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Human Factors in Civil Aviation Security Operations

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International Civil Aviation Organization

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AMENDMENTS

The issue of amendments is announced regularly in the *ICAO Journal* and in the monthly *Supplement to the Catalogue of ICAO Publications and Audio-visual Training Aids*, which holders of this publication should consult. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS			CORRIGENDA		
No.	Date	Entered by	No.	Date	Entered by

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FOREWORD

The safety of the civil aviation system is the major objective of the International Civil Aviation Organization (ICAO). While considerable progress has been made in this area, additional improvements are needed and can be achieved. It has long been known that the vast majority of aviation accidents and incidents result from less than optimum human performance, indicating that any advance in this field can be expected to have a significant impact on the improvement of aviation safety.

This was recognized by the ICAO Assembly, which in 1986 adopted Resolution A26-9 on Flight Safety and Human Factors. As a follow-up to the Assembly Resolution, the Air Navigation Commission formulated the following objective for the task:

> To improve safety in aviation by making States more aware and responsive to the importance of Human Factors in civil aviation operations through the provision of practical Human Factors materials and measures, developed on the basis of experience in States, and by developing and recommending appropriate amendments to existing material in Annexes and other documents with regard to the role of Human Factors in the present and future operational environments. Special emphasis will be directed to the Human Factors issues that may influence the design, transition and in-service use of the future ICAO CNS/ATM systems.

One of the methods chosen to implement Assembly Resolution A26-9 is the publication of guidance materials, including digests and a series of manuals, which address various aspects of Human Factors and its impact on aviation safety. These documents are intended primarily for use by States to increase the awareness of their personnel of the influence of human performance on safety.

The target audience of Human Factors manuals and digests is the managers of both civil aviation administrations and the airline industry, including airline safety, training and operational managers; regulatory bodies, safety and investigation agencies and training establishments; as well as senior and middle non-operational airline management.

This manual is an introduction to the latest information available to the international aviation community on relevant Human Factors considerations in civil aviation security operations. Its target audience also includes senior safety, training and operational personnel in industry and regulatory bodies.

The manual is intended as a living document and will be updated by periodic amendments. Subsequent editions will be published, as new research results that reflect increased knowledge on Human Factors become available and further operational experience in regard to the control and management of human error in operational environments is accrued.

Readers are invited to give their comments, views and suggestions by addressing them to:

The Secretary General
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INTRODUCTION

The threat of terrorist attack on civil aviation is an ever present danger, as was tragically demonstrated on 11 September 2001 by the hijacking and destruction of four jet aircraft in the United States airspace, where all on board were killed along with thousands on the ground. The tragedy highlighted the overriding objective of the civil aviation security system to use all available resources (e.g. technology and personnel) to prevent acts of terrorism as well as other acts of unlawful intervention in the civil aviation system. In this civil aviation security system, the most critical component is the operators who make the safety-critical decisions.

While the central importance of human performance (or Human Factors issues) to many areas of civil aviation (e.g. aircraft cockpit design) has been recognized for several decades, the importance of Human Factors issues in improving the effectiveness and efficiency of civil aviation security has only recently been acknowledged. It was not long ago that this Human Factors perspective was applied in civil aviation security operations, where the deployment of increasingly sophisticated technologies against a backdrop of accelerating growth in air travel has heightened and intensified the demands on the human operators.

If we are to achieve the highest standards of security in civil aviation, it is imperative that the Human Factors considerations in relation to the civil aviation security system are addressed through concerted international efforts. One mechanism for building international consensus and collaboration is the International Technical Advisory Group (InterTAG) which coordinates the exchange of research and development information relating to Recommended Practices for Human Factors among all participating States.

Clearly, the pressing urgency of this issue cannot be overemphasized. Already, the securing of the air transportation system, which encompasses countless airports, aircraft, flights as well as 1.6 billion passengers (1999 ICAO figures) and their accompanying luggage, has become an increasingly complex task. A single lapse in aviation security operations can result in huge fatalities, the destruction of equipment and the erosion of the travelling public's confidence in air travel. Essentially, it takes the presence of just one explosive device on board an aircraft — among a billion or more bags screened — to shatter the credibility of the entire civil aviation security system.

For this reason, numerous regulatory authorities have recently increased allocation of resources to address Human Factors issues in aviation safety and security systems. Through its Flight Safety and Human Factors Programme, ICAO has developed numerous SARPs reflecting the contribution of Human Factors in all aspects of civil aviation safety and security. In 1997, the Air Navigation Commission approved a proposal to include SARPs related to the role of Human Factors in current and future operational environments in the following Annexes to the *Convention on International Civil Aviation*: Annex 1 — *Personnel Licensing*, Annex 3 — *Meteorological Service for International Air Navigation*, Annex 4 — *Aeronautical Charts*, Annex 5 — *Units of Measurement to be Used in Air and Ground Operations*, Annex 6 — *Operation of Aircraft*, Annex 8 — *Airworthiness of Aircraft*, Annex 10 — *Aeronautical Telecommunications*, Annex 11 — *Air Traffic Services*, Annex 13 — *Aircraft Accident and Incident Investigation*, Annex 14 — *Aerodromes*, Annex 15 — *Aeronautical Information Services*, and Annex 16 — *Environmental Protection*.

On the issue of civil aviation security, the eighth meeting of the Aviation Security Panel (AVSECP/8, 23–26 May 1995) discussed, inter alia, the feasibility of developing and including in Annex 17 — *Security* SARPs which address the role of Human Factors in operational environments. Since AVSECP/8, developments within ICAO and among Contracting States vis-à-vis research and practical consideration of Human Factors issues in aviation operations have enhanced the understanding of Human Factors issues related to civil aviation security operations.

Consequently, the AVSEC panel (AVSECP/10, 11–14 April 2000) approved a proposal for the development of SARPs related to the role of Human Factors in civil aviation security operations, to be included in Annex 17. The proposal includes definitions of Human Factors principles and human performance in Chapter 1; a Standard regarding human performance training for aviation security personnel and a Recommendation regarding security aviation equipment in Chapter 3; and a Standard concerning the assessment and effectiveness of security controls in Chapter 4.

An objective of Human Factors considerations in civil aviation security operations is to make the aviation security system resilient to the consequences of human error. Human Factors helps achieve this objective by leveraging human capabilities and adaptabilities to enhance overall system performance. This is done by matching the limitations and capabilities of the operators to the technologies that support civil aviation security operations. A second objective is to improve the efficiency of the overall aviation security system. Efficiency in the system can be defined in many different ways: how many screeners are required to screen all baggage, how much time is required to screen a given number of passengers, how should the threat detection performance be evaluated, etc. Applied Human Factors knowledge achieves these objectives by:

a) defining safety regulation;

b) integrating Human Factors knowledge into the design and certification process of equipment;

c) developing and defining procedures designed to enhance error-resilience; and

d) providing guidance for the selection, training and assessment, and performance management of security personnel.

In response to recent developments in civil aviation security, Contracting States have promoted ongoing Human Factors research programmes that would be applied in the development of new security equipment. There is also a growing awareness among States about the need to develop human performance training and to include this in the training programmes of civil aviation security personnel. Increasingly, States have also considered the need to inspect their security controls and to assess the effectiveness of the controls from an integrated systems perspective. States have established aviation security Human Factors programmes — some over a decade ago — with a view to developing guidelines, specifications, and certification criteria for system performance levels in civil aviation security operations. In all cases, the rationale is that, with the systematic deployment of people and equipment into civil aviation security operations, proper consideration of Human Factors will ensure optimal safety performance and efficiency. With this in mind, this manual presents various aspects of the civil aviation security operations that would benefit from greater attention to Human Factors.

The purpose of this manual is to present recently applied Human Factors knowledge in the areas of personnel selection, training and assessment, new technologies, and organizational structures and culture. This guidance information is intended to support the implementation of SARPs that are relevant to Human Factors considerations in civil aviation security operations as documented in Annex 17 — *Security*.

Human Factors Framework

The structure of the manual is based on a Human Factors framework which identifies four principal axes along which available resources will be deployed to address relevant civil aviation security operational requirements and considerations with respect to Human Factors (see Figure I-1).

As illustrated in Figure I-1, the first two axes, Axis 1 — *Operators* and Axis 2 — *Technology*, are labelled as requiring **User Focus**. Almost all of the resources have been allocated to these two axes, specifically to Axis 2 — *Technology*. It is therefore necessary to implement a more balanced approach by increasing resource levels to Axis 1 — *Operators*. To date, however, the **User Focus** has been almost entirely applied to Axis 2 — *Technology*.

The other two axes, Axis 3 — *Operational Environment and Organizational Culture* and Axis 4 — *Certification*, have been relatively neglected in terms of Human Factors, even though they grew out of the **Regulatory Focus**. It is important that greater attention and resources (from a Human Factors perspective) be given to Axis 3 — *Operational Environment and Organizational Culture*. If we are to reap the benefits of resources allocated to Axes 1 and 2, i.e. *Operators* and *Technology* respectively, then it is necessary that organizations develop and implement supportive policies, processes and procedures (as part of Axis 3). In addition, the standards and procedures for Axis 4 — *Certification* must be properly assessed for any adverse implications in relation to the other axes.

Moving across columns, Axes 1 — *Operators* and 3 — *Operational Environment and Organizational Culture* are grouped under the heading of **Operations-based**. This grouping is important as it highlights the fact that operational realities are central to any application of Human Factors. These two axes are concerned with personnel selection, training and retention. Meanwhile, Axes 2 — *Technology* and 4 — *Certification* are grouped under the heading **Performance-based** and are primarily concerned with the performance objectives that must be met by technologies in order to provide objective data for the certification of security personnel, technology and organizations.

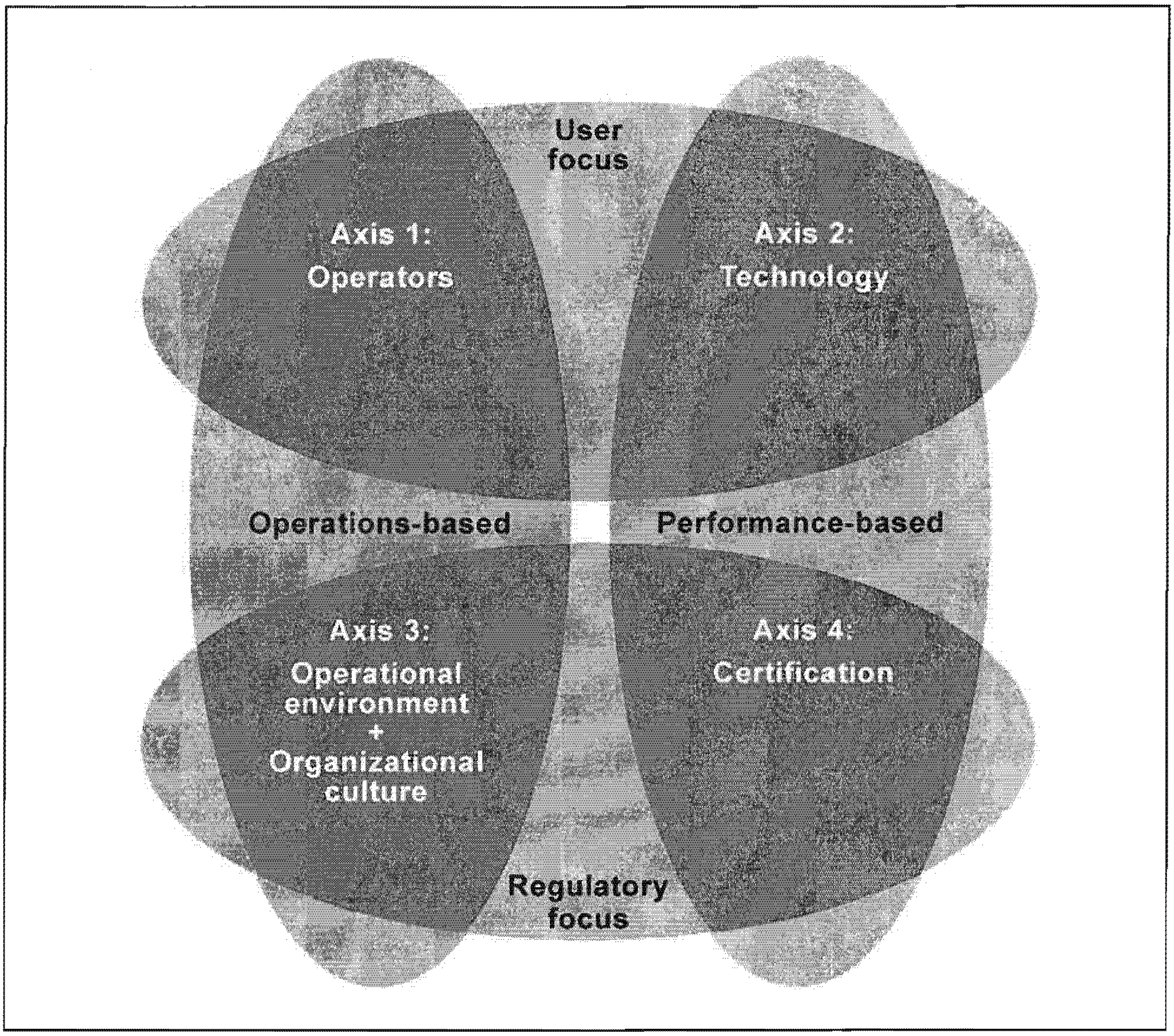

Figure I-1. A schematic representation of the Human Factors framework.

In this manual, Chapters 1 to 4 discuss comprehensively the issues representing each of the four axes in accordance with the Human Factors framework. They are:

Axis 1	*Operators* (including supervisors)	Chapter 1	*Operators: Personnel Selection, Training and Assessment, and Retention*
Axis 2	*Technology*	Chapter 2	*Technologies in Civil Aviation Security Operations*
Axis 3	*Operational Environment and Organizational Culture*	Chapter 3	*Operational Environment and Organization Culture*
Axis 4	*Certification*	Chapter 4	*Certification*

Finally, Chapter 5, entitled "Summary and Future Directions", sums up key elements elaborated in the manual and also raises some notable points for reflection with respect to the future direction of Human Factors in civil aviation security operations.

Throughout this manual, the tasks and challenges related to the screening of threat objects and threat passengers are discussed extensively. For the purpose of this manual, X-ray screener/screening is used as the point of reference when elaborating on the four dimensions of Human Factors in the context of civil aviation security.

Acknowledgments

This manual was prepared in cooperation with the Federal Aviation Administration (FAA) of the United States, the Defence Evaluation and Research Agency (DERA) of the United Kingdom, and the International Transport Security Human Factors Technical Advisory Group (InterTAG).

Special recognition is also due to Eric Neiderman, PhD, United States FAA; Wayne Rhodes, PhD, Rhodes and Associates; Andrew McClumpha, DERA of the United Kingdom; and Larry Conway, École Nationale d'Aviation Civile of France.

LIST OF ACRONYMS

AVSEC	Aviation Security
CBT	Computer-based training
CHS	Centre of Human Sciences (previously part of the Defence Evaluation and Research Agency of the United Kingdom)
CRT	Cathode ray tube
d^1	d prime or the normalized difference between hit rates and false alarm rates.
DERA	Defence Evaluation and Research Agency (United Kingdom)
DGCA	Direction Générale d'Aviation Civile (France)
ECAC	European Civil Aviation Conference
EDS	Explosives Detection Systems
EPICSS	Elevated Podium for Integrated Checkpoint Security Supervision (United States)
ERS	Error Reporting System
FAA	Federal Aviation Administration (United States)
FTIs	Fictional threat items
IED	Improvised explosive device
IET	Initial employment training
IID	Improvised incendiary device
IMS	Ion Mobility Spectrometry
InterTAG	International Transport Security Human Factors Technical Advisory Group
KOR	Knowledge of results
KSAs	Knowledge, skills and abilities
LOSA	Line Operations Safety Audit
NASP	National Aviation Security Programme
NG	Nitroglycerine
NPRM	Notice of Proposed Rule-making (United States)
OJT	On-the-job training
p(d)	Probability of detection
p(fa)	Probability of false alarms
SAT	Screener assist technologies
TBD	To be determined
TEDS	Trace explosive detection systems
TIP	Threat image projection
TNT	Trinitrotoluene
TRM	Team resource management

Chapter 1

OPERATORS: PERSONNEL SELECTION, TRAINING AND ASSESSMENT, RETENTION

1.1 INTRODUCTION

1.1.1 This chapter deals with the first axis of the Human Factors framework, the Operators, and reviews personnel selection, training and assessment, and retention. The first component relevant to an operator is *Selection*. The objective is to select the people who are most able to perform well on the job. There are several factors to consider, including the ability to deal with stress and high workload, interact with different types of people, and use diverse technologies. The selection of suitable, reliable personnel for the tasks involved in civil aviation security is extremely important if we are to maintain and enhance current levels of safety and security in the air transportation system.

1.1.2 The second component is *Training*, which usually includes two major parts: initial employment training (IET) and on-the-job training (OJT). IET is increasingly being complemented by computer-based training (CBT). OJT, on the other hand, may be quite variable and its relation to the initial training may not always be optimal or obvious. A critical component is *Training Assessment* which is necessary for determining whether or not the training provided to operators is valid (i.e. appropriate) and is of sufficient depth and breadth to maximize the probability that each individual operator will perform to a desired criterion level. A related element requires an objective evaluation of operators who should achieve, through a particular training programme, some predetermined and objective level of performance proficiency that then has to be validated in the operational environment. Once qualified personnel have been properly selected, trained and assessed, numerous measures have to be implemented in order to retain qualified personnel.

1.2 PERSONNEL SELECTION

1.2.1 There is a lack of international standards for selecting the most appropriate candidates for civil aviation security operations. Selection policies, procedures and processes receive minimum attention because of the operational staffing requirements that must be met continuously. In particular, there is a lack of specific selection criteria for screeners, a lack of properly validated selection procedures and a general absence of any psychometric assessment.

1.2.2 It has been shown that the use of appropriate and valid selection techniques ensures the recruitment of the most suitable and able personnel for civil aviation security operations in a fair and efficient fashion. Selecting appropriate personnel will enhance on-the-job performance, optimize the effectiveness of training, increase job satisfaction, and reduce staff turnover. There are several selection tools that may be used to assess competencies associated with civil aviation security tasks, primarily those of X-ray screening.

1.2.3 The systematic approach in determining the competencies needed to become a proficient security screener is to conduct a job analysis. A formal scientific and systematic job analysis can identify a comprehensive list of the relevant aptitude requirements or the characteristics of the job in terms of:

- task requirements (i.e. procedures involved),
- functions performed,
- personal competencies (i.e. knowledge, skills, and abilities), and
- the organizational environment where functions are to be performed.

This job analysis can then be used as a basis for ensuring the validity of the selection process, particularly in terms of legal and audit requirements.

1.2.4 One cognitive[1] model describing some of the competencies required of good X-ray screeners include (refer

1. Cognition refers to how the human brain processes information available in its surrounding environment.

to Figure 1-1): perceptual speed, the ability to visualize in three-dimensional space, the ability to discriminate core target features (i.e. signal) from irrelevant background material (i.e. noise), and the ability to mentally rotate objects. Such psychological attributes are not easily assessed and it may be likely that some abilities are not assessed by currently available commercial tests. Current selection practices tend to be structured to provide an overall assessment of suitability as a security agent.

1.2.5 In spite of these challenges, a number of organizations are in the process of developing selection tests to identify those candidates who possess, to a sufficient degree, the competencies necessary to meet the task requirements of a civil aviation security screener. Selection tools include a variety of methods, such as interest inventories and structured interviews. Some psychometric tests can be designed and administered to provide additional information on some of the perceptual and cognitive abilities required in X-ray image interpretation. A number of Contracting States are developing standardized selection tests to help identify applicants who have aptitudes for the screening task.

1.2.6 From a Human Factors perspective, it is critical to identify the abilities required for X-ray image interpretation and to assess these abilities through objective selection tests. Critical cognitive and perceptual abilities include: vigilance, attention, image generation, pattern integration, object recognition, classification and decision making.

1.2.7 While there is a tendency to focus on the cognitive competencies, the Defence Evaluation and Research Agency (DERA) of the United Kingdom is exploring the personality requirements of screeners. An important aspect of this work involves cognitive assessment which will identify those screeners who "can do" the task and personality tests which will identify those screeners who "will do" the task. Furthermore, whatever battery of selection tests may be used, it is vital that the chosen procedures are validated against objective screener performance.

Test qualities

1.2.8 Technical qualities are of utmost importance in the development and use of a test. Two primary technical

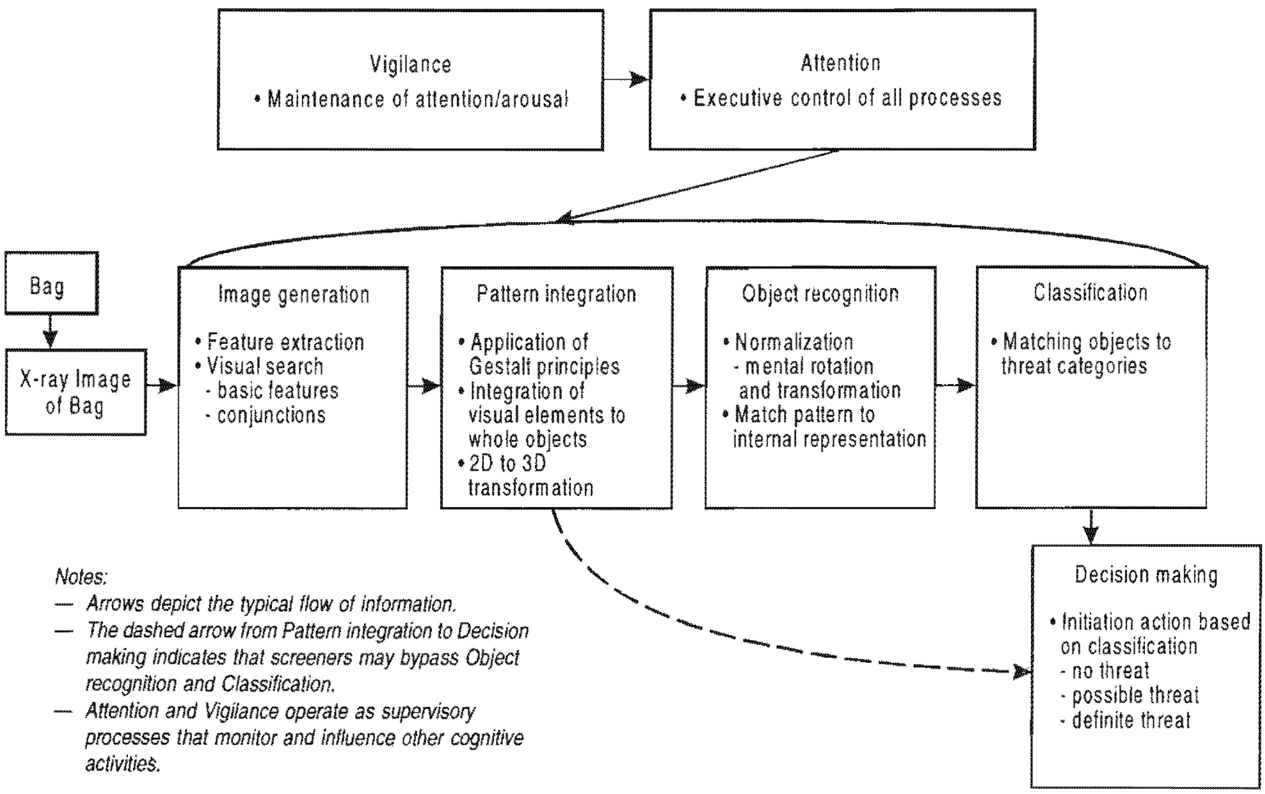

Figure 1-1. A cognitive model of X-ray screening (From Neiderman and Fobes, 1997)

requirements of tests are their *reliability* and their *validity*. *Reliability* can be considered as the consistency of the results. For example, the same result is obtained when a particular individual takes the test on two different occasions. With respect to *validity*, the most important type is predictive validity which addresses the test's ability to predict performance on the job. Without predictive validity, a selection test is of little use. Tests should show the correlation of selection test score to on-the-job performance for the tests to be considered useful and cost-effective. Much of the information on test *reliability* and *validity* should be available from the testing manual supplied by the test publishers. For a commercially available test, it is critical that the users of the tests should determine the suitability of the test for a given situation.

1.2.9 Additional relevant qualities include *item analysis* and *fairness*. The former allows us to determine what factors affect error rates, item discrimination, and quality. The latter is important in determining if a test has any adverse impact on specific ethnic groups, and if so, what strategies can be employed to assess bias and minimize the adverse impact of such test items.

Commercially available tests

1.2.10 A recent review performed by the DERA in the United Kingdom identified a number of commercially available selection tests that may be appropriate for the X-ray task. These tests covered cognitive abilities and personality characteristics. Some existing selection tests may offer some value in predicting X-ray screener performance. The predictive validity of any test should be determined so that guidance can be sought from test publishers regarding the appropriateness of the test for X-ray screener selection and information obtained on suitable normative data. It is important to note that it is not possible to create/purchase a "perfect" test battery for immediate use. Effective tests must be operationally validated against performance on the job. Consequently, commercially available candidate tests require testing and validation in experimental trials.

1.2.11 When choosing tests, care should be taken to ensure their technical quality and appropriateness to the screener task. Operational considerations (such as cost-effectiveness) should also be taken into account. Several commercially available tests may be appropriate for use in the screener selection process; however, systematic and thorough validation of these tests is necessary before using them in an aviation security operational context. Other issues to consider include determining the relevance of speed (i.e. timed) versus a power test, the length and duration of the test, a paper and pencil or web-based administration, and the modification of test items. Those responsible for purchasing, administering and providing feedback on tests should have the necessary qualifications and training.

Test validation

1.2.12 It is important to compare the psychometric test scores of candidates for screening positions against their objective threat detection performance within the operational environment. This can be accomplished through the use of a Threat Image Projection (TIP) system (also refer to Chapter 2) which inserts, in real time, virtual threat items into an actual X-ray image. Studies using TIP technology have provided valuable information in understanding the relationship between X-ray screening performance and selection test scores. Data derived from TIP could identify screeners who demonstrate high competence in completing the threat detection task.

1.2.13 Other measures of performance can include an assessment of walk-through metal detection performance and trace detection systems. These data represent an objective assessment of job proficiency and avoid relying on existing job performance data in validating candidate selection criteria. With the additional use of covert testing (i.e. attempting to get prohibited items concealed in luggage through a security checkpoint), it is possible to derive measures of convergent validity where the validity of the selection tests are determined using different evaluation procedures.

1.2.14 The use of testing early in the selection process will allow for the identification of training aptitude and performance on the job. After suitable candidates have been selected, the mandated initial training is required. The first phase of training is usually of the classroom type. In the future, this may include the use of assessment centres where candidates can be evaluated in a realistic yet controlled environment.

1.3 TRAINING AND ASSESSMENT

1.3.1 Training needs

A systematic job analysis will indicate the type of training needed to achieve a required level of competency and proficiency for the tasks assigned. Classroom instruction is an important element of the training and will typically include the following topics:

— the legislative framework;
— the management of airport security;

— financial and human resource management;
— recruitment, selection, training, and operational procedures;
— surveys, inspections, and systems testing;
— contingency planning; and
— management of responses to acts of unlawful interference.

Some States require up to 99 hours of initial training for airport security agents, covering topics such as security objectives, legislation and structures, the national security programme, airport security objectives and methods, and working knowledge of automated equipment (including metal detectors, X-ray systems, and Explosives Detection Systems (EDS)). Classroom training is usually supplemented by Computer-based Training (CBT) or web-based training that may be more interactive.

1.3.2 Computer-based training (CBT)

1.3.2.1 CBT involves the use of computer technology to provide training material and feedback on performance. One aim of CBT is to support learning activities through the use of computer technology. CBT may be a combination of computer-based instruction and simulation.

a) ***Computer-based instruction*** consists of tutorials providing information on a particular topic area, with questions and applied examples interspersed throughout a training session. This enables trainees to check their understanding and learn through feedback throughout the session. The main objective of computer-based instruction is the development of knowledge.

b) ***Simulation***, on the other hand, trains the practical skills of how to operate an X-ray system and interpret the X-ray image by providing the trainee with a replication of their field task.

1.3.2.2 CBT offers many opportunities to supplement and enhance training programmes in a cost-effective and efficient way. The use of CBT however does not ensure improvements in training impact. What is critical is the extent to which the principles of training design and instructional technology have been applied during the development of the technology and the way in which the CBT is then used and coordinated within the overall training programme.

1.3.2.3 Several advantages of the CBT technology are noteworthy. In the case of baggage screening, simulation provides a way to expose screeners to threat images in a safe environment where they can practice and test their practical skills. CBT can also enable self-paced learning and adapt to the individual learning requirements of the trainee by adjusting difficulty levels and by focusing on particular areas requiring development. CBT has the potential to enhance motivation in the baggage screening task. It can provide a means for standardizing training and assessment and can also provide detailed information to instructors on the training units covered by trainees as well as their knowledge and performance levels.

1.3.2.4 Aside from the training component, CBT usually includes test items used to evaluate the knowledge acquired by the trainees. It has been found that a significant portion of the test items can be answered with general knowledge. Testers should be aware that when choosing multiple choice questions, answer items should not allow for easy identification of the correct response. Such questions would contribute to inflating the final test score and would decrease the discrimination between good and poor performers, making it more difficult to assess the training's contribution to performance on the job. It is important that proper test construction procedures be applied in evaluating any training content and that the validity, reliability and impartiality of the test be demonstrable.

1.3.2.5 As with other training technology, CBT should be based on a thorough analysis of the task as well as on the knowledge of the operating conditions and the performance standards to be met. Computer-based instruction should incorporate well-organized courseware with menus, modules and units. The flow of information should build and develop knowledge in a logical order, including adequate repetition and elaboration of key facts. The lesson content should provide the trainee with clear links between theory and operational practice. For example, descriptions of a particular X-ray image feature should be accompanied by corresponding graphic illustration. An image library accessible to trainees and which includes threats and non-threats is a useful facility available on CBT. A simulation of the X-ray screening task should provide practice facilities which incorporate all operationally relevant aspects of the task. Recent research has been focused on generating a full range of objective image complexity. CBT training are thus being redesigned based on the research outcome in order to maximize skill acquisition.

1.3.3 Training: Organizational issues

1.3.3.1 Along with the technical considerations in training, a number of organizational issues should be considered before using CBT: management of the CBT, logistics of CBT use, design of initial and refresher training, coordination and integration of CBT with the use of other training media, and the fit of CBT into the overall training programme. An assessment of the knowledge, skills, and abilities (KSAs) is important in determining the content of the CBT required for initial training. In addition, an assessment of the KSAs prone to fading will allow for identification of the validity of CBT in refresher training. Some CBT systems have images specific to one X-ray system manufacturer, whereas others may have images from a variety of systems. Currently, trainees can be expected to work on several different types of X-ray systems. It is however advisable that they gain experience and understanding of the differences among the machines during training so that they can better cope with such differences when encountered in the operational environment. Within this state of affairs, there is the potential for negative as well as positive transfer of training. Similar elements among technologies would lead to positive transfer of training while dissimilar elements lead to negative transfer of training.

1.3.3.2 It is also important to develop a standardized, uniform computer-based assessment for the different CBT packages. Such an assessment should address three primary components:

a) the usability of CBT systems in addressing software, human-computer interaction (HCI), and hardware factors as well as procedural factors that all contribute to training effectiveness;

b) evaluation guidelines in assessing the instructional content of CBT; and

c) criteria used to identify the appropriate training media for particular KSAs.

1.3.3.3 It is important to judge if the training system is acceptable in terms of the Human Factors principles of usability. Appendix A provides a complete description of key usability evaluation parameters. These include aspects of data entry and data display, user guidance, health and safety requirements for display equipment, etc.

1.3.3.4 CBT systems that are currently available were developed to provide training support for two broad categories of learning, knowledge and skills. The acquisition of declarative knowledge is supported by providing information on the components of the task to be completed. The development of skills or procedural knowledge is supported through practice on the task. Recent studies undertaken by the DERA Centre of Human Sciences (CHS) of the United Kingdom have shown that the use of CBT can have immediate impacts on knowledge acquisition; however, the development of skills are found to require a longer training regimen that is equally distributed between IET and OJT.

1.3.3.5 There are a variety of different media which can be used to train for the luggage screening task. While CBT can play an important role in enabling screeners to acquire the skills and knowledge for the task, other types of training media have an important role to play. Appendix B provides a complete description of the relative merits of different media for specific training objectives. These include classroom training, real equipment demonstrations, individual exercises, group discussion, grouped or paired exercises, and operational training, etc.

1.3.3.6 Classroom and CBT training are usually followed by varying periods of OJT. OJT is provided to allow for mastery of the following tasks: walk-through metal detector; hand-held metal detector; consent search; bag search; X-ray screening; and exit lane management. Civil aviation authorities will typically establish the standards for OJT which would define the topics that must be covered, the amount of time to be dedicated to each subject, and the evaluation process for the training.

1.3.4 Training requirements

1.3.4.1 The training required to become a screener can vary significantly among States, as illustrated by the following examples:

— The Netherlands requires screener candidates to train and be certified as general security officers and then undertake specialized training and be certified to work as checkpoint screeners. The requirement is 40 hours of specialized training for screeners, including classroom work, CBT, and role playing. This is followed by two months of OJT and 24 hours of additional yearly training to maintain certification.

— In Belgium, the basic training for certification as a checkpoint screener includes 40 hours on aviation issues, followed by specialized training in various civil aviation security topics (e.g. X-ray system operation) ranging from 4 to 64 hours.

— Canada requires 20 hours of classroom training followed by 40 hours of OJT. After successful completion of the training, screeners are certified by the regulatory authority.

— The United States has required 12 hours of classroom training and 40 hours of OJT. Recently, they have adopted the *Aviation Security Improvement Act* that mandates 40 hours of initial training and 40 hours of OJT that are to be remunerated.

— In France, screeners must complete 90 hours of training followed by 20 hours of OJT, coupled with tasks such as checking tickets and performing guard duty. After completing the OJT, new screeners must pass tests administered by the Direction Générale d'Aviation Civile (DGAC) of France.

— In the United Kingdom, following a week of classroom training, screeners complete 40 hours of OJT. The tasks covered in OJT reflect the tasks covered in the classroom, including: general security awareness; the airport security programme; searching people; searching passengers and staff baggage; conventional X-ray equipment; and explosive detection systems (EDS). At least 15 hours of the OJT is to be allocated to X-ray and EDS technologies. Typically, during the OJT, newly hired screeners will be supervised by experienced screeners for a specified period of time. During this time, trainees cannot make independent judgement as to whether persons or property may enter a sterile area or aircraft without further inspection.

1.3.4.2 It is important that initial classroom training and OJT include instructional and behavioural objectives which describe the behaviours that a trainee must exhibit to perform a task effectively. Such objectives provide inputs to the design of the training programme and measures of effectiveness by which the programme may be judged. The objectives include observable behaviours at the completion of training, the conditions under which the behaviour will occur, and the criteria for acceptable performance. The observable behaviour consists of the actions the trainee is expected to perform upon completion of instruction. Actions such as identify, demonstrate, classify, or operate are used since they portray observable behaviours that can be verified.

1.3.5 Cognitive component

1.3.5.1 The decision-making objective of the security screening task is to ensure that baggage are clear of threat items. This goal-oriented behaviour is influenced by attention and vigilance levels, response bias, and operational stresses. There are two levels involved in the identification of threats within an image:

a) ***Perception of the image***. If the image is not clear enough to make a decision, select an image enhancement function and repeat until the image is clear.

b) ***Assessment of the image***. Compare the image of the object to an inventory of objects in memory, classify and then categorize objects within the image based on object reference library that is held in long-term memory and is built up through training.

1.3.5.2 This analysis of human performance and decision making demonstrates the importance of objectively evaluating the mental (i.e. cognitive) strategies used by operators. This is necessary for two reasons: a) Cognitive errors can include improper judgement or decision making. b) Although all operators may reach the minimal performance standard required, some operators may objectively demonstrate significantly higher levels of proficiency possibly due to the strategies used. It may then be possible to feed back these strategies into the selection and training procedures. Recent studies undertaken by the DERA Centre of Human Sciences have used eye movement recording to evaluate the cognitive strategies of screeners. These studies have shown that over 60 per cent of the errors in threat detection are errors of decision making. This implies that screeners are generally looking in the areas where threats are located but are failing to correctly identify the threat. It is clear from this work that improved training techniques have the potential to improve threat assessment.

1.3.5.3 The incorporation of Threat Image Projection (TIP) as an element of classroom training, CBT and OJT will enhance efforts to make objective assessment of performance levels and its relation to earlier training programmes. This is an important way to evaluate the effectiveness of training programmes by unobtrusively assessing performance on the job. It is also possible to implement TIP off-line as a fitness-for-duty test (Rhodes and Vincent, 2000 discussed the issues surrounding fitness-for-duty evaluations). Comparable assessment concepts should be developed for the other security technologies.

1.4 PERSONNEL RETENTION

1.4.1 Retaining highly skilled civil aviation security personnel is a major problem in some countries around the world. The State with the most acute problem is the United States where rapid turnover has been a long-standing problem that was formally identified in 1979. Available turnover rates from May 1998 through April 1999 averaged

126 per cent at the country's largest airports, with five airports reporting turnover rates of 200 per cent or more and another reporting a turnover rate of 416 per cent.

1.4.2 It should be noted that high turnover rates among aviation security personnel is also of significant concern in many other States. In a sample survey of States, turnover rates were about 50 per cent or less, with Belgium having a turnover rate of less than 4 per cent. This phenomenon may be attributed to several reasons. Security personnel have repeatedly stated that low wages and minimal benefits, high commuting costs to and from the airport, infrequent supervisor feedback, combined with frustrating and stressful working conditions have caused them to seek employment elsewhere. Indeed the level of salary and benefits can vary greatly among States.

1.4.3 Experience in other States also indicates that higher salary and benefits, more training, and frequent testing of screeners results in lower turnover rates which, in turn, may lead to enhanced screener performance. However, this observation of enhanced screener performance should be verified by using the TIP.

1.4.4 The difference in performance levels was underscored in a joint test where U.S. special agents and personnel from an European Union State tested security personnel in their respective countries using the same methods. On average, screeners in the EU State were able to detect twice as many test threat objects as their U.S. counterparts. A possible explanation for this is that the EU operators have greater experience on average than operators in the United States. This outcome is also associated with the EU security personnel undergoing significantly more training combined with their receiving higher salaries and better social benefits.

1.4.5 Recently, the U.S. Federal Aviation Administration and Northwest Airlines have undertaken to develop and implement a series of incentives for screeners designed to reward performance and foster positive team spirit. The measures are closely related to the evaluation of performance and training evaluation standards as well as the utilization of the information to provide (dis)incentives or increased motivation through improved wages, training, and equipment. This may possibly lead to lower turnover rates, thereby allowing airport authorities to maintain highly skilled, trained, and motivated security operators for longer periods and consequently, also improve security levels.

1.4.6 High turnover rates contribute to high recruitment and training costs. In addition, the attrition rates during training and in the initial phase of the OJT are quite high. To this can be added the costs of required background, drug testing, and fingerprint checks for job applicants that raise the price of doing business for security companies. Better selection and training would certainly impact positively on decreasing such direct costs associated with a high turnover rate. There is also the non-negligible indirect "cost" associated with providing security-sensitive information to a large number of people who no longer have the need to know.

1.4.7 It is important to note that different States have different requirements for potential applicants. For example: Belgium requires screeners to be Belgian nationals. The Netherlands requires screeners to have resided in the country for at least five years. France requires screeners to be citizens of a European Union member nation. Canada requires screeners to be citizens or permanent residents. The United States only recently requires screeners to be citizens or resident aliens.

1.4.8 There is increasing recognition in the civil aviation industry of the demanding nature of the roles and responsibilities of checkpoint security personnel. These tasks require high-calibre personnel who are highly trained, highly motivated and adequately remunerated in order to help ensure that the highest possible security standards are maintained in airports. More action needs to be taken to address the issues surrounding selection, training and retention that will optimize system effectiveness and performance standards and thereby reduce the risk to civil aviation safety and security.

Chapter 2

TECHNOLOGIES IN CIVIL AVIATION SECURITY OPERATIONS

2.1 INTRODUCTION

2.1.1 Over the past decades, the human elements in civil aviation security has been neglected as resources have been focused on the development and deployment of new technologies. This is despite a historical perspective that demonstrates clearly that ignoring the Human Factors aspects of technological solutions is associated with reduced operational effectiveness. This chapter deals with the second dimension of the Human Factors framework — Technologies and the issues associated with their deployment in the operational environment.

2.1.2 The review assesses available technologies used in civil aviation security operations. These include Screener Assist Technologies (SAT), Threat Image Projection (TIP) technologies for X-ray systems, Trace Explosive Detection Systems (TEDS), and bottle content analysers. Additional ergonomic design issues of these various technologies and their integrated deployment in the airport environment are also addressed.

2.1.3 Most States have a number of safeguards in place to minimize the risk of attacks against commercial aircraft. Among the most important are the checkpoints at airports where passengers and their carry-on items are screened for threat items. The United States first required domestic passenger screening in 1973 in response to increased hijackings. The primary focus of the screening was to detect weapons (e.g. handguns, knives) through the use of X-ray and metal detection systems at checkpoints. This greatly reduced the number of hijacking incidences. Unfortunately, in the 1980s and 1990s, the type of threat mutated, with aircraft being impacted through the use of small improvised explosive devices (IEDs) and plastic explosives that are more difficult to detect. The traditional X-ray and metal detector technologies have been supplemented since the mid-1990s with new advanced screening technologies that are capable of automatic threat detection.

2.1.4 The most difficult aspect of the screener's task is making a correct interpretation of the X-ray image. The reason is that threat objects can be difficult to locate and non-threat objects can appear similar to threat items. We know from a long history of research that operators are not reliable at tasks that require sustained monitoring for infrequently occurring events. The question remains: What are the operators' limitations and how can we best extend their capabilities through technologies?

2.2 NEW TECHNOLOGIES

2.2.1 Over the past several years, conventional technologies such as X-ray imaging and metal detection have improved significantly. However, new technologies to address the changing nature of the potential threat have not yet been developed nor deployed. Such technologies would include millimetre wave devices that are sensitive to threats and pattern recognition of threat objects that uses neural networks derived from an adaptive system linked to an X-ray baggage scanner. Nevertheless, there is a growing realization of the criticality of human performance in civil aviation security based on the fact that, although engineering evaluations could readily determine the physical capabilities of screening equipment, the reasons that a threat item might pass undetected during checkpoint screening are complex and go beyond technology. Consequently, the limiting factor in determining the effectiveness of the screening process was seen to be the ability of an operator to correctly recognize and identify threat objects embedded within X-ray images. New equipment will thus automate some aspects of the baggage inspection process and provide the screener with more detailed and timely information.

2.2.2 The achievement of 100 per cent automated detection in the absence of any false alarms is a laudable objective and contributes to reducing operating costs, thereby removing human error from the operating loop or procedure.

Automated detection technologies have not been shown to actually improve system (Operator + Technology) performance levels. Any potential improvements in performance will be critically dependent on the levels of automated hits, false alarms and nuisance alarms because a high number of false and/or nuisance alarms will lower the confidence of the operators in the technology. In such cases, operators may abandon, ignore or circumvent the system altogether, thereby leading to high levels of error. Conversely, a high number of hits can lead to a false level of confidence and an over reliance on the technology. This in turn can lead to decreased hand searches and decreased situational awareness. Only high hit rates combined with extremely low false alarm rates (i.e. high d prime, estimated as the normalized difference between hit rates and false alarm rates) may actually provide the necessary conditions for improvement in system performance and thereby minimize risk.

2.2.3 In general, inspection effectiveness will remain dependent on the proficiency of the human operator. Moreover, it may be useful, and sometimes vital, to keep the human in the decision-making process, especially if they must respond during emergency or abnormal conditions. Given these important issues, a compromised approach has emerged whereby the technology will assist the operator in detecting threat items (e.g. automated threat alert).

2.3 IMAGE ENHANCEMENT

2.3.1 Because it can be readily programmed into technology software, automated threat detection function is now present in Screener Assist Technology (SAT) that is also now widely available on X-ray systems. However, although the X-ray system can be programmed to detect properties of known explosives, it is of very little use in countering the threat from improvised explosive devices (IED). It may also have a negative impact as it decreases the detection of other threats. This automated detection feature is accompanied by other image enhancement options.

2.3.2 Although numerous image enhancement and manipulation functions are available (e.g. zoom magnification, penetration levels, organic/inorganic stripping, variable contrast, edge enhancement, inverse video, rotate, etc. — see Figure 2-1 where the available options are indicated along the right hand edge of the image), only a

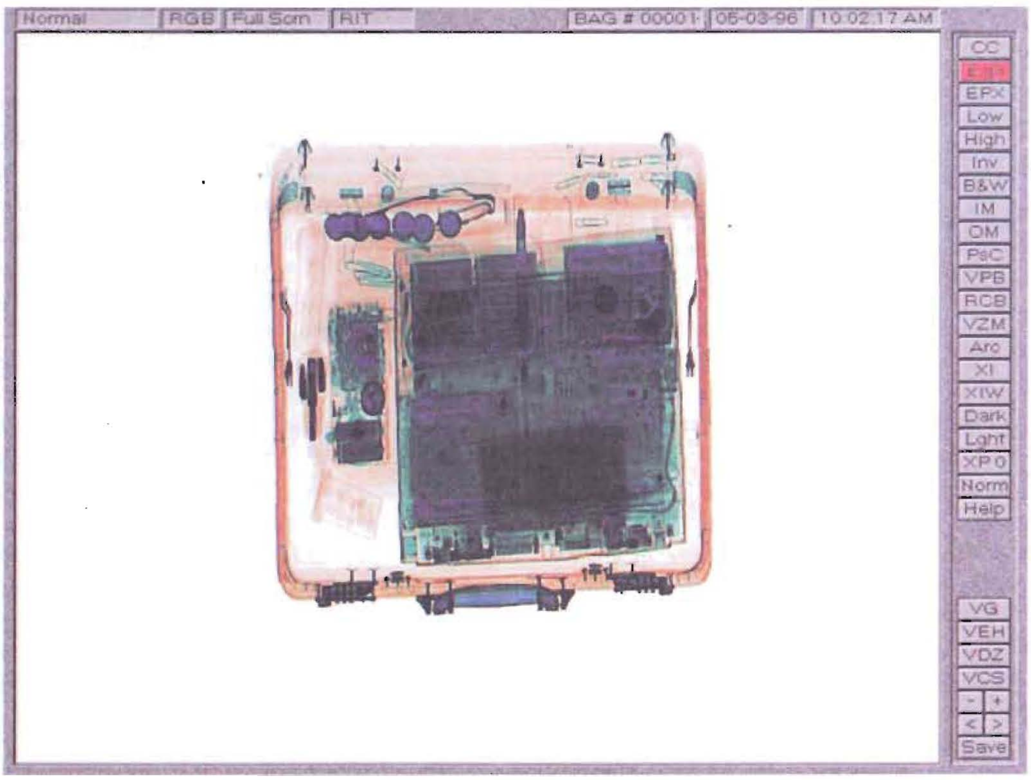

Figure 2-1. Example of X-ray image enhancement and manipulation features

few options (image magnification, black and white, and colour enhancement) are used by X-ray operators in the operational environment.

2.3.3 There is a very wide range of types of image enhancement and manipulation options. This is associated with very little standardization, increased technical specifications (where each manufacturer increases the number of functions available in response to competition) and an overall utility level that is still undefined. It is necessary to research Human Factors issues to determine which enhancement options are necessary and can be used to enhance threat detection performance.

2.3.4 Studies undertaken by the DERA Centre of Human Sciences through the use of operational trials have uncovered several important Human Factors issues requiring attention. For instance, operators may lack the detailed knowledge of the image enhancement functions available for the enhancement and manipulation of on-screen image. More importantly, they have an apparently limited understanding about the use of the enhancement functions and of the type of image that those functions are useful in exploiting. The use of image enhancement function is also not consistent between different equipment types within and across airports. Operators do not apply any particular criteria in selecting which image enhancement functions are to be used on particular images.

2.3.5 The use of image enhancement functions to optimize image analysis depends on the type of image presented. There is room for some form of automated image assessment and enhancement based on the particular characteristics of an image before its display to the operator. The DERA Centre of Human Sciences in the United Kingdom has undertaken studies to determine the most appropriate image enhancement functions for optimizing screener detection performance. Their work has shown that the most appropriate image enhancement algorithm is critically dependent on the complexity and content of a particular piece of luggage. It underscores the fact there is no single algorithm that will be optimal for every type of bag. Furthermore, the work has led to the development of a prototype intelligent and adaptive system which can recommend to the screener the most appropriate algorithm for enhancing and manipulating the image in order to assess a piece of luggage. This is an example in which the development of advice and support technologies are adapted to the limitations and capabilities of the user. In general, there is need for closer link between equipment manufacturers, users, and Human Factors specialists in order to tease out the use of image enhancement functions on X-ray systems.

2.3.6 A recent U.S. FAA report has indicated that screener performance in the interpretation of X-ray images could be significantly improved through the use of automatic threat detection technology that provides both detection and operator alerting. However, there are concerns not only with the maturity of the technology, the variability and high false alarm rates required for an acceptable detection rate, but also with the Human Factors issues related to the introduction of automation into what is currently a primarily human task of image interpretation. In addition, the introduction of SAT to central search should be given careful consideration because of a number of concerns related to visual search, attention and object recognition. In order to optimize SAT impact in the operational environment, the image enhancement functions should be:

- — screener selectable during the threat assessment, or
- — applied as a default secondary search method once the screener has cleared the image of threats from the assessment.

2.4 THREAT IMAGE PROJECTION (TIP)

2.4.1 An important recent technological development that provides continuous online refresher training and assessment of the threat detection performance of screeners is the development and implementation of Threat Image Projection (TIP) technology. TIP allows the virtual inclusion of threat images into the physically derived image of scanned baggage, or alternatively, the system may virtually include an image of a whole luggage containing a threat. The image of the threat object is "false" only in the sense that the object is not physically in the baggage. However, the appearance of the "virtual threat object" in the X-ray image is identical to the image from a real object (see Figures 2-2 and 2-3). This was demonstrated in a recent lab test of the TIP that was carried out to assess screener performance by using real and TIP presentations of threats and innocuous items. The X-ray screeners were shown what they would see if a threat object were physically present in the baggage. The results were that both the physically present and virtually inserted threat objects appeared identical to the screener. This TIP technology therefore allows X-ray screeners to be confronted with what they would see if the actual threat item were in the piece of luggage, but without the danger of having a threat item be physically present in the luggage.

2.4.2 For this reason, one way to help regulators, airport authorities and operators make an objective evaluation of the threat item detection performance of X-ray screeners is to require that all X-ray systems have TIP.

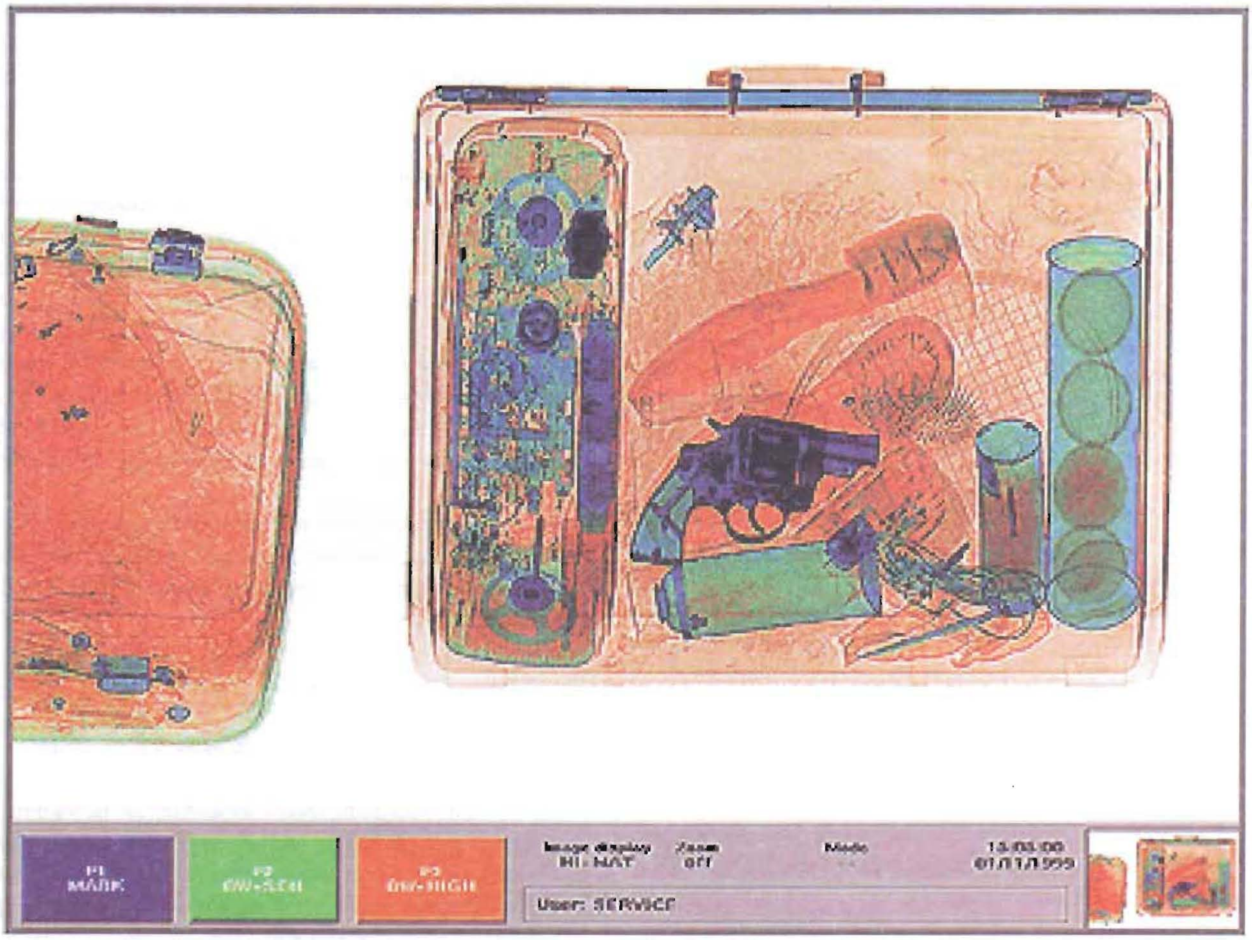

Figure 2-2. X-ray image with embedded virtual threat item

Currently deployed TIP systems conform to the functional requirements laid down by the U.S. FAA in the early 1990s. These functional requirements enable TIP to meet three fundamental objectives: continual refresher training free of down time, objective performance assessment (i.e. estimation of the probability of detection, false alarms, misses and correct rejections), and the maintenance of operator vigilance. The TIP thus allows for the identification and evaluation of the highest performing operators, and as a result, the technology can be vital in the certification of X-ray screeners.

2.4.3 Other benefits of using TIP include:

- Enhanced screener motivation.
- Enhanced screener vigilance.
- Exposure to and practice in detecting a wide range of threats.
- Practice in detecting threats under operational conditions.
- Immediate feedback to operators.
- Objective monitoring of threat detection performance.

2.4.4 In the past, the only method available to assess screener performance in the operational environment was covert testing. Testing personnel in this way is highly labour intensive and a screener would be tested only infrequently (in terms of the number of baggage that the screener sees in any given period of time). Moreover, once a first infiltration had been carried out, it was generally known throughout a duty station that testing was taking place. Consequently, what is in principle a "closed" (i.e. unknown) test is not so in reality. With the advent of the TIP technology, a false threat item image could be projected to a screener as part of an objective performance evaluation. At the same time, the number of resources required in testing is reduced significantly even as the testing is kept "open" (i.e. known).

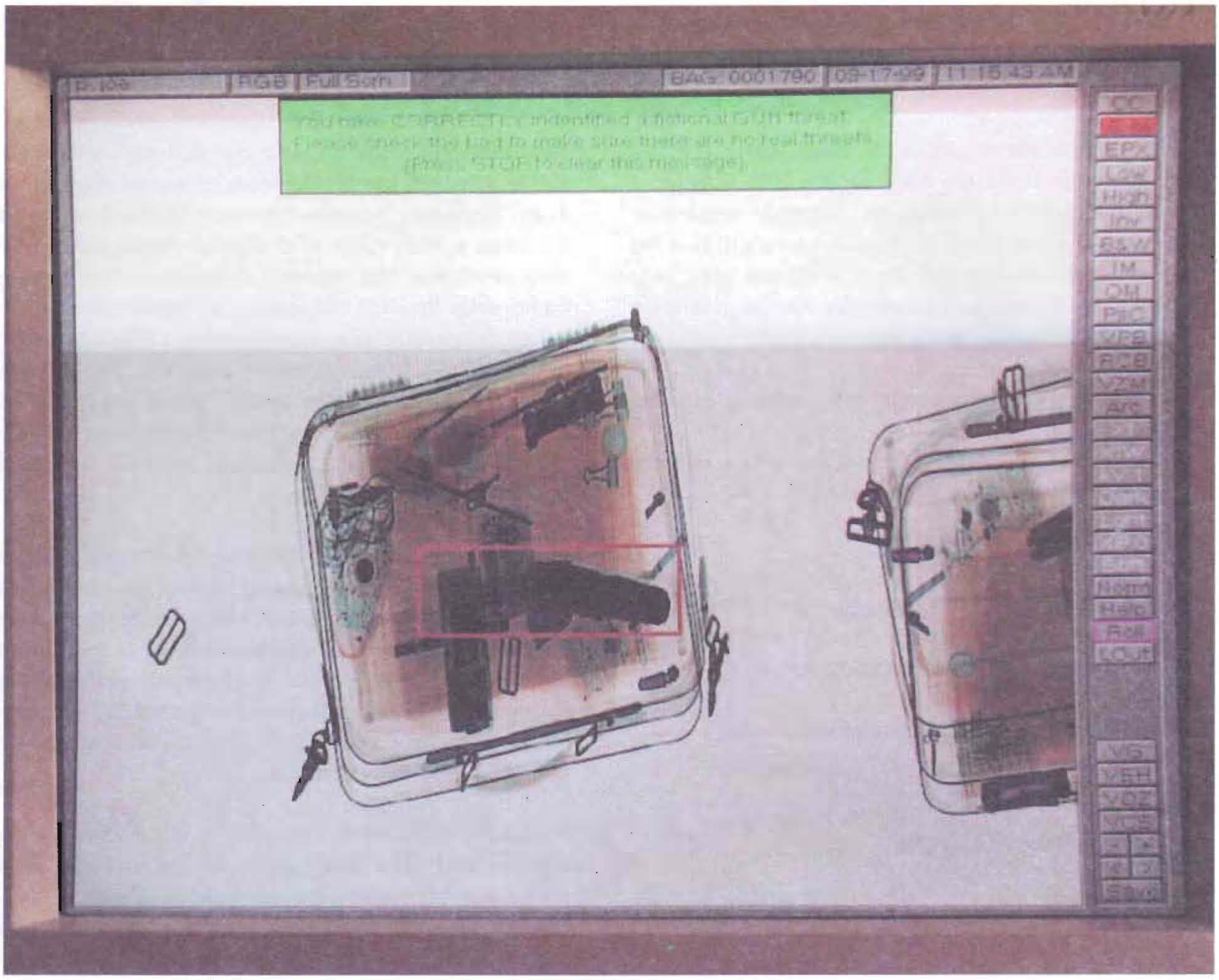

Figure 2-3. X-ray image with embedded virtual threat item

2.4.5 It is also possible to modulate the presentation rate of test objects to a screener in order to increase or maintain the level of screener vigilance. The following three parameters can be manipulated:

a) The first is the bag ratio or one TIP image per X-number of bags (e.g. 1 TIP/100 bags), making the TIP image dependent on the passenger and baggage flows.

b) The second is bag range or the bounds around the bag ratio (e.g. +/- 20 per cent), to prevent screeners from counting bags to predict the next TIP.

c) The third is a random ratio which allows for the presentation of threat images at any time (e.g. 10 per cent of all threat images) to keep screeners vigilant immediately after a TIP image.

All operators can also be presented with a full range of the most current and likely threat objects known.

2.4.6 The TIP system can calculate, score, store and report screener performance. When a screener identifies the presence of a projected threat item, this event is scored as a HIT. When a screener does not identify the presence of a projected threat item, this event is scored as a MISS. When a screener reports the presence of a projected threat item when none was projected, this event is scored as a FALSE ALARM. When a screener does not report a threat item and none was projected, this event is scored as a CORRECT REJECTION. These events are accompanied by immediate visual feedback indicating whether screeners did (i.e. HIT) or did not (i.e. MISS or FALSE ALARM) correctly report the presence of a projected threat item. Through the use of a unique identifier for each screener, combined with the X-ray machine serial number, it is possible to obtain the screener identification that can then be cross-referenced with selection, training, work schedule/organizational, and equipment data.

2.4.7 While the original U.S. FAA Human Factors specifications provided the basis for the TIP systems, a number of Contracting States are currently developing second and third generation TIP systems which will have the capability to present fictional threat items that have been modified according to image complexity. Second-generation TIP systems will include new features such as:

— improved data management and interpretation tools;

— controllable image transition and position orientation for each individual bag;

— improved image libraries;

— images selected for automatic occurrence either individually or in a series based on time of day, checkpoint activity, or screener identity;

— automatic modulation of complexity level;

— rotation of threat items;

— potential for 3-D images;

— improvements to the content and quality of feedback for missed threat items; and

— enhanced remedial off-line training through the presentation of individual performance data and previously missed images.

2.4.8 Third-generation TIP systems should be able to automatically assess image complexity and adaptively match the image with a fictional threat item (FTI) so that the FTI is placed in the most suitable area in the bag. Furthermore, third-generation systems should be able to diagnose individual performance levels and adaptively support a screener's training requirements through the presentation of FTIs of appropriate complexity. The incorporation of an objective complexity measure within TIP systems will ensure that these systems are truly fair, valid and reliable. This will then provide an effective and accurate identification of the screener's performance, and in turn lead to valid screener certification and competency assessment. Some of these developments are in an advanced state, thanks to research development programmes in the United Kingdom and Switzerland, and may potentially be operational in the near future. Such research and development activities will have to continue and the innovation made available to all States.

2.5 TRACE EXPLOSIVES DETECTION SYSTEMS (TEDS)

2.5.1 One of the most significant advances made in addressing the threat from improvised explosive devices (IEDs) has been the development of vapour detection and Trace Explosives Detection Systems (TEDS). Over the past 30 years, a wide range of explosive vapour sensors have been developed. The chemical detection of explosives has traditionally involved the sensing of vapours emitted from volatile explosives (e.g. nitroglycerine (NG) and trinitrotoluene (TNT)) with high vapour pressures. The task today is singularly more complex because plastic explosives with exceedingly low pressure vapours have become more available and are much more difficult to detect through vapour analysis.

2.5.2 Fortunately, it has been shown that traces of explosives are always present as microscopic particles and can be collected and analysed. The term "trace" describes the technology that can analyse material in the form of trace particles and/or vapour. Trace particle analysis is now the most widely accepted detection method. By the end of 1999, there were nearly 1 000 TEDS used routinely in airports around the world.

2.5.3 Trace particle sampling is in principle the most effective way of detecting any type of explosive, if appropriate sampling and analysis protocols are adopted. It should be noted that the actual collection of a trace is the most important and also the weakest link in the chain of tasks related to the analysis of collected trace particles. The traces are usually collected onto porous filters by vacuuming or by a swipe or swab technique. It has been learned that vacuums are not typically used in the operational setting due to their noise, periodic lack of power, and slowing of passenger throughput. Additionally, the proper use of trace and swab techniques requires training and is quite prone to human error and fading. These errors include: swabbing in inappropriate areas of a piece of luggage, cross contamination, using soiled swabs (the swabs are relatively expensive so there is a built-in cost incentive to overuse them), thoroughness of particle sampling decreasing over time, and throughput pressures leading to superficial sampling. Another drawback of the trace particle sampling, in terms of usability, is the calibration of the system which can be quite complex, involving numerous non-intuitive steps to complete the process properly. It is necessary to document the calibration and its results with an up-to-date log, making sure that feedback from the display show clearly when maintenance and calibration are not being completed in a proper or timely fashion. (To counter these drawbacks, the U.S. FAA has developed quality control aids for screeners and field inspectors.)

2.5.4 The interface design and display of TEDS require that attention be paid to Human Factors considerations. It is important to display the identity and quantity of the explosive present; however, an open question is the level of information that should be available to screeners. Attention should also be paid to the system status display. A fault condition has to be indicated in a way that can be easily noticed, encoded, and comprehended by the user and that leads to proper compliant intervention by the operator. The system status display may also support the user by indicating the potential causes and areas requiring operator intervention.

2.5.5 Operationally derived data have demonstrated that TEDS can be quite sensitive and reliable.[1] It appears that TEDS may be able to provide the necessary conditions for optimal threat detection performance with high detection (i.e. high d-prime) levels. It should be noted however that TEDS is only one piece of technology used at a checkpoint and that other technologies need to approach similar high levels in order for the security system to minimize the risk of a threat item going undetected. It should also be kept in mind that the trace particle sampling and X-ray image analysis are performed by human operators who are somewhat less sensitive and reliable.

2.5.6 With recent improvements in trace collection, trace detection walk-through portals are now widely used and common in the marketplace. When walking through such a portal, the passenger will be exposed to a controlled airflow for a few seconds, and the particles liberated are passed on to an Ion Mobility Spectrometry (IMS) detector for analysis. One such portal can detect and identify up to 30 different types of explosives (e.g. RDX, PETN, Semtex and Ammonium Nitrate) and chemical warfare agents (e.g. tabun (GN), sarin (GB), soman (GD), cyclosarin (GF), and methylphosphonothioate (VX)). The nominal passenger throughput of such portals is seven passengers per minute. Regulatory authorities in the United States are planning Human Factors usability assessment (Operator and Passenger) as well as a laboratory effectiveness and efficiency assessment of trace portal technologies.

2.6 LIQUID DETECTION

Explosives and flammable materials may be concealed in bottles in carry-on or checked baggage. Given the volume of passenger baggage and the fact that bottles are often elaborately packed or sealed, manual inspection of a bottle's content is potentially ineffective. To improve the screening of containers with unknown liquids, new technologies and devices are currently being developed to screen the content of bottles and other containers. It should be noted that bottle content analysers are still in the early stages of development and provide opportunities to apply Human Factors knowledge to design. Early versions of the analysers were reasonably user-friendly and required minimal user intervention. Sample analysis times were however quite long (on average 1.5 minutes), thereby negatively impacting passenger throughput levels, increasing the stress level of screeners and contributing to errors in the security system.

2.7 PASSENGER PROFILING

Airline security experts believe that technology must be used in conjunction with passenger profiling. Profiling is a method of separating potentially threatening individuals from other travellers. There are two general approaches to operational profiling:

a) One compares passenger demographic and other background data to historic or recent intelligence-derived "threat profiles".

b) The other is based on the screener's psychological assessment of the passenger, taking into account anxiety, hostility or other suspicious characteristics.

Most profiling systems use elements of both approaches to varying degrees. Automated profiling systems are currently being developed. It is important that a Human Factors perspective be applied in the development, implementation and evaluation of human-centred or automated profiling systems. This is especially important given industry acceptance of profiling technology, the unregulated environment in which the systems are being developed, and the potential enhanced capabilities and future needs. All these technologies need to systematically and comprehensively address ergonomic design and usability issues.

2.8 ERGONOMIC DESIGN

2.8.1 Applying ergonomics to the design of technology is important for the following reasons:

— The likelihood of operator errors is minimized.

1. For example, in the United States, 400 IONSCAN units have accumulated a sample base of more than 30 million measurements, an operating time of 3.5 million hours with a false alarm rate below 0.05 per cent and an average mean time between failure of 9 000 hours.

— The systems will be more usable.

— The technology will be appropriate for the users.

— Transfer of training can be optimized.

2.8.2 It is important to incorporate good ergonomic design principles in the development of technology for civil aviation security. For this reason, it is vital to describe the ergonomic requirements of technology being developed in response to civil aviation security requirements. This includes but is not limited to:

— the properties of the displays used in presenting visual or auditory information (e.g. screen size, viewing distance, interlace, refresh rate, and flicker);

— the physical properties of the image or sound;

— the controls and menus required to access the necessary information, including their layout, their number, etc.;

— how the interface is developed to take into account that some operators using the equipment will have had no prior exposure to computers (e.g. colours and graphical user interface);

— the sampling method required of operators which is especially critical in the use of TEDS;

— standardization of the ergonomic elements of technology (e.g. visual/auditory or silent alarms or signals to screener);

— how system status should be displayed so as to indicate a fault condition; and

— the steps required in calibrating a system.

Unfortunately, the consideration and integration of good Human Factors practice in the development of civil aviation security technologies is still lacking.

2.8.3 Transferring the boring and repetitive tasks that people perform poorly to machines is an approach that can reduce system errors. However, automated devices may inadvertently create new sources of human error. For example, excessive false alarms unnecessarily distract operators and may lead to the device being ignored or deactivated. During atypical or emergency situations, the lack of flexibility in many automated systems can be a severe limitation and the human back-up may not be mentally (i.e. situational awareness) or physically prepared to intervene.

2.8.4 In summary, it is important that operators are able to read the displays easily and without error, interact with the menus/options effectively and efficiently, and interpret alarms quickly and accurately. At a more general level, it will become increasingly important to integrate technological systems to an overall strategic and tactical framework for security in airports. In addition to combining the operation of different technologies from diverse, and sometimes competing, manufacturers with the flow of passengers, new technology must operate in a dynamic environment where weight, size, maintenance, and volume of passenger traffic are important factors. A related consideration of importance is how to maximize the deterrence impact of aviation security operations.

2.8.5 What is currently known is that each type of screening and its associated technology is unique and requires different knowledge, skills and abilities (KSAs). For example, monitoring a portal metal detector requires a limited understanding of the technology involved and does not involve image interpretation. Conversely, operating a TEDS is much more complex and requires operators to exercise independent judgement as they render decisions regarding outputs that are all distinctly different. These screening tasks require a different set of KSAs and training in order to optimize performance for a particular KSA set that is related to the task using dedicated technology. At the same time, the civil aviation community would like to have maximum transfer of KSAs that have been developed during training to as many screening tasks as possible.

2.8.6 Interoperability of technology is very important and requires the standardization of interfaces, protocols, and Standard Operating Procedures. New technology also needs to be integrated into different security tasks (e.g. bottle content analysers and automated profiling) in a seamless and transparent fashion. A full system approach grounded in Human Factors is the key to reducing system (human + technology) errors. Such an approach must take into account the impact of the operational environment and the organizational culture on operator performance and its relation to system errors.

Chapter 3

OPERATIONAL ENVIRONMENT AND ORGANIZATIONAL CULTURE

3.1 INTRODUCTION

3.1.1 The third axis of the Human Factors framework deals with the operational environment and organizational culture. This topic does not have as high a profile as those described in the two previous chapters. Nevertheless, security personnel are part of an organizational culture, work as members of a team, and are supervised within a particular operational environment. All of these factors will have a significant influence on the well-being, motivation, and job satisfaction of the security screeners and passengers. It is therefore important to ascertain the influence of these issues on successful airport security operations. Selecting well-suited individuals, training them properly, designing their work environment and rotation schedule to maintain the best possible performance, and providing motivating incentives are fundamental requirements for successful operations, regardless of the type of technology in place. The influence of management "culture" on human performance as one area where basic research is needed has recently gained much prominence. If the organizational climate (i.e. working conditions, quality of equipment, wages, and management) and culture (i.e. shared attitudes, beliefs and behaviours) do not allow an individual or team to perform optimally, it would make little difference on performance if the best personnel were selected, if they received the most expensive and extensive training, and if the technology designs were perfect.

3.1.2 Given the demanding work environment where pressure from passengers, peers and various agencies is present, screeners are actively discouraged from having high false alarm rates since it slows the throughput of the system and can be seen as a negative reflection on the screeners' ability and efficiency. Time pressure to accept a bag as safe to travel or to reject a bag for subsequent hand search is considerable. For operational and motivational reasons, the decision to inspect a bag must not be perceived negatively. Operators are typically required to carry out this task for 20 minutes. At a maximum throughput rate, they would have to make these complex decisions on over 300 bags. Numerous factors within the operational environment will impact the ability to effectively handle this standard throughput rate.

3.2 OPERATIONAL ENVIRONMENT

3.2.1 General

3.2.1.1 With respect to the operational environment, the important factors include the physical aspects of the workplace (e.g. noise, dust, lighting, temperature, and humidity). Recently, a number of States have increased their interest in improving the ergonomic design of the security checkpoint to improve threat detection and passenger throughput. Any security requirement should account for technological advances in conjunction with operational requirements, while incorporating sound Human Factors design principles. There are a number of commercially available workspace design tools that may provide some of the security checkpoint development requirements, but none that would integrate the organizational cultural and team resource requirements for passenger activity and security. Global checkpoint operations and measures of effectiveness will be influenced by variables such as passenger volume and staffing levels, experience, and technologies deployed.

3.2.1.2 An evaluation of checkpoint operations should focus on important aspects such as flow, threat detection, training, supervision, and screener communication. The checkpoint operation can be subdivided into a set of discreet tasks performed by screeners and supervisors to support the overall mission of effectively and efficiently processing passengers and their baggage. Tasks to be included are walk-through and hand-held metal detectors, pat down, hand search, X-ray, trace detector, exit lane and supervision. Performance and efficiency measures should answer the following questions:

— Are effective procedures being followed?

— Are the security staff adequately trained to follow effective procedures?

— Do the security staff communicate effectively in performing tasks?

— Are staffing levels and staff knowledge adequate to accomplish tasks quickly?

3.2.1.3 The criteria for measuring the efficiency/ effectiveness of checkpoint operations could be comprised of the following:

a) Passenger/baggage throughput

— Number of passengers processed and the average amount of time used to process with the X-ray system.
— Number of passengers processed and the average amount of time required in using the walk-through metal detector.
— Number of passengers and the average amount of time needed to process with the hand-held metal detector.
— Number of passengers processed and the average amount of time needed to process with TEDS.
— Staffing numbers as a function of flight (e.g. Airbus A380)

b) Threat detection

— TIP performance (i.e. probability of detection, probability of a miss, probability of false alarm, d^{I}, and response bias).
— Training (initial, OJT and recurrent) and performance.
— Incident reports.
— Measures of compliance with effective threat SOPs.

3.2.2 Checkpoint design

3.2.2.1 New technologically based approaches will have significant impact on the checkpoint of the future. One example is the development of the automated exit lane, with doors that close automatically in the presence of a threat. A major project being piloted by the U.S. FAA is the Elevated Podium for Integrated Checkpoint Security Supervision (EPICSS). This elevated platform will be present at each security checkpoint in an airport, giving an unobstructed view of the immediate area to the supervisor. Such a set-up may confer numerous advantages:

a) The platform will be somewhat removed from the noise of the checkpoint.

b) The platform contains video screeners from strategically located cameras which can show output from X-ray systems.

c) Through radio-links, the various platforms can be in communication with each other, increasing communication and coordination and reducing the sense of isolation that current checkpoints induce.

Such platforms are now being introduced for thorough evaluation but they do show strong potential.

3.2.2.2 Some preliminary work completed by the Direction Générale d'Aviation Civile (DGAC) of France has introduced some modifications to the checkpoint design that would improve passenger flow, security efficiency and effectiveness.

a) The first element is how best to inform passengers about items that they must place on the X-ray conveyor belt or in the bin in order to minimize positive signals from the metal detector portal that would require time and personnel to resolve. This study revealed that passengers do not read signs near the portals; however, when security personnel specify verbally to passengers where to place various items (e.g. portables, cellular phones, and clothing) portal alarms are readily reduced by approximately 30 per cent. This greatly improves the working conditions of operators. Consequently, a change in the operational procedures, i.e. having personnel explain procedures to passengers, can positively impact the efficiency of civil aviation security operations. This process could be improved further with the use of a semi-automated system to verify the boarding tickets of passengers before allowing them access to a checkpoint. This could thus preclude access to meeters and greeters.

b) The second element is a physical improvement that was found to significantly reduce bottlenecks around X-ray machines and portals. The modification requires extending the X-ray conveyor rollers to a minimum of three metres, with a plexiglas partition preventing passengers from reacquiring their luggage before the end point. This simple modification was found to improve the throughput of passengers and received positive comments from security personnel. All procedural and physical modifications are implemented within a larger organizational context.

3.2.3 Organizational levels

3.2.3.1 There are three organizational levels across which the operational environment is established: the national regulatory agency, the airport operator, and the air carrier.

— The national regulatory agency is responsible for:

- identifying and analysing threats to security,
- prescribing security requirements,
- coordinating security operations,
- enforcing the appropriate regulations and standards, and
- directing law enforcement activities under the governing statutes and regulations.

— The airport operators are charged with providing a secure operating environment for the air carriers. They are responsible for ensuring that:

- responsive security programmes and emergency action plans are maintained and updated,
- air operations areas are restricted and protected,
- law enforcement support is provided in response to various security threats, and
- physical security measures for the airport are provided.

— The air carriers are responsible for the most visible security measures for safe and secure travel, which include:

- screening passengers with metal detectors, X-ray and other equipment,
- inspecting carry-on baggage,
- securing baggage and cargo,
- protecting the aircraft, and
- maintaining responsive security programmes.

3.2.3.2 It should be noted that air carriers, security companies, and airport operators are not structured nor resourced to perform Human Factors research and development. Hence air carriers in many States can contract private security firms to perform most of their security functions. However, within the larger system environment, it is important to consider the screening guard companies that actually complete the tasks required. The reason is that there are legal issues that are increasingly more harmonized internationally and that impact the screening operations and security.

3.2.4 Team issues

3.2.4.1 Performance and efficiency issues are rooted in the complex interactions of people and equipment within the larger system, namely the institutional and organizational structures and procedures that drive the planning, design, and management of aviation security systems. At a checkpoint, there is a team of security personnel to perform various functions. The team composition can change from day to day; it usually includes two to six individuals. Team members rotate through the various checkpoint (e.g. X-ray, hand wanding, and EDS) positions during their shift. Operationally, personnel rotate many times during their shift due in part to the issue of sustained vigilance at the X-ray machine and to the need to maintain their proficiency in all aspects of the checkpoint. Rotation also provides a degree of relief from possible boredom and inattention caused by repetitive performance of the same limited set of actions.

3.2.4.2 Regarding the teams that work a checkpoint, we must be aware of the operational realities that can lead to team function/dysfunction problems. Establishing teams is useful for solving cognitively complex tasks; however, the demands associated with working together also effectively increase. Team tasks require the team to detect and recognize relevant cues, make decisions, solve problems, remember relevant information, plan, acquire knowledge, and design solutions as an integrated unit. It has become increasingly important to integrate the information collected from different teams at security checkpoints both within one airport and among different airports. Currently, the security system in general is unable to coordinate and integrate information collected across time and/or space.

3.2.4.3 Team issues may be the reason that some aviation security personnel cannot effectively work with others. Cultural factors and associated linguistic differences can impact team and system performance at varying degrees, even to possibly high risk levels. It may then be valuable to apply team resource management training to all security personnel.

3.2.4.4 Team training and team management have only recently come under systematic testing and evaluation by a few States. For example, in the United Kingdom, work by the DERA Centre of Human Sciences has led to recommendations for improvements to the management of personnel at central search, thereby improving the effectiveness of teams and interaction among team members. This, in turn, has culminated in recommendations for the training of team skills, leadership training for supervisors and establishment of a well-organized performance appraisal system. This is necessary in order to develop a methodology and a rating system to evaluate the screening checkpoint's overall team performance.

3.2.5 Shift management

3.2.5.1 Another element found to be critical in the operational context of aviation is the increased awareness related to shift management in order to help sustain operator alertness and attention. Two primary factors known to affect a person's level of alertness are the time of day (associated with endogenous circadian patterns) and the time elapsed since the end of the last sleep period. To these can be added any sleep deficits/debts and time on task. Time on task (i.e. duty period) will have very acute effects when associated with high workload levels. These factors all interact to produce individually varying levels of alertness over a 24-hour period.

3.2.5.2 Several best practices can be implemented to minimize the adverse impact associated with fatigue on the alertness of operators/supervisors. These include:

— Proper design of roster to rotate forward to avoid "quick returns" (i.e. inadequate rest periods between consecutive duty periods).

— The shift system should rotate rapidly to limit the number of consecutive night shifts.

— Duty periods should be limited to eight hours.

— Limits should be placed on consecutive periods of night work.

— Shift rosters should be designed by taking into account periods of high throughput.

— Time on task should be limited as a function of time and/or performance levels.

— Task rotation should be maintained.

— Timing and duration of rest periods during each duty period should be properly considered.

— Adequate rest facilities should be made available.

— Due consideration should be given to commuting times.

— Operators should be allowed some choices in selecting the shift periods according to their preference.

3.2.5.3 The implementation of such recommendations can also go a long way in reducing turnover rates. The recommendations can however only be implemented with the support of management and personnel in developing appropriate policies and procedures within a supportive organizational culture. Recently, in the United Kingdom, the national regulator has issued guidance material to the industry on best practices for shift management related to security personnel.

3.2.6 Disruptive passengers

3.2.6.1 The ever-increasing presence of disruptive passengers on board civil aircraft is contributing to higher risk to safety and security in civil aviation. As the number of passengers continues to increase[1], so will the number of disruptive passengers. Research indicates that most incidents of interference occur during international long-haul flights. A determined passenger who behaves in a violent or distressed manner can be as serious a threat as the presence of an IED, a hijacker, or a fire in the aircraft.

3.2.6.2 There are numerous hypotheses cited as contributing to the increased rate of disruptive passenger behaviour. The first is the more complete and systematic reporting of such incidents by airlines and greater media coverage. Other factors include: stress (e.g. fear of flight and airport environment), alcohol/chemical consumption (including medication), nicotine deprivation, aircraft environment, lack of physical space, psychological perception of lack of space, aircraft filled to capacity, mental/physiological distress, disconnect between the marketed images and the reality of commercial flight, and social factors. (An example of one such social factor is to envisage the changes in the behaviour of individuals who, linked to a global network, are accustomed to obtaining any information, product or service at the touch of a few mouse clicks and whose unrealistic expectations of instant gratification are not met.)

3.2.6.3 Fear of flying is a Human Performance issue unique to aviation. It affects a large percentage of air travellers and is frequently accompanied by other phobias such as acrophobia (fear of high places), claustrophobia (fear of

1. The number of scheduled passengers carried is forecast to increase at an expected average annual rate of 3.5 per cent and from 1.6 billion to 2.3 billion passengers during the period of 1999 to 2010 (Circular 281).

confined spaces) and agoraphobia (fear of large open spaces). Research has shown that 65 per cent of fearful flyers used alcohol and drugs before and during flight to combat their phobia. The disturbing incidents have highlighted the need for improved understanding of passenger behaviour linked to mental illness. What training do security personnel receive to assist them in making a preliminary assessment of passenger behaviour? What, if any, warning signs may be observed at a security checkpoint?

3.2.6.4 A recent survey completed by the world's airlines provided a ranking of the causes of disruptive behaviour by respondents: alcohol ingestion, demanding passenger, or intolerant personality, flight delays, stress of travel, smoking ban, cramped conditions in cabin, passenger denied carry-on luggage, excessive passenger expectations, crew mismanagement of problem, and passenger denied upgrade.

3.2.6.5 Once an unsafe act has been committed on board an aircraft, it then becomes an issue of how to deal with the disruptive passengers during and after the flight so that their fundamental rights and freedoms are not compromised. Proactively preventing potentially high-risk passengers from boarding an aircraft in the first place may be a civil aviation security matter. One way to minimize the risk of passenger disruption is through the exchange of information among airlines with regards to passengers who have been warned or detained following unsafe acts aboard aircraft. Such action may however have legal implications.

3.2.6.6 The integration of Human Factors knowledge will be critical in developing the specific training for security personnel for the purpose of identifying passenger behaviours that may be valid cues in identifying high-risk passengers. Profiling technology will be unable to complete such a task automatically; however, the technology may be used as a database of disruptive passenger-related occurrences. Training focused on human performance will also be critical in the training of cabin personnel on dealing with a disruptive passenger (or a coordinated group of passengers) during flight. The success of a preventive strategy relies on three conditions:

- greater awareness among passengers of how the airline will respond to disruptive acts;
- the implementation of a zero-tolerance policy; and
- the likelihood and type of consequences in response to their disruptive behaviours.

3.2.6.7 A well-designed, Human Factors-based, error-reporting system that leads to an analysis of potential causal factors is essential for operators and regulatory authorities. The former are in a key position to gather and analyse data from the airport and aircraft environments. Enhanced training programmes based on the information gathered from the error-reporting system could help reduce preventable incidents in the airport and on board aircraft.

3.2.6.8 The first objective of civil aviation security operations is still to prevent disruptive passenger incidents with preventive measures through aviation security procedures and personnel, and the second is to contain the event after it has occurred through appropriate cabin safety measures. In order to proactively prevent such incidents, it is necessary to gain a clearer understanding of the causes of behaviour. Data have to be gathered about the profile of passengers who commit such disruptive acts, travel conditions, potential triggers, the nature of the disruption, the outcome (e.g. arrest), and the impact on the passenger and their family. The challenge caused by disruptive passenger behaviour may quickly become the leading aviation safety and security issue within the next five years.

3.3 ORGANIZATIONAL CULTURE

3.3.1 General

3.3.1.1 Other organizational elements include: the performance standards that have been implemented and how they are enforced; how such standards mesh into the policies, processes, and procedures in place within a particular organizational culture; and how these standards support optimal security levels. For example, potential errors can be forestalled by using Standard Operating Procedures, checklists and job performance aids for routine and emergency tasks, by planning work shifts and assignments that do not induce inattention and fatigue, and by properly designing the work environment. As Professor Earl Wiener, formerly of the University of Miami, pointed out:

> If Human Factors engineering is done properly at the conceptual and design stage, the cost is high, but paid only once. If training must compensate for poor design, the price is paid every day.

3.3.1.2 The importance of proper Human Factors engineering at the conceptual and design stage also applies to the management practices and procedures as they impact on the entire aviation security system. The system will be comprised of equipment (displays and controls), work-rest schedules, work management practices, demands of the airport environment, the social and organizational structure, and the overall goals of the task. Any analyses or remedies that look at isolated segments are likely to lead to isolated and short-lived improvements, with the potential for creating new problems elsewhere in the system. A Human Factors culture should thus be instilled into civil aviation security operations in order to develop and implement long-lasting systemic solutions to performance and efficiency issues. Such a Human Factors culture places the human operator, rather than technology, at the core of all activities to ensure that all operational and organizational aspects (including policies, processes and procedures) are designed and implemented so as to support optimal system performance levels.

3.3.2 Human error and error management

3.3.2.1 One crucial element of an organization's safety and security culture is the ability to deal with human error. From an organizational perspective, human error should be viewed as a symptom where operators are seen to have been unable to achieve operational objectives because of difficult working environments, flaws in policies and procedures, inadequate allocation of resources, or other deficiencies within the system. Because of omnipresent human error, unintentional deviations from established norms (operational and organizational) will occur. Such operational deviations provide a unique opportunity for developing a process of error management. Effective error management is based on the free exchange of information about operational errors which lead to deviations.

3.3.2.2 In developing the Line Operations Safety Audit (LOSA — 2001), Robert L. Helmreich of the University of Texas at Austin found that all observed errors could be classified into five types:

— Procedural errors, where personnel are trying to follow procedures but execute them incorrectly.

— Communication errors, in which information is improperly or incompletely communicated, withheld or misunderstood.

— Proficiency errors, where tasks are improperly executed because of a lack of Knowledge, Skills and Abilities (KSAs).

— Decision errors involving situations not covered by procedure or regulation, in which personnel take actions that unnecessarily increase risk.

— Intentional non-compliance, when personnel knowingly violate company policy or regulations.

3.3.2.3 Error detection, classification, quantification and reduction must be a priority for the organization. The necessary processes and tools to detect, monitor and counteract errors within the organization (including errors in operations and management) must be developed, refined and constantly tested to ensure the application of best practices. Counteracting these errors involves determining the cause(s), potential risks posed by the errors, and the corrective action required to ensure that the organization minimizes error and is error-tolerant.

3.3.2.4 A first step in understanding how errors emerge in an operational setting is the implementation of an error reporting system, where personnel can report any perceived errors to a trusted and impartial party who compiles and manages an error database. The reporting process has to be completely confidential and structured so that core data are collected in a user-friendly format, where open-ended corroboration and contextual information are included. It may be possible for some technology to automate part of the data collection process. Analysis of the error data using such an error-reporting system provides powerful insights into the nature of the errors, their causes and their relationship to the error-supporting latent conditions that were present at the time of occurrence. It also allows for an assessment of how well the defensive components of the system work to prevent errors from developing into unsafe conditions (i.e. the organization's fault tolerance). Such an error-reporting tool is essential for assessing and managing the level of risk in the system. Consequently, any change in the level of threat can be assessed with respect to the current level of risk.

3.3.2.5 Error reporting underscores the need to foster an operational environment and an organizational culture where all personnel feel secure in coming forward and sharing observations on error-induced deviations. The establishment of a non-punitive and blame-free culture should however still retain individual and organizational accountability.

3.3.2.6 Human Factors knowledge provides the basis for collecting, documenting and processing information related to error occurrences in order to improve civil aviation security operational effectiveness (e.g. number of threat items detected) and efficiency (i.e. cost and time). Using the errors-related information available from numerous daily events would make it more likely to prevent catastrophic failure in the system (i.e. when a threat makes its way on board an aircraft). A similar perspective has led to the development and implementation of flight data monitoring and voluntary reporting systems, where information from recorded flight parameters and confidential reports are collected and analysed to enhance flight safety.

3.3.2.7 Human operators will err and systems will incur deviations of varying degrees. Errors made by operators may occur because of fatigue resulting from working on rotating shifts or prolonged duty periods. Motivation to complete the tasks effectively may be lacking due to the absence of appropriate incentives or teamwork. Management expectations with respect to job performance levels may be unrealistically low or high. Identifying such organizational conditions and making appropriate changes will reduce the probability of error and deviations. Ensuring that secondary methods are implemented to detect the errors will reduce system risk.

3.3.2.8 Error recovery methods are based on the knowledge of what errors and deviations are occurring, under which circumstances they are detected, and how they are mitigated by staff or other components of the system. Such knowledge can be incorporated into the initial and recurrent training of personnel when redesigning technologies and the work environment, and when modifying processes and procedures. The source of error recovery information is best derived from an Error Reporting System (ERS). One such ERS currently under development by ICAO and its airline and academic partners is the LOSA. The conceptual underpinnings of LOSA could be modulated to an aviation security operation.

3.3.2.9 The question is to determine to what extent the civil aviation security operations can tolerate errors and deviations while minimizing risk at the same time. When errors are perceived for what they are, i.e. normal occurrences in the system, they can be usefully mined to improve civil aviation security operations by continuously providing input for enhanced Standard Operating Procedures and processes, selection, training and performance assessment, technology and workplace design, and management policies.

3.3.2.10 In conclusion, with respect to operational environment and organizational culture, a new Human Factors-centred culture has to take hold within a very complex operational environment. This culture would then support the management of errors and deviations which occur daily in any operational environment. Without a shift in organizational culture, however, the implementation of any systems of tools to complete this endeavour are unlikely to succeed.

Chapter 4

CERTIFICATION

4.1 INTRODUCTION

The fourth axis is comprised of elements related to aviation security certification issues. The process by which States certify personnel, technology, and organizations should be taken into account. Specifically, it is important that regulatory authorities develop Human Factors-oriented validation and certification standards for civil aviation security personnel, technology and organizations that will enhance both security effectiveness and operational efficiency, while also ensuring adequate health and safety for personnel. Civil aviation security personnel and equipment have not received (and have not required) the same level of regulatory and certification attention that regulatory authorities have placed on flight crews, air traffic controllers, maintenance personnel and their respective aviation equipment. Regulatory efforts have instead focused on the elements of the civil aviation system that are essential to maintain flight safety. It is self-evident that the performances of pilots and aircraft systems are critical for maintaining safety; a failure could cause an accident. In contrast, the performance of the civil aviation security system is rarely critical — flight safety is at risk only when security performance fails at the same time that a threat is present. Nevertheless, the certification of personnel, technology and security companies is mandated in numerous States.

4.2 PERSONNEL CERTIFICATION

4.2.1 In most States, the regulatory authority will certify the training programme, material and tests provided to civil aviation security screeners. Screeners are then tested and must meet some minimum score in order to receive their certification. They are then retested periodically (usually yearly) — through either the successful detection of test items or infiltration tests during normal operations — in order to maintain their certification.

4.2.2 Several States are developing specific requirements and guidelines for certification testing of security personnel and legislation in this area is scheduled in the coming years. Other Contracting States have already implemented screener certification programmes.

4.2.3 ***Type Certification.*** Once screeners are certified, they can operate all screening technology deployed at a checkpoint; however, with the increase in technology complexity and diversity, it is important to evaluate if type certification is appropriate in optimizing system performance. Type certification will specify the equipment that a screener is qualified to operate. There is now growing awareness that type certification should also be considered in the use of trace explosive detection systems (TEDS) or other advanced technology and that it be accompanied by more focused training and higher testing requirements. It is, of course, somewhat more cumbersome to keep track of the different personnel who may have various types of certification. It may compromise the ability to rotate staff through the different checkpoint positions. For this reason, it is important that proper policies, procedures and systems be implemented to ensure that records are accurate and up to date. Nowadays, screeners are certified and assessed as being proficient to operate technology in the civil aviation security environment. One benefit of such an approach is the standardization of basic competencies across airports and internationally.

4.3 TECHNOLOGY CERTIFICATION

4.3.1 General

4.3.1.1 When X-ray and metal detector technologies were introduced, there was limited direct relevant experience with respect to Human Factors. These technologies were also relatively simple to operate as compared to more advanced systems such as aircraft cockpits and Air Traffic

Controller (ATC) consoles. The development of Human Factors standards for security was then a relatively low priority; however, properly developed Human Factors certification standards for these technologies would improve system performance for civil aviation safety and security.

4.3.1.2 In the past, airports were operated by the civil aviation regulatory authorities of Contracting States, making certification of technology systems unnecessary. Today, as civil aviation authorities devolve airports to private entities, it has become increasingly necessary to develop standards for certifying civil aviation security equipment. Some States are in the process of developing standards for all equipment that will be used in civil aviation security operations, including equipment to screen freight. For instance, the United States has developed certification criteria for explosives detection systems (EDS), while the European Civil Aviation Conference (ECAC) has developed a test procedure for X-ray display quality.

4.3.1.3 The certification and procurement process ensures that the equipment can detect, under actual operational conditions, the amounts, configurations, and types of explosives materials likely to be used in improvised explosive devices (IEDs). The certification and procurement standards specify the types and quantities of explosive materials that must be detected, the minimum detection rate for each category of explosive charges, and the overall detection and maximum false alarm rates. Essentially, the standards specify the probability of detection [p(d)] and the probability of false alarms [p(fa)]. In addition, the standards define the minimum automated system throughput processing rate and have also been expanded to include "effective throughput" as well as operator testing prior to procurement and field implementation. However, few States have developed procurement requirements which include extensive Human Factors design and testing requirements. There is thus a strong need to develop Human Factors standards for security technologies that would include human engineering development plans and protocols for testing and evaluation.

4.3.1.4 Although several States do have Human Factors testing and evaluation, these are completed after the equipment has been developed and are often conducted concurrently with the deployment of the equipment technology. It is therefore recommended that a Human Factors integration programme be established during the design and development of aviation security equipment so as to ensure that effective Human Factors principles are embedded into all future technology development. So far, such integration exists in other areas of system procurement and should be applicable in the civil aviation security environment.

4.3.2 Equipment procurement

It is recommended that Human Factors be considered in the purchase of aviation security equipment. Generally, equipment that is less costly, smaller and lighter is more practical for use in airports than a system that is more expensive, larger and heavier, especially if the installation and/or operation of such equipment would require separate structures or significant modifications to airport infrastructure. Similarly, systems which are easy to operate and maintain and are proven to be reliable will be more readily accepted than systems that require extensive specialized training for operation, calibration and maintenance. Basically, these recommendations are based on Human Factors considerations which should be systematically and thoroughly evaluated before they are adapted to different technologies. Recommendations on operations are related to throughput rates which should exceed the minimum established standard in order to avoid delays and congestion and thereby meet the requirements for screening large numbers of passengers in a short period of time. Similar standards and recommendations can be adapted for other technologies.

4.4 CERTIFICATION OF SECURITY COMPANIES

4.4.1 General

4.4.1.1 The most developed and encompassing rule on the requirements for certifying screening companies is documented by a recent United States Notice of Proposed Rule-Making (NPRM) which specified that the U.S. regulatory authority will require the certification of all screening companies that inspect, on behalf of air carriers, persons or property for the presence of any unauthorized material. Screening companies would apply for screening company certificates (valid for five years). The U.S. regulator will however not propose a certification requirement of individual screeners, as is the case currently in other States. It will nonetheless require approvals of operational specifications, including the location of screening sites, the types of screening performed, the equipment and methods used to screen, and screener training curricula. It will also specify training requirements for screening companies regarding training programmes and knowledge content areas. Similar requirements on security screening companies are also provided by the U.S. Aviation Security Implementation Act of 2001.

4.4.1.2 The U.S. NPRM also requires that all screening personnel pass computerized-approved knowledge-based and X-ray interpretation tests before and after their OJT as well as at the conclusion of their recurrent training. Under the NPRM, screening companies have to adopt and implement an approved company security programme that includes procedures to perform screening functions (including operating equipment); screener testing standards and test administration requirements; Threat Image Projection (TIP) standards and operating requirements; data collection methods; and performance standards.

4.4.1.3 The proposed U.S. NPRM delineates the responsibilities of the air carrier vis-à-vis the screening company. The air carrier will continue to be responsible for providing proper screening equipment and will carry primary responsibility in dealing with airport operators on issues regarding the locations of screening equipment in airports. Most importantly, the carriers will be responsible for overseeing the performance of the screening companies to ensure they carry out their duties. Meanwhile, the screening companies will be responsible for inspecting persons and material. They will also be responsible for ensuring that they use the equipment properly, staff the screening locations adequately, train the screeners properly, and manage the screening locations to meet screening standards.

4.4.2 Performance monitoring

4.4.2.1 It is the performance of the individual screener — as a result of the operational deployment of TIP systems — that will be used to monitor the performance of screening locations, screening companies, and individual screeners. This operationally based data will be analysed in order to focus resources on improving threat detection by screening. TIP data can be used to determine the working conditions that are associated with better performance, topics on which the screeners require further instructions, and the remedial measures or training programmes that prove to be most effective.

4.4.2.2 The performance monitoring of screening locations can be accompanied by the establishment of performance standards. The regulatory authority, through the analysis of TIP data, can determine the range of company/airport detection rates in the State. Subsequently, it may then set minimum detection rates for each screening company, airport authority, or air carrier. However, the actual metrics by which this minimum detection rate is determined is still subject to assessment and validation. The correct interpretation of TIP performance data is vital if we are to ensure fair, valid and reliable assessment and subsequent adjudication. The use of TIP data is one of the most relevant issues for regulatory authorities, since they can use the data to perform their oversight function in an unobtrusive and cost-effective manner.

4.4.2.3 The use of TIP data can improve the quality of the personnel hired for screening positions, provide them with better training, and offer more incentive for companies to retain their best screeners longer in order to meet performance standards. One of the potential benefits of performance monitoring and certification processes and the associated procedures is that it contributes to fundamentally altering the institutional dynamics and the economic circumstances of aviation security internationally.

Chapter 5

SUMMARY AND FUTURE DIRECTIONS

5.1 INTRODUCTION

5.1.1 The underlying premise of this manual is that a holistic and systemic framework is necessary to comprehensively address Human Factors issues in civil aviation security operations. This more complete framework could be applied usefully to improve the system-wide performance of civil aviation security. If Human Factors knowledge is applied in a piecemeal manner, then the potential benefits from this framework will not be realized. The attempt to achieve a more complete perspective on the critical Human Factors issues relevant to aviation security operations will require sustained activity along the four dimensions described in the previous chapters of the present manual.

5.1.2 In Chapter 1, with respect to Personnel Selection, tests are currently being developed to evaluate the cognitive and personality competencies of screeners. It is recommended that the results from selection tests be correlated with performance from training assessments, on-the-job performance and Threat Image Projection (TIP) data. In this way, a fully developed and validated selection test battery can be recommended. This can only occur through close international collaboration among States.

5.1.3 With respect to Personnel Training and Assessment, there are three training components to be developed, delivered, and evaluated: initial employment training, OJT, and recurrent. It is recommended that the Knowledge, Skills and Abilities (KSAs) be objectively evaluated at the end of each training component and that these assessment test scores be correlated with selection test results and on-the-job performance. It is important to keep in mind that there is significant variability among different States in the training programmes that they develop and which they certify as adequate. Only through systematic evaluation using TIP will the international civil aviation community be able to determine the necessary elements within each training component that will maximize on-the-job performance.

5.1.4 With respect to Personnel Retention, turnover rates vary among the States sampled, ranging from 4 per cent to over 200 per cent. Salary levels, benefits and working conditions will all impact the retention of individual screeners. The relationship between turnover rates and threat detection performance is not known precisely, but it can be assumed that high turnover rates will lead to reduced threat detection performance. It is therefore necessary that security screeners be remunerated to a level that will maximize performance. Pay rates may need to be regulated and internationally harmonized in order to minimize turnover rates and consequently, the risks to the system. The increases in salaries and benefits would however be easily offset by decreases in selection and training costs. It may be important to collect data on this issue.

5.1.5 Chapter 2 expounds on how technologies have developed in response to the changing threat environment and how they have made the screening tasks more complex. Research has demonstrated the need to better integrate Human Factors knowledge into the design and development of new technology, instead of spending significant resources on post-implementation evaluation and redesign. A process should be developed to integrate the training requirements of these new technologies seamlessly into existing training programmes. Before these technologies are integrated into the operational environment, a thorough ergonomic assessment of the impact on passenger flow and security personnel should also be undertaken.

5.1.6 The technological development that has the greatest potential impact in assessing security effectiveness is TIP. Yet TIP is only available on X-ray systems. We are still lacking the processes to objectively evaluate performance for all screening tasks (e.g. TEDS). Nevertheless, the data derived from the development and deployment of TIP systems will have a major impact on civil aviation screening over the coming decade.

5.1.7 Chapter 3 discusses the potential impact of the organizational culture and the operational environment on personnel and technologies. It is often the case that the implication of these issues on policies, processes and procedures supporting the screener commitment, communication and coordination is not addressed. This is true across all levels within an organization and among organizations (i.e. regulatory authorities, airport operators and air carriers). In order to recommend appropriate changes to the organization's policies, processes and procedures within a particular culture, it is important to collect information on system performance.

5.1.8 Chapter 4 describes how various elements of the civil aviation security system (personnel, technologies, and companies) may be certified. The policy decisions determining certification will also directly specify the performance standards that must be met as part of the certification process. The United States has established rules to certify screening companies while other Contracting States are certifying individual screeners. Regardless of the approach, once implemented, these certification programmes will have direct operational consequences that will require careful monitoring.

5.2 FUTURE DIRECTIONS

5.2.1 General

With 27 acts of unlawful interference recorded in the year 2000 (including aircraft accidents caused by such acts), in which 53 persons were killed and 46 were injured, civil aviation security continues to be important, as was tragically demonstrated on 11 September 2001 with the hijacking and destruction of four jet aircraft in U.S. airspace, killing all on board along with thousands on the ground. The casualty numbers are expected to increase given the sustained increase in the volume of passengers transiting through the world's airports. Consequently, civil aviation security personnel must continually be able to screen an ever-increasing number of passengers per unit of time (increasing workload levels), while still maintaining acceptable levels of effectiveness and efficiency (i.e. tolerable risk) in the system. An increase in passenger throughput can be achieved through improved selection and training methods as well as the development of new technologies. There are however severe limits to system capacity. It is possible to enhance security operations through the use of technology to augment the skills and abilities of the human operator. Expert systems that provide human operators with appropriate information quickly and accurately, based on high-speed processing, can increase passenger throughput.

5.2.2 Expert systems

Technology has enhanced the screening of passengers as they enter secure areas in an airport. In principle, automated systems should be able to detect a likely threat, process images and other outputs, perform comparisons with known and novel threats, and provide a rapid positive and accurate response to security personnel. Personnel would still learn and apply procedures that would keep them informed of new developments and allow them to minimize the risk of inappropriate reliance on the expert system, thereby maintaining an appropriate level of situational awareness. It is imperative that such expert systems be developed within a Human Factors framework that will take into account the operational environment and the organizational culture within which such systems will be deployed.

5.2.3 Error recovery and tolerance

5.2.3.1 It is important to keep in mind that in any human-machine system, deviations (or errors) will occur that can lead to system failure. The central question for all stakeholders of the civil aviation security system is to assess the tolerance level of the system for deviations and failure. The standardized use of valid selection tools, appropriate training combined with objective training assessment, objective assessment of in situ performance levels, and the development and deployment of human-centred technologies contribute to increasing the system's error tolerance. Great progress has been made and will continue in these areas with respect to Human Factors considerations.

5.2.3.2 The civil aviation security system must also have safeguards in place to detect deviations and reduce their impact — as do back-up systems in aircraft. It is therefore necessary to have a dedicated means of recording, archiving, and analysing deviations and errors. This will allow for the extraction of real world knowledge that will reduce the impact of such deviations. Only with proper policies, processes and procedures will errors be mitigated in such a way as to minimize the impact of acts of unlawful interference, notwithstanding the anticipated continued increase in passenger volume. Otherwise, the general absence of systems, policies, processes and procedures that support this objective, combined with high turnover levels and low remuneration rates, will contribute to higher overall risk level in the civil aviation security system.

5.2.3.3 Given that threat levels change dynamically in different regions of the world, the impact of threats will be determined to a significant degree by the changing level of risk in the civil aviation security system. The outcome associated with threats will be very closely associated with the risk level. This risk level can be determined through an appropriate organizational culture that supports the application of Human Factors principles in error management.

5.2.4 End state of human factors in civil aviation security

5.2.4.1 Historically, the approach in civil aviation security has been to focus on technology, with the objective of eliminating error by removing the human operator from the system. Some airport operators envisage security screening that would be completely invisible to passengers and others as they make their way through a terminal. Such a system would use sophisticated high-definition cameras for facial recognition and profiling, contents of luggage would be X-rayed from a distance through a laser system, and explosive traces would be collected from dedicated portals in the terminal. All of these would be completed with minimal human intervention in order to get away from issues of recruitment, training, rostering, etc. Apart from requiring absolute detection rates, no false alarm rates and the perfect integration of systems, these scenarios could contribute to maximizing the deterrence effect that the current security checkpoints provide to the international civil aviation environment.

5.2.4.2 In a recent report entitled *Potential System Integration of Existing Airport Security Equipment* by P. Levelton and A. Chagani and which looked at the potential for integrating security systems, the authors concluded that integration is not expected to reduce the number of security personnel required at checkpoints because:

— high alarm rates require physical inspection and manual screening of passengers and carry-on items;

— effective X-ray equipment use requires that bags be spaced apart and positioned to maximize image size and minimize jamming;

— sufficient personnel are required to ensure that suspect passengers can be detained with minimal disruption to the continued processing of passengers;

— despite clear signage at inspection points, passengers routinely neglect to remove metal objects from their person, thus requiring intervention.

5.2.4.3 The strength of human intervention was highlighted when an earthquake hit northwestern United States in 2000, seriously affecting the Seattle Tacoma Airport and putting its security checkpoint systems out of operation. Only the timely and coordinated intervention of the security personnel made possible the maintenance of the sterile areas. It is specifically under such emergency or abnormal conditions that human intervention becomes critical.

5.2.4.4 It is also important to note that there are functions and tasks that only human observers can perform with any reasonable level of accuracy. One such task is facial recognition. (The human visual system has evolved over time to become extremely effective and efficient at facial recognition over long stretches of time.) Other functions include the deductive and inductive processes to extract knowledge from information collected across time and space and to learn from situations and experiences of different teams, airports and States.

5.2.4.5 The effective integration of the different systems applied in civil aviation security is another key issue which deserves closer attention. For instance, the passenger identification system could be integrated with an expert system to select a subset of passengers for in-depth screening. Further integration of detection systems with passenger identification systems could produce a more complete profile of each passenger that would be archived and used later for other profiling activities. Integration will also make possible the collection of statistical data on the frequency of alarms and TEDS output. These data can then be used to optimize TEDS performance through the selection of an optimal detection threshold.

5.2.4.6 Summing up, the issues that affect effective integration are numerous and complex, but through enhanced international collaboration, it is possible to increase knowledge transfer from different parts of the world.

5.2.4.7 Other emerging issues that require further efforts include the use of virtual environments for modelling (e.g. for the rapid prototyping and evaluations of new checkpoint designs), web-based training and assessments, and the inclusion of Human Factors considerations in the maintenance of security systems.

5.3 RECOMMENDED PRACTICES AND CONCLUSION

5.3.1 General

5.3.1.1 This manual has attempted to demonstrate that the relative neglect of any component of the Human Factors framework will lead to deficiencies in one or more areas of the civil aviation security system. The reason is that the impact of these Human Factors components do not occur in a vacuum. The components interact and the neglect of one will lead to deficiencies and inefficiencies within the entire civil aviation security system.

5.3.1.2 It should also be noted that new operational requirements (e.g. increased throughput) may also impact the civil aviation security system in ways unknown. One such new phenomenon is the growing presence of disruptive passengers. This issue needs to be addressed in the same perspective as other threats to civil aviation security.

5.3.1.3 Notwithstanding that regulatory authorities need to take the lead in Human Factors security research and development, this effort cannot occur in a vacuum and should be carried out in conjunction with air carriers, security companies and Contracting States in order to provide the expertise and results covering a variety of operational and regulatory issues. Air carriers and security companies can provide access to equipment, data and support, such as access to employees and operational settings during operational trials.

5.3.2 Recommended operational practices

5.3.2.1 The following recommended operational practices are drawn from this manual. It is suggested that an action plan be generated to identify how best to develop these Recommended Practices. This action plan should identify areas for the development of SARPs. Further, it is proposed that the action plan be developed through the auspices of the existing mechanisms within the ICAO Secretariat.

5.3.2.2 The recommended operational practices are:

— explicitly and systematically integrate Human Factors knowledge in all aspects of aviation security planning;

— prioritize and fund Human Factors research;

— use formalized Human Factors integration plans and procedures as an integral part of the system design process;

— improve the operational environment and organizational culture within which personnel complete their tasks;

— develop systematic policies supporting processes and procedures to collect, analyse and share information and knowledge available from the examination of existing operational errors occurring in the aviation security system (i.e. a security quality assurance programme);

— establish and support a no-blame culture among all civil aviation security stakeholders; and

— share best practices by promoting national and international inter-agency collaboration through conferences and seminars on Human Factors in civil aviation security operations. This may include collaboration through the International Technical Advisory Group (InterTAG).

5.3.3 Conclusion

Over the past several decades, the greatest safety benefits in civil aviation and other areas of human activity have been gained most quickly and cost-effectively by investing in Human Factors rather than technology. The greatest opportunities for positive improvement in civil aviation security operations will come with the evolution towards a Human Factors culture which supports risk assessment through error management. Given that human operators are unlikely to disappear from future security systems, a more systematic approach in addressing the Human Factors aspects of civil aviation security is required through a commitment by the international civil aviation community.

Appendix A

Training System Usability Evaluation Checklist for Human Factors Engineers

[Reproduced with the authorization of the United States Federal Aviation Administration.]

Appendix A

TRAINING SYSTEM USABILITY EVALUATION CHECKLIST FOR HUMAN FACTORS ENGINEERS

Human Factors Principle	*Evaluation*			*Comments*
	Acceptable	*Acceptable with deficiencies*	*Unacceptable*	
A. ATA ENTRY				
1. Users need enter data only once.				
2. Display feedback for all user actions during data entry; display keyed entries stroke by stroke.				
3. Provide fast response by the computer in acknowledging data entries.				
4. When critical data are to be processed, require an explicit 'Enter' action to initiate the processing.				
5. Provide feedback for the completion of data entry.				
6. For position designation on an electronic display, provide a movable cursor with distinctive visual features (shape, blink, etc.).				
7. Design the cursor so that it does not obscure any other character displayed in the position designated by the cursor.				
8. Ensure that the computer will acknowledge entry of a designated position quickly.				
9. Ensure that the displayed cursor will be stable, i.e., that it will remain where it is placed until moved by the user (or by the computer) to another position.				

Human Factors Principle	*Evaluation*			*Comments*
	Acceptable	*Acceptable with deficiencies*	*Unacceptable*	
10. When moving a cursor from one position to another, design the cursor control to permit both fast movement and accurate placement.				
11. Ensure that control actions for cursor positioning are compatible with movements of the displayed cursor, in terms of control function and labeling.				
12. If a cursor must be positioned sequentially in redefined areas, such as displayed data entry fields, ensure that this can be accomplished by simple user action.				
13. When there are areas of a display in which data entries cannot be made (blank spaces, protected field labels, etc.), make those areas insensitive to pointing actions, i.e., prevent the cursor from entering those areas.				
14. Ensure that display capacity, i.e., number of lines and line length, is adequate to support efficient performance of tasks.				
15. An UNDO action should be able to reverse more than the most recent command.				
16. Make field labels consistent; always employ the same label to indicate the same kind of data.				
17. Protect field labels from keyed entry.				
18. Ensure that labels are sufficiently close to be associated with their proper data fields, but are separated from data fields.				
19. Choose a standard symbol for input prompting and reserve that symbol only for that use.				
20. Clearly delineate each data field.				

Human Factors Principle	Evaluation			Comments
	Acceptable	Acceptable with deficiencies	Unacceptable	
21. Distinguish clearly and consistently between required and optional entry fields.				
22. Provide automatic justification in computer processing; a user should not have to justify an entry either right or left.				
23. Make labels for data fields distinctive, so that they will not be readily confused with data or other displayed material.				
24. In labeling data fields, employ descriptive working or standard, predefined terms, codes, and/or abbreviations; avoid arbitrary codes.				
25. Include in a field label additional cueing of data format when that seems helpful.				
26. When a measurement unit is consistently associated with a particular data field, include that unit as part of the field label, rather than requiring a user to enter it.				
27. Employ units of measurement that are familiar to the user.				
28. Order data items in the sequence in which a user will think of them.				
29. The order of data items should represent a logical sequence of data entries.				
30. When a form for data entry is displayed, the computer should place the cursor automatically at the beginning of the first entry field.				
31. Design distinctive formats for column headers and row labels, so that users can distinguish them from data entries.				
32. Ensure that column headers and row labels are worded informatively, so that they will help guide data entry.				

Human Factors Principle	Evaluation: Acceptable	Evaluation: Acceptable with deficiencies	Evaluation: Unacceptable	Comments
33. During tabular data entry, allow users to tab directly from one data field to the next, so that the cursor can move freely back and forth.				
34. Provide users some means for designating and selecting displayed graphic elements for manipulation. When a user has changed or altered a displayed element, provide some indication so that other users will be aware of the consequences of that users actions.				
35. Ensure that every possible correct data entry will be accepted and processed by the computer.				
36. If automatic data validation detects a probable error, display an error message to the user. If data validation from a secondary source detects a probable error, allow the primary user access to all functions required to check data accuracy.				
37. When interface designers cannot predict what default values will be helpful, permit users (or a system administrator) to define, change, or remove default values for any data entry field.				
38. On initiation of a data entry transaction, display currently defines default values in their appropriate data fields.				
39. Provide users with some simple means to confirm acceptance of a displayed default value for entry.				
40. When data entries made in one transaction are relevant to a subsequent transaction, program the computer to retrieve and display them for user review, rather than requiring re-entry of those data.				

Human Factors Principle	Evaluation: Acceptable	Evaluation: Acceptable with deficiencies	Evaluation: Unacceptable	Comments
B. DATA DISPLAY				
1. Ensure that whatever data a user needs for any transaction will be available for display.				
2. Tailor displayed data to user needs, providing only necessary and immediately usable data for any transaction; do not overload displays with extraneous data.				
3. Display data to users in directly usable form; do not make users convert displayed data.				
4. For any particular type of data display, maintain consistent format from one display to another.				
5. Allow users to change displayed data or enter new data when that is required by a task.				
6. When protection of displayed data is essential, maintain computer control over the display and do not permit a user to change controlled items.				
7. Ensure that each data display will provide needed context, recapitulating prior data as necessary so that a user does not have to rely on memory to interpret new data.				
8. The wording of displayed data and labels should incorporate familiar terms and the task-oriented jargon of the users.				
9. Choose words carefully and then use them consistently.				
10. Ensure that wording is consistent from one display to another.				
11. Use consistent grammatical structure within and across displays.				

Human Factors Principle	*Evaluation*			*Comments*
	Acceptable	*Acceptable with deficiencies*	*Unacceptable*	
12. When abbreviations are used, choose those abbreviations that are commonly recognized, and do not abbreviate words that produce uncommon or ambiguous abbreviations.				
13. Ensure that abbreviations are distinctive, so that abbreviations for different words are distinguishable.				
14. Minimize punctuation of abbreviations and acronyms.				
15. If abbreviations are used, provide a dictionary/glossary of abbreviations available for on-line user reference.				
16. When a critical passage merits emphasis to set it apart from other text, highlight that passage by bolding, brightening, color coding, or some auxiliary annotation.				
17. Organize data in some recognizable order to facilitate scanning and assimilation.				
18. Display continuous test in wide columns, containing at least 50 characters per line.				
19. Display continuous text conventionally in mixed upper and lower case.				
20. Ensure that displayed paragraphs of text are separated by at least one blank line.				
21. Maintain consistent spacing between the words of displayed text, with left justification of lines and ragged right margins if that is the result.				
22. In display of textual material, keep words intact, with minimal breaking by hyphenating between lines.				
23. Use conventional punctuation in textual display; sentences should end with a period or other special punctuation.				

Human Factors Principle	*Evaluation* Acceptable	Acceptable with deficiencies	Unacceptable	*Comments*
24. In designing text displays, especially text composed for user guidance, strive for simplicity and clarity of wording.				
25. Put the main topic of each sentence near the beginning of the sentence.				
26. Use short simple sentences.				
27. Use affirmative statements rather than negative statements.				
28. Compose sentences in the active voice rather than passive voice.				
29. When a sentence describes a sequence of events, phrase it with a corresponding word order.				
30. Format lists so that each item starts on a new line (i.e., a list should be displayed as a single column).				
31. When a single item in a list continues for more than one line, mark items in some way so that the continuation of an item is obvious (i.e., so that a continued portion does not appear to be a separate item).				
32. When listed items will be numbered, use Arabic rather than Roman numerals.				
33. Adopt some logical principle by which to order lists. When no other principle applies, order lists alphabetically.				
34. If a list is displayed in multiple columns, order the items vertically within each cell.				
35. When words in text displays are abbreviated, define each abbreviation in parentheses following its first appearance.				

Human Factors Principle	Evaluation: Acceptable	Evaluation: Acceptable with deficiencies	Evaluation: Unacceptable	Comments
36. When text is combined with graphics or other data in a single display, thus limiting the space available for text, format the text in a few wide lines rather than in narrow columns of many short lines.				
37. Separate the data in a table by some distinctive feature, to ensure separations of entries within a row.				
38. In dense tables with many rows, insert a distinctive feature to aid horizontal scanning at regular intervals.				
39. Ensure that row and column labels are distinguishable from the data displayed within tables and from the labels of displayed lists, such as menu options or instructions to users.				
40. When rows or columns are labeled by number, start the numbering with "1," rather than "0."				
41. Show columns of alphabetic data with left justification to permit rapid scanning.				
42. Justify columns of numeric data with respect to a fixed decimal point; if there is no decimal point, then numbers should be right justified.				
43. Use consistent logic in the design of graphic displays, and maintain standard format, labeling, etc.				
44. Tailor graphic displays to user needs and provide only those data necessary for user tasks.				
45. When graphics contain outstanding or discrepant features that merit attention by a user, consider displaying supplementary text to emphasize that feature.				

Human Factors Principle	*Evaluation*			*Comments*
	Acceptable	*Acceptable with deficiencies*	*Unacceptable*	
46. When a user's attention must be directed to a portion of a display showing critical or abnormal data, highlight that feature with some distinctive means of coding.				
47. Adopt a consistent organization for the location of various display features from one display to another.				
48. Make the different elements of a display format distinctive from one another.				
49. Use blank space to structure a display.				
50. Begin every display at the top with a title or header, describing briefly the contents or purpose of the display.				
51. Reserve the last several lines at the bottom of every display for status and error messages, prompts, and command entry.				
52. Ensure that displays are formatted to group data items on the basis of some logical principle.				
53. Provide distinctive coding to highlight important display items requiring user attention. Highlighting is most effective when used sparingly.				
54. If highlighting is used to emphasize important display items, remove such highlighting when it no longer has meaning.				
55. Adopt meaningful or familiar codes, rather than arbitrary codes.				
56. Adopt codes for display (and entry) that conform with accepted abbreviations and general user expectations.				
57. Assign consistent meanings to symbols and other codes, from one display to another.				

Human Factors Principle	Evaluation: Acceptable	Evaluation: Acceptable with deficiencies	Evaluation: Unacceptable	Comments
58. Treat brightness as a two-valued code, bright and dim, i.e., consider coding by difference in brightness for applications that only require discriminating between two categories of displayed items.				
59. Color code for relative values.				
60. It will prove safer to use no more than five different colors for coding.				
61. When selecting colors for coding discrete categories of data, ensure that those colors are easily discriminable.				
62. Employ color coding conservatively, using relatively few colors and only to designated critical categories of displayed data.				
63. Make color coding redundant with some other display feature, such as symbology; do not code only by color.				
64. When color coding is used, ensure that each color represents only one category of displayed data.				
65. Choose colors for coding based on conventional associations with particular colors.				
66. Use brighter and/or more saturated colors when it is necessary to draw a user's attention to critical data.				
67. Use saturated blue only for background features in a display, and not for critical coding.				
68. When blink coding is used, select a blink rate in the range from 2 to 5 Hz, with a minimum duty cycle (ON interval) of 50 percent.				
69. When data have changed, especially following automatic display update, consider highlighting those data changes temporarily.				

Human Factors Principle	*Evaluation*			*Comments*
	Acceptable	*Acceptable with deficiencies*	*Unacceptable*	
C. SEQUENCE CONTROL				
1. Defer computer processing until an explicit user action has been taken.				
2. Employ similar means to accomplish ends that are similar, from one transaction to the next, from one task to another, throughout the user interface.				
3. Display some continuous indication of current context for reference by the user.				
4. Adopt consistent terminology for on-line guidance and other messages to users.				
5. Choose names that are congruent with natural usage, especially for paired opposites (e.g., UP / DOWN).				
6. Ensure that the computer acknowledges every entry immediately; for every action by the user there should be some apparent reaction from the computer.				
7. Each menu display should permit only one selection by the user.				
8. When multiple menu options are displayed in a list, display each option on a new line, i.e., format the list as a single column.				
9. If there is no immediately observable response when a user has selected and entered an option from a menu, the computer should display some other acknowledgment of that entry.				
10. Display an explanatory title for each menu, reflecting the nature of the choice to be made.				
11. Design a menu to display all options appropriate to any particular transaction.				
12. Design a menu to display only those options that are actually available in the current context for a particular user.				

Human Factors Principle	*Evaluation*			*Comments*
	Acceptable	*Acceptable with deficiencies*	*Unacceptable*	
13. When menus are provided in different displays, design them so that option lists are consistent in wording and ordering.				
14. If menu options are included in a display that is intended for data review and/or data entry, ensure that they are distinct from other displayed information; incorporate some consistent distinguishing feature to indicate their special function.				
15. List displayed menu options in a logical order; if no logical structure is apparent, then display the options in the order of their expected frequency of use, with the most frequent listed first.				
16. Format a menu to indicate logically related groups of options, rather than as an undifferentiated string of alternatives.				
17. When the menu selection must be made from a long list, and all options cannot be displayed at once, provide a hierarchic sequence of menu selections, rather than one long multipagè menu.				
18. When hierarchic menus are used, display some indication of current position in the menu structure.				
19. When hierarchic menus are used, ensure that display format and selection logic are consistent at every level.				
20. When hierarchic menus are used, require users to take only one simple key action to return to the next higher level.				
21. When hierarchic menus are used, require users to take only one simple key action to return to the general menu at the top level.				
22. Make available to users a list of the control options that are specifically appropriate for any transaction.				

Human Factors Principle	Evaluation			Comments
	Acceptable	Acceptable with deficiencies	Unacceptable	
23. Offer users only control options that are actually available for the current transactions.				
24. When a user is performing an operation on some selected display item, highlight that item.				
25. Design the interface software to deal appropriately with all possible control entries, correct and incorrect.				
26. When a user completes correction of an error, require the user to take an explicit action to reenter the corrected material; use the same action for reentry that was used for the original entry.				
D. USER GUIDANCE				
1. Design standard procedures for accomplishing similar, logically related transactions.				
2. Ensure that only relevant data are displayed by tailoring the display for any transaction to the current information requirements of the user.				
3. Create display formats with a consistent structure evident to the user, so that a particular type of data is always presented in the same place and in the same way.				
4. Format each different type of user guidance consistently across displays.				
5. Label all displayed data clearly.				
6. Ensure that symbols and other codes have consistent meanings from one display to another.				
7. Ensure that the names for functions and data are consistent for similar or identical functions.				
8. Adopt terminology familiar to users.				
9. Adopt task-oriented wording.				

Human Factors Principle	*Evaluation*			*Comments*
	Acceptable	*Acceptable with deficiencies*	*Unacceptable*	
10. Adopt affirmative rather than negative wording for user guidance messages.				
11. Adopt active rather than passive voice in user guidance messages.				
12. When user guidance describes a sequence of steps, follow that same sequence in the wording of user guidance.				
13. Be consistent in grammatical construction when wording user guidance.				
14. Provide some indication of system status to users at all times.				
15. Ensure that every input by a user will consistently produce some perceptible response output from the computer.				
16. Ensure that computer response to user entries will be rapid, with consistent timing as appropriate for different types of transactions.				
17. Provide a unique identification for each display in a consistent location at the top of the display frame.				
18. When the computer detects an entry error, display an error message to the user stating what is wrong and what can be done about it.				
19. Make the wording of error messages as specific as possible.				
20. Make error messages brief but informative.				
21. Adopt neutral wording for error messages; do not imply blame to the user, or personalize the computer, or attempt to make a message humorous.				
22. The computer should display an error message only after a user has completed an entry.				

Human Factors Principle	Evaluation			Comments
	Acceptable	Acceptable with deficiencies	Unacceptable	
23. Display an error message a minimum of 2 to 4 seconds after the user entry in which the error is detected.				
24. As a supplement on-line guidance, include in the system documentation listing and explaining all error messages.				
25. In addition to providing an error message, mark the location of a detected error by positioning the cursor at that point on the display, i.e., at that data field or command word.				
26. When an entry error has been detected, continue to display the erroneous entry, as well as an error message, until corrections are made.				
27. Following error detection, require the user to reenter only that portion of a data/command entry which is not correct.				
28. Ensure that a displayed error message is removed after the error has been corrected; do not continue to display a message that is no longer applicable.				
29. Display menu options in logical groups.				
30. Provide a simple, standard action that is always available to request HELP.				
E. VISUAL DISPLAYS				
1. *Contrast*: Sufficient contrast shall be provided between displayed information and the display background to ensure that the required information can be perceived by the operator under all expected lighting conditions.				
2. *Location*: Displays shall be located and designed so that they may be read to the degree of accuracy required by personnel in normal operating or servicing positions without requiring the operator to assume an uncomfortable, awkward, or unsafe position.				

Human Factors Principle	*Evaluation*			*Comments*
	Acceptable	*Acceptable with deficiencies*	*Unacceptable*	
3. *Orientation*: Display faces shall be perpendicular to the operator's normal line of sight whenever feasible and shall not be less than 3.14/4 rad (45°) from the normal line of sight.				
4. *Reflection*: Displays shall be constructed, arranged, and mounted to prevent reduction of information transfer due to the reflection of the ambient illumination from the display cover. Reflection of instruments and consoles and other enclosures shall be avoided.				
5. *Frequency of use*: Displays used most frequently should be grouped together and placed in the optimum visual zone.				
CRTs				
1. *Viewing distance*: A 400 mm (16-inch) viewing distance shall be provided whenever practicable. When periods of observation will be short, or when dim signals must be detected, the viewing distance may be reduced to 250 mm (10 inches). Design should permit the observer to view the CRT as close as desired.				
2. *Reflected glare*: Reflected glare shall be minimized by proper placement of the CRT relative to the light source and the use of a hood, shield, or optical coating on the CRT.				
3. *Ambient surfaces*: Surfaces adjacent to the CRT shall have a dull matte finish.				
4. *Font legibility*: Where alphanumeric characters appear on CRT-like displays, the font style shall allow discrimination of similar characters, such as the letter l and the number 1 and the letter z and the number 2.				

Human Factors Principle	*Evaluation*			*Comments*
	Acceptable	*Acceptable with deficiencies*	*Unacceptable*	
Audio Displays				
1. *Type of voice*: The voice used in recording verbal signals shall be distinctive and mature.				
2. *Delivery style*: Verbal signal shall be presented in a formal, impersonal manner.				
3. *Message content*: In selecting words to be used in audio warning signals, priority shall be given to intelligibility, aptness, and conciseness in that order.				
4. *Volume control* (automatic or manual): The volume (loudness) of an audio warning signal shall be designated to be controlled by the operator, the sensing mechanism, or both.				
Touch Screen				
1. The dimensions and separation of responsive areas of the touch screen shall conform to S1, S2, and S3 of Figure 14, page 119, MIL-STD-1472D.				
Equipment Labeling				
1. Each control and display shall be labeled according to function, and the following criteria shall apply: (a) similar names for different controls and displays shall be avoided; (b) instruments shall be labeled in terms of what is being measured or controlled, taking into account the user and purpose; (c) control labeling shall indicate the functional result of control movement (e.g. on, off); (d) when controls and displays must be used together (in certain adjustment tasks), appropriate labels shall indicate their functional relationship -- the selection and use of terminology shall be consistent.				

Human Factors Principle	Evaluation: Acceptable	Evaluation: Acceptable with deficiencies	Evaluation: Unacceptable	Comments
2. Ease of control operation shall be given priority over visibility of labels. Labels would normally be placed above the controls and displays they describe. When the panel is above eye level, labels may be located below if label visibility will be enhanced.				
Workspace Design				
1. All cabinets, consoles, and work surfaces that require an operator to stand or sit close to their front surfaces shall contain a kick space at the base at least 100 mm (4 inches) deep and 100 mm (4 inches) high.				
Seated Operations				
1. A lateral workspace of al least 760 mm (30 inches) wide and 400 mm (16 inches) deep shall be provided whenever practicable.				
2. Desk tops and writing tables shall be 740 to 790 mm (29 to 31 inches) above the floor.				
Standard Console Design				
1. Consoles which constitute operator workstations should be designed to conform with the dimensions shown in Table XX and Figure 30, pages 154-155 MIL-STD-1472D.				
2. The total required left-to-right viewing angle shall not exceed 190 degrees (see Figure 2, MIL-STD-1472D). This angle should be reduced whenever possible through appropriate control-display layout.				

Human Factors Principle	Evaluation			Comments
	Acceptable	Acceptable with deficiencies	Unacceptable	
Accessibility				
1. Structural members or permanently installed equipment shall not visually or physically obstruct adjustment, servicing, removal of replacement equipment, or other required maintenance tasks. Panels, cases, and covers removed to access equipment shall have the same access requirements as replaceable equipment. Mounting provisions shall be visually and physically accessible by the maintainers. No special tools shall be required for removal or replacement, unless required by security considerations.				
2. Large items which are difficult to remove shall be mounted so that they will not prevent convenient access to other items.				
3. Sufficient space shall be provided for the use of test equipment and other required tools without difficulty or hazard.				
Covers				
1. It shall be made obvious when a cover is not secured, even though it may be in place.				
2. If the method of opening a cover is not obvious from the construction of the cover itself, instructions shall be permanently displayed on the outside of the cover. Instructions shall consist of simple symbols such as arrows or simple words such as "push" or "pull."				

Appendix B

Training Media Optimization

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Appendix B

TRAINING MEDIA OPTIMIZATION

ASPECTS OF TRAINING

A) KNOWLEDGE DEVELOPMENT	Training design features	Objective evidence	Suggested media
i) Content			
1) How to visually scan a bag and knowledge of strategies available.	• Information on different strategies for scanning: different perceptual strategies and patterns of visual search • Mistakes commonly made and how to avoid them • Features to look for when searching for electrical, organic and dense objects	Is there the opportunity to practise visual scanning techniques? Are explanations given of a variety of different visual cues and what they may indicate? Are explanations provided of how it is possible to miss threats through inadequate visual search and how to overcome this? Are trainees given detailed information on how to detect electrical/dense/organic material and particular advice on spotting abnormalities? Are trainees given practice with a number of varied examples for each of these categories?	Operational Training CBT
2) The range of threat and non-threat items and their components and how they look under the X-ray.	• Threat library containing wide range of threats and restricted items as listed in the NASP including: restricted/prohibited, normal, opaque, obvious and possible threats • Information on the features of threat and non-threat objects: how to identify and classify them using criteria • Specific and detailed information on different types of threat — IIDs, IEDs, knives, guns, dangerous goods, miscellaneous etc. • Specific and detailed information on restricted and prohibited objects • Specific and detailed information on components of non-threat objects	Is there a threat library available for trainees to refer to for extra information on different items? Does this include information on the features and the components of the different types of threats and meanings of combinations of features? Are there photographs and X-ray images or live examples of threat objects and opportunities to view them under the X-ray? Is advice available on how to identify and classify different threats e.g. decision tree? Is there the opportunity to relate objects to what is seen on the X-ray image? Is information available on non-threat objects; how they look under the X-ray and any potential confusabilities with threat objects? Are there exercises which encourage trainees to identify the different components of threat items? Is understanding of how these components link together developed and tested?	Demonstrations CBT Classroom training Video Group exercises

A) KNOWLEDGE DEVELOPMENT	Training design features	Objective evidence	Suggested media
3) Colour and density of Objects	• Information on the differences between black/white and colour X-rays in terms of representation and optimal usage • Relationship between density, colour and shade • Shapes of objects at different angles	Are explanations available of the significance of different tones and colours on the X-ray screen in terms of material type and density? Are the skills of interpretation for colour practised and reinforced, is there feedback available? Are trainees exposed to a variety of different objects with a variety of different densities? Are there exercises which develop and test the skills of colour and density interpretation?	Classroom training Demonstration Group exercises Videos CBT Simulation
4) Shape, size and orientation (re-scan)	• How the X-ray affects the appearance of shape • Description and demonstration of the differences in shape according to orientation for range of items — mapping of object to the X-ray image • Relationship between orientation and density on X-ray • Descriptions and demonstrations of confusability of different objects at different angles • Overlapping objects and combinations of objects in bags (merging) • How to use visual scaling techniques to assess size • How the X-ray affects the appearance of shape • Distortion of the image	Are pictures of objects available from different angles? (X-rays and photographs) Are there exercises in the training which encourage the trainee to focus on the shapes of objects as they are rotated? Does the training illustrate similarities and differences in the representation of different objects and materials on the X-ray screen? Does the training provide examples of confusable objects? Does the training demonstrate the differences in apparent density of the object under the X-ray according to orientation? Does the training illustrate the effects on the X-ray image of overlapping objects and combinations of objects in bags? Does the training illustrate use of known objects on the X-ray screen to estimate object size? Does the training encourage trainees to mentally rotate objects and imagine the result on the X-ray screen? Does the training incorporate any special visual techniques (e.g. morphing, dynamic rotation) to train the relationship between objects, their orientation, size, shape and how they appear on the X-ray? Does the training include exercises to encourage the trainee to view images from a different perspective i.e. different shapes and orientations? Does the training include detail on the causes and effects of distortions and how to interpret these images? Is there information on ways of overcoming distortions?	Classroom training Demonstrations CBT Operational training
5) Hand search and Concealment strategies.	• Knowledge of hand search • Description and examples of different concealment strategies • Link to bag profile — which strategy for which bag type	Does the training include demonstrations of how to hand search? Does the training develop knowledge of the hand search procedure? Does the training provide explanations of different types of concealment strategies? Does the training outline the symptoms of concealment strategies and how they work? Does the training include exercises in which trainees have to try to detect concealed goods using skills of X-ray image interpretation? Does the training contain examples of bag profile types and concealment strategies that might be used for a particular bag type? Are trainees encouraged to experiment with their own ideas for concealment?	Individual exercises Group exercises Demonstrations Classroom training

A) KNOWLEDGE DEVELOPMENT	Training design features	Objective evidence	Suggested media
6) Image enhancement functions	• When to use enhancement functions • Understanding of what they do and how they affect the image • Effects on a range of different objects at different orientations and with different densities • Use of enhancements for particular threat items	Does the training provide detailed descriptions of the image enhancement functions and their effects on the visual image? Are the functions demonstrated in circumstances appropriate to their use? Does the training provide explanations of when to use the different enhancements? Are there practical exercises in which trainees use image enhancement for specific purposes and receive feedback and guidance on how to do this with maximum effect?	Classroom training CBT
7) Explicit decision making criteria	• Criteria for hold, reject and pass • Explicit process through which to eliminate threats and strategically test hypotheses • Knowledge of time for task and proportions of bags to be searched • Knowledge of airport procedures and actions • Reasons for search — to reflect policy changes i.e. random to reasoned • Consequences of actions and understanding of role	Does the training incorporate decision trees to aid visualisation of the decision? Are the criteria for decisions made explicit and understandable? Are practical examples given and exercises with feedback in their use? Are DETR requirements and local airport requirements explained and their purpose e.g. bag search ratios, time spent per image? Are the reasons for search made explicit to the trainees? Are trainees made aware of the consequences of their actions? Is understanding of their role developed and how it fits with overall aviation security?	Classroom training Individual exercises
8) Use of other information in the decision making process	• Hypothesis about the theme of the bag • Passenger profiling • Knowledge of flight destination and origin	Does the training include descriptions of different bag themes and how to spot the unusual? Does the training include techniques of passenger profiling and making a meaningful link with a bag? Does training include information on how awareness of flight destination and origin should be used to interpret the contents of the bag?	Classroom training Role play
9) Refresher training	• Modules for refresher training providing new material and different examples	Does the refresher training emphasise the infrequently occurring aspects of the job? Does the refresher training find new and different means of presenting the material to maintain interest?	Classroom training Video CBT

ii) Learning features			
1) Structure	• Modular training with menus/hierarchical structure • Sequencing of information and building on previous lesson content • Explicit statements of training objectives and the knowledge to be mastered (and an estimate of lesson length) • Instructor controls for individual learning programs	Is the training organised into units with menus, modules and hierarchical structure? Is the information introduced in a sequence which leads to optimal learning i.e. are skills and knowledge developed in a logical order? Are objectives for training available and explicit to trainees as well as estimates for time allocation of the different aspects of training? Can instructors identify trainees for specific tests or practice sessions? Can instructors check on individual progress? Are there facilities for controlling progress?	Classroom training CBT
2) Learning techniques	• Guidance and advice on the task • Provision of links between theory and practice: worked examples, demonstrations • Interactive exercises and diagrams • Practical exercises which enhance understanding of theory of image interpretation	Explicit information provided to the trainee on the subtleties of the task, advice for specific threat objects or bag types. Does the training provide summaries of key important pieces of information for trainees to refer back to? Aids to visualisation of new/different configurations of threats e.g. mental rotation exercises, build or design a bomb exercises. Avoidance of lengthy and complex written material Are trainees shown demonstrations of the various points made in training in the form of images with explanations, worked examples, interactive exercises and diagrams? Practice to aid the active processing of information.	Demonstrations Group exercises CBT
3) Feedback and formative assessment	• Multi-choice questions with immediate explanatory feedback • Review of performance/ progress across lessons	Are there opportunities for trainees to test their knowledge levels and obtain simple feedback to facilitate learning? Are there facilities for students to review their performance and progress across the training? Avoidance of a need for lengthy written responses.	Classroom testing CBT Group exercises
4) Feedback and summative assessment	• End of unit knowledge tests with feedback on performance at the end • Certification	Are there end of unit tests which have to be passed? Do trainees receive certification for reaching the necessary knowledge standard?	CBT Classroom testing

B) PRACTICE AND SIMULATION	Training design features	Objective evidence	Suggested Media
i) Content			
1) Visual fidelity of image	• Does the image accurately represent the X-ray image in the operational environment?	Does the clarity, quality and colours of the image match the real environment?	Simulation Operational training
2) Visual fidelity of image enhancement functions	• Does the image accurately represent the X-ray image in the operational environment following enhancement functions (such as zoom, edge enhancement)?	Is there the opportunity for experiencing realistic training in terms of enhancement functions?	Simulation Operational training
3) Temporal and visual fidelity of movement of images	• Direction of conveyor • Movement smoothness • Speed of conveyor belt/ length of time to make decision	Is there the opportunity for experiencing realistic training in terms of image movement speed and direction?	Simulation Operational training
4) Physical fidelity of controls	• Accurate representation of hold, search, pass and belt controls	Is there the opportunity for experiencing realistic training in terms of the physical controls?	Simulation Operational training
5) Physical fidelity of enhancement functions	• Accurate representation of image enhancement functions and zoom functions	Is there the opportunity for experiencing realistic training in terms of enhancement functions?	Simulation Operational training
6) Wide range of threat and non-threat items for practice and test items	• Different types of items and how these look under X-ray compared to real life • Obvious/possible threats, non-threats, restricted/ prohibited, opaque; hold, reject and pass bags • Different densities, shapes, sizes and orientations of objects • Concealed items • Objects in isolation and embedded within bags	Are there numerous examples of threat items available to view as objects, photos or as X-ray images? Is there the opportunity to practise making decisions with images of different types? Are there facilities to examine images of different objects from different orientations to see the representation of density, the shapes formed and their apparent size. Are there opportunities to try and find concealed items on images and in practice? Are there facilities to practise image recognition skills with objects in isolation as well as in combination with other objects in bags?	Real equipment demonstrations CBT Operational training
7) Refresher practise	• Practice with different examples of threat objects	Does refresher training incorporate practice of the less frequent aspects of the task? Does the training present the task from a new and different perspective?	CBT TIP

ii) Learning features			
1) Instructor controls	• Instructor controls for individual learning programs • Instructor control for demonstration purposes	Can instructor check and control individual progress of trainees?	CBT Classroom training
2) Learning techniques	• Practice exercises for identification and location of objects (gradual reduction in cueing and help) • Difficulty of practice graded in accordance with the progress of the individual trainee (different levels) • Practice schedule to focus on weak areas • Practice schedule can enable over-learning of the skill	Are there exercises with immediate feedback in which trainees must identify and locate a variety of objects on the X-ray image: threat and non-threat? Are there practical hand search exercises in which the trainee gains experience of the task? Are there different levels of practice available which can be given to trainees based on previous test performance? Are there adaptive learning facilities? Are there facilities to enable the over-learning of skills in particular skill areas of importance?	CBT Group exercises
3) Feedback and formative assessment	• Multi-choice tests with feedback and knowledge of results immediately following or during training sessions • Explanation of errors made via review in which locations of threat objects pointed out (cueing) • Fixed mastery not fixed time • Review of performance/ progress — individual and class comparisons. Response time for each answer, SDT theory, % errors	Are there opportunities for trainees to test their skill levels and obtain feedback to facilitate learning? Are there facilities for students to review their performance and progress across the training? Is there the provision of augmented feedback during practice e.g. images with labels available, pointing out components and objects within the image, and identifying distinctive visual cues? Is there a definition of the expected performance level?	Classroom testing CBT
4) Feedback and summative assessment facilities	• Tests to assess image interpretation and decision making skills with appropriate time pressures and restrictions • Differential scoring on tests i.e. penalised more for some mistakes compared to others • Certification facilities	Are there tests with differential scoring systems based on the severity of the mistake? Are there certification systems for reaching the necessary performance levels?	Classroom testing CBT

Appendix C

Course Outline: Human Factors Elements for Civil Aviation Security Training

Appendix C

COURSE OUTLINE: HUMAN FACTORS ELEMENTS FOR CIVIL AVIATION SECURITY TRAINING

I. Fundamental Human Factors Concepts (for trainers and management)

A Introduction
B The definition of Human Factors
C Aviation security need for Human Factors

II. Human Factors, Management and Organization (for trainers and management)

A Introduction
B From individuals to organizations
C Resource allocation
D Management's contribution to security
E Management of error

III. Personnel selection, training, and performance assessment

A Personnel selection (for management): Issues

— Proper use of standardized and validated selection tests
— Proficiency level assessment
— Standardized computer-based evaluation
— Candidate selection interviews

B Training programmes

i) Initial training programmes (material learned/reviewed by trainers initially, then delivered to security screeners): Two components

Classroom component

— Standardized course content
— Practice sessions
— Simulated procedures training
— Standardized and validated computer-based proficiency level assessment

Computer-based training component

— Interactive exercises on all procedures and technologies
— Mock situations for practice
— Standardized and validated computer based proficiency level assessment

ii) On-the-job training programmes (material learned/reviewed by trainers initially, then delivered to security screeners)

— Purpose and benefits of technology

— In situ practical training on all procedures and technologies, including:

- Walk-through detectors
- Hand-held detectors
- X-ray systems (Screener assist technologies (SAT), Explosive detection systems (EDS), and Threat image projection (TIP))
- Trace explosive detection systems (TEDS)
- Profiling technology

— Standard Operating Procedures for:

- use
- calibration
- maintenance and troubleshooting

— Objective evaluation of demonstrated proficiencies, including:

- Relations with airport users
- Prevention of and conflict management
- Profiling

iii) Recurrent and continuous learning programmes

1) Recurrent learning programmes: topic coverage includes:

- Interactive refresher sessions for specific topics (e.g. shift work awareness, team resource management, critical security procedures, and fitness for duty)
- Procedures
- New threats
- New/updated technologies
- New or modified policies, processes or procedures designed to improve efficacy and efficiency levels

2) Continuous learning programme, includes:

- Online real time training/assessment through TIP.

IV. Ergonomics (material learned/reviewed by trainers initially, then delivered to security officers)

A Introduction
B Basic facts
C Elements of technology ergonomics
— Technology integration
D Elements of checkpoint ergonomics
— Global performance measures

V. Resource management

A Rostering practices

— Rotation practices
— Attentional and vigilance issues

B Performance management

— Individuals
— Team resource management (TRM)
— Three Cs: Commitment, communication, and coordination
— Team performance evaluation
— Efficacy (threat detection)
— Efficiency (time)

C Error management

— Collection
— Archiving
— Analysis
— Procedures amendment

Appendix D

Sample Training Content Outlines for the X-ray Screening

[Reproduced with the authorization of the United States Federal Aviation Administration]

Appendix D

SAMPLE TRAINING CONTENT OUTLINES FOR THE X-RAY SCREENING

Outlines	**Multimedia Courseware**
Customer Approval Signature: ______________________	**Date:** __________

Module 1 **Lesson 1**	Unit: Introduction to Checkpoint Security and X-Ray Operations Lesson: Screeners' roles and responsibilities
Objective	Upon completion of the "Screener's role and responsibility" lesson, the trainee will correctly cite the role and responsibility of the screener, as prescribed in the lesson.
Purpose	To demonstrate the following KSAs: 1. Knowledge of: • the role and responsibilities of the screener 2. Ability to: • cite the role and responsibilities of the screener
Content	1. Checkpoint security is required by Federal Aviation Regulations and every air carrier is required to have a security program. Checkpoint screeners help the air carriers carry out their security responsibilities. The role of the screener is vital to aviation security. 2. The role and responsibilities of checkpoint screeners include: • screening all passengers and other persons and all property intended to be carried past the checkpoint. • preventing or deterring any explosive, incendiary, or other deadly or dangerous weapon from being carried aboard airplanes or past the checkpoint area. • ensuring that only persons authorized are permitted to carry firearms past the checkpoint area. • ensuring that all persons passing through the checkpoint are given uniform, courteous, and efficient treatment to the maximum extent practicable.
Strategy Learning Principle: Media:	 Trainee readiness CBT, interactive multiple choice exercises with verbal response
Glossary	
Customer Required Information	

Outlines **Customer Approval Signature:** ____________________	**Multimedia Courseware** **Date:** __________
Module 1 **Lesson 2**	Unit: Introduction to Checkpoint Security and X-Ray Operations Lesson: X-ray machines and how they work
Objective	After completing the "X-ray machines and how they work" lesson, the trainee will correctly identify the following X-ray machine functions: • a tool to allow screeners to see the contents of bags, • a device that displays X-ray images, • images that are different from normal photographs, • X-rays are absorbed differently by materials, • heavy elements, such as iron, and calcium are less readily penetrated by X-rays.
Purpose	To demonstrate the following KSAs: 1. Knowledge of X-ray functions. 2. Ability to describe X-ray machine functionality.
Content	1. X-rays are a type of electromagnetic radiation, like light or radio waves. 2. X-rays are invisible. 3. X-rays move in straight lines. 4. X-rays may be reflected, refracted and polarized by using materials such as mirrors, lenses, and polarizers. 5. X-rays are differentially absorbed by matter. Heavy elements, such as iron, and calcium are less readily penetrated by X-rays. Elements such as oxygen, carbon, hydrogen and nitrogen are easily penetrated by X-rays. In X-ray screening, metal objects appear as dark shapes on the screen, while objects such as sneakers and clothing show up as light shapes.
Strategy Learning Principle: Media:	 Trainee readiness Modeling/demonstration, simulation/animation, interactive exercises
Glossary	
Customer Required Information	

Outlines **Customer Approval Signature:** ______________________	**Multimedia Courseware** **Date:** __________
Module 1 **Lesson 3**	Unit: Introduction to Checkpoint Security and X-Ray Operations Lesson: Using X-ray Machine Features
Objective	1. Given a simulated or real X-ray device, the trainee will correctly operate the ON, OFF, FORWARD, REVERSE, and STOP functions. 2. Given a simulated or real X-ray device, the trainee will correctly specify the purpose of each function.
Purpose	To demonstrate the following KSAs: 1. Knowledge of: • ON, OFF, FORWARD, REVERSE, and STOP functions of the X-ray device. 2. Skill in operating the ON, OFF, FORWARD, REVERSE, and STOP functions on the X-ray device. 3. Ability to: • engage the ON, OFF, FORWARD, REVERSE, and STOP functions at the appropriate times for purposes of bag movement and image analysis.
Content	1. The ON and OFF functions turn the power to the X-ray machine on or off. 2. The FORWARD and REVERSE functions move the conveyor belt forward or backward. Use the FORWARD and REVERSE functions to position the bag in the X-ray tunnel for the best possible view of a bag's contents. 3. The STOP function stops the conveyor belt. Use the STOP function to hold the bag in the X-ray tunnel. Use this function for both observation, as well as safe-keeping of the bag, if a threat is detected.
Strategy Learning Principle: Media:	 Massed practice, transfer of training CBT simulation of conveyor belt and controls (medium — high fidelity)
Glossary	
Customer Required Information	

Outlines	**Multimedia Courseware**
Customer Approval Signature: ______________________	**Date:** __________
Module 2 **Lesson 1**	Unit: Image Analysis Lesson: Identifying common carry-on objects
Objective	Given a selection of objects and X-ray images of the objects, the trainee will correctly match all objects with the X-ray image of the object.
Purpose	To demonstrate the following KSAs: 1. Knowledge of typical objects found in passenger bags. 2. Ability to match real objects with X-ray image representations of the object.
Content	(It is important that screeners learn to identify typical carry-on objects since their criteria for classifying a bag is to be able to name the objects in it. Therefore, variations of this lesson should occur throughout the training. Also, there are many "typical" carry-on objects. Many may be familiar, but others may be unfamiliar.) 1. Explain that X-ray images allow a screener to see inside a bag without the need to open a bag and disturb the bag contents by physically searching each bag passing through the checkpoint. An analogy would be a doctor using an X-ray to detect a broken bone. A regular photograph allows a person to view the outside of an object but does not permit an "inside" view. Present examples of photos of objects and X-ray images of objects. 2. Match real object (or photo representation) with X-ray image of object. 3. Match real object with X-ray image of object in bag. 4. Match real object with X-ray image of object at various angles. 5. Match real object with X-ray image of object in bag with varying degrees of clutter. 6. Some typical objects include shoes, books/magazines/newspaper, clothing, notebook, jacket (suit and outerwear), calculator, bath articles, laptop, hair dryer, pens/pencils, curling iron, portable radio/cassette/cd, iron, headsets, alarm clock, cassettes/CDs/video cass, contact lens cases, floppy disks, glasses, ruler (metal/wood/plastic), aerosol cans (hair spray, shaving creme), rolled up plans, hangers, umbrella, jewelry, craft articles (sewing, etc.), medications, technician equipment/tools, diaper bag contents, meters/test equipment, diapers, keys, baby bottles, camera (still/video), toys, film, baby food/spoons, religious articles, pacifier, souvenirs, baby powder, bottles, baby wipes, clothes.
Strategy Learning Principle: Media	 Spaced practice, KOR, high fidelity CBT, high fidelity graphics, photos, gaming, interactive exercises
Glossary	
Customer Required Information	

Outlines	**Multimedia Courseware**
Customer Approval Signature: ______________________	**Date:** __________

Module 2 **Lesson 2**	Unit: Image Analysis Lesson: How to look at an X-ray image
Objective	Upon completion of the Image Analysis unit, the trainee will be able to perform the correct procedure for scanning a bag image, as prescribed in the training unit.
Purpose	To demonstrate the following KSAs: 1. Knowledge of image scanning procedures. 2. Skill in scanning images. 3. Skill in using the X-ray equipment functions to aid in image interpretation.
Content	1. Use the FORWARD, REVERSE, and STOP features of the X-ray equipment to aid in the analysis. Use FORWARD to move the bag to the best possible location. Use Reverse for same purpose. Use STOP to keep the bag in place for closer inspection. 2. Look for items that do not belong together or are out of place with the rest of the bag contents. Some items could be part of a disassembled threat object. Other parts of the threat object could be in other bags.
Strategy Learning Principle: Media:	 Spaced practice — this concept will be reinforced in other units and lessons CBT, high fidelity graphics, interactive exercises
Glossary	
Customer Required Information	

Outlines	**Multimedia Courseware**
Customer Approval Signature: ______________________________	**Date:** ____________

Module 2 **Lesson 3**	Unit: Image Analysis Lesson: Identifying common carry-on objects in X-ray images
Objective	Given a variety of real or simulated bags, the trainee will correctly name all objects (generic item type, i.e., shoe, clothing, toilet article) in carry-on bags. The trainee will maintain a high level of performance in identifying objects in X-ray images of bags under conditions of increasing: • bag clutter • environmental noise • time constraints
Purpose	To demonstrate the following KSAs: 1. Knowledge of typical objects found in passenger bags. 2. Ability to match real objects with X-ray image representations of the object. 3. Ability to perform X-ray analysis in an airport environment. 4. Ability to perform X-ray analysis in a timely manner.
Content	This builds on the previous objective — now the trainee must name all the objects in a bag under a variety of circumstances: 1. Bags will be packed with common carry-on objects — varying degrees of clutter. 2. Bags will be packed with common carry-on objects — varying degrees of environmental noise (to simulate airport environment). 3. Bags will be packed with common carry-on objects — time limit on naming objects.
Strategy Learning Principle: Media:	 Spaced practice, KOR CBT, high fidelity graphics, interactive exercises
Glossary	
Customer Required Information	

Outlines	**Multimedia Courseware**
Customer Approval Signature: ______________________________	**Date:** ____________

Module 2 **Lesson 4**	Unit: Image Analysis Lesson: Image classification
Objective	After completing the "Image Analysis" training unit, the trainee will correctly name the three X-ray image classifications (obvious threat, possible threat, no threat) used for screening bags and other carry-on items.
Purpose	To demonstrate the following KSAs: 1. Knowledge of X-ray image classification criteria (obvious threat, possible threat, no threat) used for screening bags and other carry-on objects. 2. Ability to name X-ray image classifications.
Content	1. Image classification criteria are obvious threat, possible threat, pass. 2. Criteria for obvious threat: threat object can be identified. 3. Criteria for possible threat: shadows or masking prevents positive identification, or object in the bag cannot be identified. 4. Criteria for no threat: All items can be identified as non-threat or non hazardous.
Strategy Learning Principles: Media:	 Massed learning, KOR High fidelity graphics, interactive exercises
Glossary	
Customer Required Information	

Outlines **Customer Approval Signature:** ____________________	**Multimedia Courseware** **Date:** __________
Module 2 **Lesson 5**	Unit: Image Analysis Lesson: Shadows and masking
Objective	Given X-ray images of bags with shadows or masking, the trainee will judge bags as pass or possible threat, as prescribed in the training unit.
Purpose	To demonstrate the following KSAs: 1. Knowledge of the size of shadow in an X-ray image that could mask a threat object. 2. Skill in using X-ray equipment functions to investigate shadow or masked areas of an image. 3. Ability to determine whether a shadow area in a bag image is large enough to mask a threat object. 4. Ability to judge whether a bag should be repositioned on the conveyor belt or physically searched to investigate a masked or shadowed area.
Content	1. Some objects of heavy density in an image can mask or cast a shadow on other objects in a bag. 2. Some shadows may be large enough to mask a threat object. 3. Very small shadows may not be large enough to mask a threat object. If all objects in the bag can be identified and the shadow does not interfere with the identification process, the bag is categorized as meeting the pass criteria. 4. If there is any doubt about a shadow or masked area, try repositioning the bag and rescanning it. If all objects in the bag cannot be accounted for after this measure, call for a bag check.
Strategy Learning Principle: Media:	 Spaced practice, KOR CBT, high fidelity graphics
Glossary	
Customer Required Information	

Outlines	**Multimedia Courseware**
Customer Approval Signature: ______________________	**Date:** ____________

Module 3 **Lesson 1**	Unit: IED Conceptual Models Lesson: IED components
Objective	1. After completing the "IED Conceptual Models" training unit, the trainee will correctly name all components necessary to create an IED. 2. Given a selection of real or simulated components of IEDs, the trainee will be able to correctly describe (verbally or by selecting descriptors from a graphical or audio list) the characteristics of each category of components. 3. Given X-ray images of IEDs components, the trainee will identify each component from a variety of angles and orientations. 4. Given X-ray images of assembled IEDs and IED components, trainees will match the device components with the correct assembled device. 5. Given X-ray images of assembled IEDs and IED components, trainees will match the device components with the correct assembled device.
Purpose	To demonstrate the following KSAs: 1. Knowledge of the components of IEDs. 2. Knowledge of X-ray image representation of IED components. 3. Knowledge of the components of threat objects in relation to the assembled device. 4. Ability to name the components of an IED. 5. Ability to describe the characteristics of IED components. 6. Ability to identify X-ray images of the components of an IED. 7. Ability to describe the characteristic features of X-ray images of IED components. 8. Ability to distinguish X-ray images of IED components from X-ray images of innocent objects. 9. Ability to match IED components with an assembled IED.
Content	1. Review — IEDs have the following components: • timer • initiator • power source • explosive material These components are connected to form a complete IED. 2. Show simulated bags that have easily-detected, assembled IEDs (all parts are in close proximity and plainly visible) and other objects in it. An animated screener recognizes that something is not quite right and identifies the IED. 3. After viewing a variety of each component type the trainee should be guided to articulate common features of detonators, timers, etc. (salient features). Highlighting arrows may be helpful to draw attention to salient features: • Timers: show a variety of clocks, altimeters, barometric switches — Timers provide a signal to begin an action or process. They "turn the process on." Use analogies such as, (a) when your alarm clock rings, you get up and start the day, (b) when you flip a switch, you start a process that causes the lights to go on. Timers often display numbers or have some sort of dial or display.

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	• Initiators: Blasting cap — slim metal cylinder 2"–6" long, 1/8–1/4" wide, looks somewhat like a pen or a narrow pipe. • Power source: show a variety of batteries. 4. Show IED components from a variety of angles in a carry-on bag. Use highlighting and arrows to identify component. 5. Trainees select IED components from a simulated "build a bomb" kit, pack the components into a "suitcase," then view the suitcase (and the IED component) from a variety of angles. A variation would be to have another trainee identify the component. 6. Trainees now relate the parts to the whole by building an IED using simulated explosive components. 7. Trainees will "pack" the IED into a suitcase with other items and find their IED in the suitcase. Another strategy could be for one trainee to pack the bag and another trainee find the IED.
Strategy Learning Principle: Media:	 Overlearning, KOR, relationship of parts to whole, gaming, simulation, CBT simulation, animation, high fidelity graphics
Glossary	
Customer Required Information	

Outlines	**Multimedia Courseware**
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Module 4 **Lesson 1**	Unit: IED Detection Practice Lesson: Checkpoint Concentration
Objective	Given a photo of a carry-on object, the trainee will correctly match the photo with an X-ray representation of the object.
Purpose	
Content	Match photos of carry-on items with X-ray images of the same items.
Strategy Learning Principle: Media:	 Review/practice/overlearning Gaming
Glossary	
Customer Required Information	

Outlines	**Multimedia Courseware**
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Module 4 **Lesson 2**	Unit: IED Detection Practice Lesson: Safe Skies
Objective	Given a variety of X-ray images of passenger bags moving on a simulated conveyor belt, trainees will correctly discriminate bags with IEDs from bags with no IEDs.
Purpose	
Content	Improving speed of decision making (threat/no threat)while maintaining accuracy.
Strategy Learning Principle: Media:	 Practice/review/overlearning Gaming
Glossary	
Customer Required Information	

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Module 4 **Lesson 3**	Unit: IED Detection Lesson: IED detection with increasing levels of clutter, noise, and time constraints
Objective	1. Given X-ray images of uncluttered, moderately cluttered, and highly cluttered bags containing IEDs and bags with no IEDs, the trainee will correctly identify the IED bags. Evaluation criteria will be statistically significant improvement over time without a significant increase in false alarm rate. 2. Given X-ray images of uncluttered, moderately cluttered, and highly cluttered bags containing IEDs and bags with no IEDs, the trainee will correctly identify the IED bags under increasing conditions of simulated checkpoint noise. Evaluation criteria will be statistically significant improvement over time without a significant increase in false alarm rate. 3. Given X-ray images of uncluttered, moderately cluttered, and highly cluttered bags containing IEDs and bags with no IEDs, the trainee will correctly identify the IED bags under conditions of increasing time constraints (30 sec., 15 sec., 10 sec.).
Purpose	To demonstrate the following KSAs: 1. Knowledge of the components of an IED. 2. Ability to identify the components of an IED. 3. Ability to discriminate between innocent objects and IEDs. 4. Ability to discriminate between innocent objects and IEDs under conditions of increasing airport noise. 5. Ability to discriminate between innocent objects and IEDs under conditions of increasing time constraints.
Content	Competency-based checkpoint gaming simulation with uncluttered bags. The goal is to reach a TBD probability of detection with a TBD probability of false alarm. Ultimately this game has a number of levels and variables: • Clutter • No • Yes First, work only with uncluttered bags and unlimited time, then add checkpoint noise and time constraints. Add procedures as an extra interest feature. As each variable is mastered, the trainee is presented with an increasing difficulty level. Scoring/KOR: • Bonus points scored for IED detection. • Points for passing normal bags. • Bonus points for performing correct procedures. • Missed IED — no points — highlight the IED. If probability of detection falls below a TBD (adjustable) threshold, go to remediation track. • False alarms — no points — KOR (there is no IED in this bag). If false alarm rate reaches a TBD (adjustable) threshold, go to remediation track.

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	Remediation: • Remediation track for missed IEDs would include highlighting the missed IED and showing each IED component in the bag. If the P(d) falls below a TBD level, the trainee would return to module 4. • Remediation for high false alarm rate would entail additional practice in naming common objects in a bag. Also review criteria for pass, possible threat definite threat.
Strategy Learning Strategy Principle	Overlearning — Overlearning is used for procedures that may occur rarely in real life, but the consequences of not performing or misperforming the procedures are great. Emergency and safety procedures are examples. Although a screener may never encounter an actual IED on the job, the consequences of missing an IED are costly. In the checkpoint environment, another factor that must be considered is the need to keep passengers moving through the checkpoint. A high false alarm rate will slow passenger throughput to unacceptable levels. In this lesson, abundant practice is accompanied with immediate KOR, reinforcement for correct responses, and remediation when performance levels exceed a specific threshold. The intent of this approach is to raise P(d) while keeping P(fa) at an acceptable level
Media	CBT, gaming, high fidelity graphics — similar in resolution, size, and content to the B and W X-ray images used at the checkpoint. This should facilitate positive transfer of training.
Glossary	
Customer Required Information	

Appendix E

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ICAO TECHNICAL PUBLICATIONS

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 worldwide 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.