Symposium expressed their appreciation to ICAO for its initiative and conduct of the proceedings and to the United States Government for its generosity and hospitality in hosting the Symposium.

Appendix C

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The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

International Standards and Recommended Practices are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

Procedures for Air Navigation Services (PANS) are approved by the Council for world-wide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

Regional Supplementary Procedures (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

Technical Manuals provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

Air Navigation Plans detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO Circulars make available specialized information of interest to Contracting States. This includes studies on technical subjects.

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