Doc 9888

Noise Abatement Procedures: Review of Research, Development and Implementation Projects — Discussion of Survey Results

Approved by the Secretary General
and published under his authority

First Edition – 2010

International Civil Aviation Organization

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ACRONYMS

AFE	Above field elevation
AIRE	Atlantic Interoperability Initiative to Reduce Emissions
ANSP	Air navigation service provider
APU	Auxiliary power-unit
ASPIRE	Asia Pacific Interoperability Initiative to Reduce Emissions
ATC	Air traffic control
ATCO	Air traffic control officer
ATM	Air traffic management
CAEP	Committee on Aviation Environmental Protection
CDA	Continuous descent arrival or approach
CDO	Continuous descent operations
CPDLC	Controller-pilot data link communication
ECAC	European Civil Aviation Conference
EDA	En route descent advisor (NASA)
ERAT	Environmentally Responsible Air Transport
FMC	Flight management computer
FMS	Flight management systems
GBAS	Ground-based augmentation system
LAQ	Local air quality
LDEN	Equivalent noise level in dB(A) with day, evening and night weighting
MINT	Minimum CO_2 in TMA
NADP	Noise abatement departure procedure
NAP	Noise abatement procedure
NAP RD&I	Noise abatement procedure research, development and implementation
OPTIMAL	Optimized Procedures and Techniques for Improvement of Approach and Landing
PANS-OPS	Procedures for Air Navigation Services — Aircraft Operations
PARTNER	Partnership for Air Transportation Noise and Emissions Reduction
P-RNAV	Precision area navigation
R&D	Research and development
RNAV	Area navigation
RNP AR	Required navigation performance authorization required
RTA	Required-Time-of-Arrival
SEL	Sound exposure level
SID	Standard instrument departure
STAR	Standard instrument arrival
TAP	Terminal area path
TMA	Terminal area
TMA	Traffic management advisor (NASA)

OVERVIEW

1. Introduction

This document summarizes Noise Abatement Procedure (NAP) Research and Development (R&D) projects undertaken by various parties, including universities, regulatory agencies, manufacturers, air carriers and airports. The summaries are a result of survey questionnaires that were distributed to contact persons for NAP R&D in 2005-2006 and to CAEP member States and observers in 2008. As such, they should be viewed as snapshots of the efforts being undertaken at the time of the surveys. Some of these summaries report preliminary measured results of work already in progress, while others report predictions of anticipated improvements in environmental impact. While the reported benefits for Continuous Descent Operations (CDO), in particular, show promise, some of the results have been achieved in unique operating environments with single operators using similar aircraft types with advanced navigation equipment. It will take incorporation of changes in flight, airspace and air traffic control (ATC) procedures and improvements in aircraft equipage on a widespread basis, adopted by the pilots, air carriers, Air Navigation Service Providers (ANSPs) and airport operators, for these benefits to be fully realized.

2. Review of established practices

2.1 Noise abatement operational procedures are being employed today to provide noise relief from both arriving and departing aircraft to communities around airports. The *Procedures for Air Navigation — Aircraft Operations — Flight Procedures* (PANS-OPS, ICAO Doc 8168, Volume 1) contains guidance for the development of a maximum of two noise abatement departure procedures (NADPs) designed generally to mitigate noise either close in (NADP 1) to the airport or further out (NADP 2) along the departure path. Appendix A of this document contains a list of current NADPs in use by air carriers for a wide range of aircraft types.

2.2 Noise abatement operational procedures in use today can be broken down into three broad categories:

Noise abatement flight procedures

- Continuous Descent Operations (CDO), referred to in the past as Continuous Descent Arrival or Approach (CDA);
- Noise Abatement Departure Procedures (NADP);
- Modified approach angles, staggered, or displaced landing thresholds;
- Low power/low drag approach profiles;
- Minimum use of reverse thrust after landing.

Spatial management

- Noise preferred arrival and departure routes;
- Flight track dispersion or concentration;
- Noise preferred runways .

Ground management

- Hush houses and engine run up management (location/aircraft orientation, time of day, maximum thrust level);
- Auxiliary power-unit (APU) management;
- Taxi and queue management;
- Towing;
- Taxi power control (taxi with fewer than all engines operating).

2.3 Although noise abatement procedures may have quantifiable environmental benefits, effective implementation may be difficult: procedures must be developed, tested and evaluated for benefits and ATC impacts, approved and accepted by the airport and the ANSP, and adopted by the airlines and other airport users. PANS-OPS allows a maximum of two different take-off procedures to be implemented by an airline. The Air Carrier Survey shown in Appendix A, completed before the Seventh Meeting of the Committee on Aviation Environmental Protection (CAEP/7), reports how different airlines are applying the close-in and distant noise abatement departure procedure criteria to seventeen different aeroplane types. The criteria specify minimum altitudes for thrust reduction and flap retraction, but otherwise give operators considerable latitude to develop their own profile designs. For any noise abatement operating procedure to be adopted, it needs to be demonstrated that with appropriate crew training it does not compromise safety, and that ATC can accommodate the procedure with minimal or no impact on airport capacity or controller workload.

2.4 There are numerous system constraints that prevent or hinder the implementation of NAPs in general and CDOs in particular. They include:

- Lack of harmonizing guidance — As noted above, PANS-OPS establishes minimum altitudes for aircraft configuration change and thrust reduction within an NADP, but leaves development of specific aircraft profiles to the operator. Appendix A illustrates the diversity of aircraft procedures. These variations make the quantification of noise and emissions benefits very difficult and drive the requirement for very sophisticated modelling to determine the effects of the different profiles. The *Continuous Descent Operations (CDO) Manual* (ICAO Doc 9931) provides guidance and aims to harmonize the development and implementation of CDO. The implementation guidance in Doc 9331 is intended to support collaboration among the different stakeholders involved in implementing CDO including ANSPs, aircraft operators, airport operators and aviation regulators.

- Capacity requirements — Airport and airspace capacity may be adversely impacted by noise abatement procedures, particularly during high demand periods. It may be impractical to use noise preferred runways or flight procedures like CDO if they generate unacceptable levels of delay and congestion. Delay and congestion contribute directly to incremental noise and emission impacts.

- Airport/ground equipment — Hush houses and other airport infrastructure items that may contribute to the improvement in reduction of noise and emissions require space and funding, which may not be available at all locations.

- Aircraft equipage — Many aircraft do not yet have sophisticated flight management systems, data link, or the database capacity necessary to optimize arrival and departure noise abatement procedures.

- Pilot and air traffic controller acceptance — Noise abatement procedures often increase pilot and controller workload and introduce non-standard or more complex procedures. Variations in optimum aircraft performance may make it difficult for controllers to efficiently sequence and space traffic, thus making them reluctant to embrace CDO procedures in other than light traffic periods.

- Lack of skills, training and awareness — Effective implementation of noise abatement procedures requires a collaboration among airports, ANSPs and aircraft operators. Absent this collaboration and coordination, it is unlikely that procedures will gain regular use. Ideally, procedures will be incorporated into the standard operating procedures for both flight crews and controllers and thereby be included in job function and training.

– Economic constraints — Evaluation and implementation of noise abatement procedures, upgrade of aircraft or airport navigation equipment, and construction or installation of noise mitigating airport infrastructure require financial resources that may not be available. These economic constraints may delay or prevent the full environmental benefits from being realized.

– Lack or poor quality of information — Although there is a wealth of information and guidance available from a variety of governmental and commercial sources, some parties may be unaware of its existence, or how to access it.

– Airport configuration and local community characteristics — In many locations where noise and emissions problems are most acute, airports have little room to expand their land mass or modify their operations or layout to reduce environmental impacts. Similarly, adjacent communities may be well-established, and therefore without the possibility of compatible land uses, where arrivals or departures could be directed to minimize noise on surrounding residential areas.

– Terrain and obstacles — Likewise, terrain or man-made obstacles around airports may severely limit opportunities by ATC, the airport and the aircraft operator to safely and economically implement many simple and effective noise abatement procedures.

– Trade-off between noise and emissions — Although CDO procedures appear to provide both noise and emissions benefits, other noise abatement procedures have the potential to, or do in fact, increase emissions. In cases where noise abatement flight tracks, preferred runways, noise displaced landing thresholds, and other procedures increase flight path miles or taxi distance, they will proportionately increase fuel burn and emissions.

2.5 The noise abatement operational procedures described above can make a measurable contribution to reducing noise levels in the vicinity of airports. The magnitude and scope of the reductions, as well as the specific procedures to be used to achieve them, should be determined through a comprehensive noise study. The study should also include an analysis of emissions impacts and fuel burn, as these variables may be affected by procedure changes both in the air and on the ground. The aircraft operators and ANSP should be parties to the study to ensure the safety and feasibility of the procedures and to take advantage of their technical expertise. The environmental benefits of some operational procedures are straightforward and easy to visualize: preferential runways or flight tracks move aircraft away from more noise-sensitive locales. Conversely, the benefits assessments for NADPs and CDO procedures are extremely complex and may require detailed modelling in order to be well understood. It is imperative that accurate aircraft operating data and specific operator flight procedures be applied as input to the noise and emissions models and that impacts on airport and airspace capacity be analysed. It is worth repeating that some noise abatement operational procedures may increase emissions or derogate airport capacity while providing significant noise relief. Appropriate consideration of all potential environmental impacts is essential, particularly as priorities change and procedures evolve or come up for review.

3. Synthesis of collected R&D/implementation summaries presented to CAEP/7

Background

3.1 The first step in the 2005-2007 work was to establish a baseline by collecting information on noise abatement procedures in use. Appendix A contains the 2007 survey report on carrier NADPs.

3.2 To collect information on NAP R&D and implementation projects, a questionnaire was distributed to coordinators or contact persons of NAP R&D and implementation projects. The response obtained from filled-in questionnaires is considered the basis for the report to CAEP/7. Information obtained from Europe, the United States and Japan is contained in Appendix B. Attachments to this Appendix contain survey results collected from principal contacts for NAP R&D.

3.3 The number of stakeholders surveyed for ongoing NAP R&D was limited as was the scope of the responses. Therefore, it is understood that the survey does not represent all NAP R&D at that time. The study represents a snapshot in time and because of the nature of R&D the material contained within this study will have a short shelf life. There are indications that additional R&D is being defined, is for the near term, and/or that existing R&D will continue. The information supplied within the survey results was limited, and no validation was attempted by CAEP. Because of the limited survey results, it was also not possible to determine the baseline (over which the reported improvements were determined) so that meaningful comparisons between R&D programmes could be made or conclusions drawn. The emissions effects from some current practice NAPs were not assessed or modelled. The responses to the survey tended to focus on implementation of CDO whilst other proven noise abatement techniques were not extensively reported.

Summary of Research & Development and Implementation Areas

3.4 The majority of NAP R&D focuses on techniques for reducing arrival and approach noise. The exceptions contained in this report are the European SOURDINE II project and the Japan R&D project which look into the environmental impact of Noise Abatement Departure Procedures. Arrival techniques, especially CDA, have attracted much interest within the aviation community in the last several years with most of the current work focused on CDA demonstrations at selected airports with individual air carriers. CDAs have the potential for reducing noise, emissions and fuel burn, but these benefits must be quantified while demonstrating ATC compatibility and assessing capacity impact in order to be adopted on a broad scale. Variations in aircraft performance and complex airspace structures have limited widespread CDA implementation. Researchers are working on automation tools and minimum aircraft equipage to reduce the pilot and controller workload associated with the procedures.

3.5 Existing and potential operational enablers — These enablers facilitate the effective implementation of NAPs.

- Top level commitment and leadership — The development, evaluation, coordination and implementation of sophisticated NAPs require strong leadership and commitment from all stakeholders to ensure success. The definition of success for each stakeholder should be established in advance.
- Collaborative environmental management — planning by stakeholders — As international agreements on environmental goals evolve, it is imperative that all stakeholders participate in the planning process and understand the complex interactions among competing interests.
- Harmonized guidance — Aviation is inherently international in scope. The promulgation of harmonized guidance from States on noise abatement operational procedures and emissions impacts provides the foundation for broad and effective implementation.
- Standardized and accurate monitoring and modelling information — Standardized technical analysis and modelling of noise abatement procedures, including impacts on fuel burn and emissions, form the basis for rational decision making and procedure/programme selection.
- Training and awareness — Sensitivity to the environmental impacts of aviation should be established through training and the incorporation of environmental “best practices” in standard operating procedures. In many instances, corporate or operator goals and environmental goals can be aligned (e.g., reduced fuel consumption).

– Dissemination of requirements — Adequate communication — These elements form the foundation for training and awareness and are essential for effective procedure selection and implementation.

– Expertise and skills — Effective implementation of NAPs depends upon a collaboration of knowledgeable and technically competent stakeholders from a variety of disciplines, including representatives from communities and local governments around the airport.

– Adequate resources and technology — In order to insure effective implementation of noise abatement operational procedures, adequate resources must be available to support development, analysis, modelling, implementation, training and education. Sophisticated technology may be required on participating aircraft (satellite-based Flight Management Systems (FMS)) and in the ground air traffic management (ATM) infrastructure (sequencing and spacing software) to realize fully the comprehensive environmental benefits.

– Standardized ATM framework (e.g., State approval of precision area navigation (P-RNAV)) — Harmonization of ANSP airspace, procedure and regulatory requirements, and standards facilitates the development and implementation of effective noise abatement operational procedures. It also significantly increases the likelihood of aircraft operator cooperation and participation.

3.6 As one leg of the Balanced Approach, noise abatement operational procedures have shown a substantial environmental benefit. Further optimization and development of new operational procedures show a promise of additional benefits. The R&D projects reported in this document show predictions and/or measurements of the following environmental benefits:

– 3 to 12 dB noise reduction, and 8 per cent to 36 per cent reduction in noise contour areas on approach;

– 2 to 9 dB noise reduction and 23 per cent to 42 per cent reduction in noise contour areas on departure;

– As much as 35 per cent reductions in CO_2, HC and NO_X and 50 to 1 000 pound fuel savings per landing; and

– 90 to 630 kg CO_2 and 60 to 440 pound fuel savings per departure.

There is a clear incentive for conducting further R&D on noise abatement procedures, combining the efforts of universities, regulatory agencies, manufacturers, air carriers and airports to minimize the impact aviation has on the environment. This is especially true for CDAs, where reductions in noise come with reductions in emissions *and* fuel burn.

3.7 Many of the R&D projects involve arrival techniques. Because some of these techniques are relatively new and/or not universally adopted, much of the focus is on pilot and ATC workload, and capacity integration. To facilitate acceptance and mitigate pilot workload, flight deck systems are being developed to help the pilots manage the aircraft and communicate with ATC. The demonstrations of these procedures are aimed at developing ATC procedures, communications and procedure integration to mitigate capacity impact.

3.8 The reported R&D projects are either stand-alone endeavours or a part of broader research programmes. While most of the reported projects are in progress or have been completed, the time frames of the studies range from 2001 to as far as 2011. There are indications of new R&D projects to continue the development of the techniques, technologies and ATC integration of CDOs, as well as new R&D into developing and optimizing noise abatement departure procedures.

Conclusions

3.9 Noise abatement procedures form one leg of the Balanced Approach, and as such, continued development and optimization of operational procedures are essential for minimizing the environmental impact of aviation. Operational procedures can often be implemented with the existing fleet and have the potential to make an immediate improvement in the environmental impact of aviation. As described in some of the projects contained in this document, the predicted and measured improvements to noise, emissions and fuel burn can be substantial. Continuing R&D must work to optimize procedures, determine the technologies needed and identify pathways to facilitate acceptance by airports, air carriers, pilots, ANSPs and communities around airports.

4. Synthesis of collected R&D/implementation summaries presented to CAEP/8

Background

4.1 This section is a review of noise abatement procedure research, development and implementation (NAP RD&I) projects prepared for the Eighth Meeting of the ICAO Committee on Aviation Environmental Protection (CAEP/8).

4.2 This report took into consideration the following issues identified by CAEP/7:

- limited number of organizations surveyed and scope of responses;
- emphasis on CDA and not enough on other measures;
- no assessment of trade-offs against fuel burn, emissions, flight time and capacity;
- lack of a baseline against which improvements could be determined.

4.3 To address these concerns, a formal, structured request for submissions was made to CAEP member States and Observers. Information on 19 projects was submitted. The projects and participants are listed in the Table 1. Tabular summaries of the submissions are provided in the following section. The individual submissions are provided in attachments to Appendix C. To facilitate reader inquiries, contact information has been provided with each submission.

Table 1. Projects and participants

Project			*Participants*				
No.	*Name*	*Sponsor(s)*	*ANSPs*	*Airports*	*Air carriers*	*Manufacturers*	*Other*
1	Advanced Mitigation Techniques (pending)	Eurocontrol	Eurocontrol	tbd	tbd	tbd	tbd
2	German CDA	DFS	DFS	tbd	tbd	tbd	tbd
3	NAP for Stockholm-Arlanda	LFV	LFV	Stockholm-Arlanda	SAS Falcon Air Blue 1		
4	Regional Advanced ATM Migration Programme	LFV	LFV	Stockholm-Arlanda, Malmo, Landvetter, Umea	SAS, Norwegian, Malmo Aviation, City Airline		
5	Optimizing Aircraft Sequencing and Spacing in the Terminal Area Airspace to Increase Airport Capacity, Reduce Fuel Burn and Emissions, and Reduce Noise on Developed Terminal Paths	US JPDO NextGen Institute	FAA Nav Canada		FedEx US Air Force		Innovated Solutions International Georgia Institute of Technology
6	Atlantic Interoperability Initiative to Reduce Emissions	FAA EU/EC	FAA DSNA (France) IAA (Ireland) LFV NAV Portugal		Delta Airlines, Air France, KLM, SAS, Virgin Atlantic, FedEx, American Airlines, United Airlines, AirEuropa, UPS	Boeing Airbus	Georgia Institute of Technology
7	Asia Pacific Interoperability Initiative to Reduce Emissions	EAA Asian Pacific rim partners	FAA AirServices Australia Airways New Zealand Japan Civil Aviation Bureau CAA French Polynesia (Tahiti)	Airports Fiji	United, American, Continental, Delta, Air New Zealand, Qantas, Japan Airlines, FedEx, UPS, Northwest, Nippon Cargo, All Nippon, Singapore Airlines, Cathay Pacific	Boeing Airbus ARINC SITA Honeywell	
8	Continuous Descent Arrival (CDA) at Louisville Int'l Airport (SDF) under the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) [update]	FAA through PARTNER	FAA	Louisville Regional Airport (SDF) Authority	UPS	Boeing	Georgia Institute of Technology, Massachusetts Institute of Technology, NASA
9	Improved Quiet Climb	Boeing				Boeing, GE	
10	Tailored Arrivals Demonstrations	Boeing	FAA	San Francisco, Miami	?	Boeing	
11	RNAV/RNP Procedures with Noise/Emission Elements	Boeing	FAA	Seattle SeaTac, Luxembourg Findel, London Heathrow	?	Boeing	

Project			*Participants*				
No.	*Name*	*Sponsor(s)*	*ANSPs*	*Airports*	*Air carriers*	*Manufacturers*	*Other*
12	Minimum CO_2 in TMA (MINT)	SESAR JU/AIRE, consortium partners	LFV		Novair	Airbus	AVTECH Sweden Egis Avia
13	Environmentally Responsible Air Transport (ERAT)	EC Directorate-General for Transport and Energy, consortium partners	NATS LFV	Bucharest International, Stockholm Arlanda, London Heathrow	Lufthansa	Airbus, SNECMA	To70, ENVISA, DLR, Eurocontrol Experimental Centre, NLR
14	Optimized Procedures and Techniques for IMprovement of Approach and Landing (OPTIMAL)	EC, consortium partners	Eurocontrol AENA LVNL ENAV	AENA		Airbus, Eurocopter, Thales, General Electric (Smiths Aerospace), Augusta, Sperry Marine	DLR, INECO, ISDEFE, NLR, ONERA, University of Liverpool, DFS, SENASA, Davidson Ltd, GMV, SICTA
15	CDAs in London TMA	NATS, Eurocontrol, Sustainable Aviation Noise Abatement Working Group	NATS Eurocontrol	British Airports Authority, Manchester Airport Group, London City Airport	British Airways Virgin Atlantic	Airbus Rolls Royce SBAC	
16	Steeper Approaches	NATS, Sustainable Aviation Noise Abatement Working Group	NATS	British Airports Authority, Manchester Airport Group, London City Airport	British Airways Virgin Atlantic	Airbus Rolls Royce SBAC	
17	ACP Noise Assessments/ Population Exposure Analysis	NATS	NATS				UK CAA Directorate of Airspace Policy
18	Departures Code of Practice	Sustainable Aviation Noise Abatement Working Group	NATS	British Airports Authority, Manchester Airport Group, London City Airport.	British Airways Virgin Atlantic	Airbus Rolls Royce SBAC	
19	Higher Holding	NATS	NATS				

Summary of Research & Development and Implementation Areas

4.4 Fifteen of the 19 programmes for which information has been submitted (see Table 2) utilize CDA procedures, either wholly or in part, for noise reduction. Since the successful trials of CDA procedures at Stockholm-Arlanda and Louisville airports, efforts in Europe and the United States have been focussed on the wider implementation of CDA. By and large, these efforts have been restricted to low traffic operations. However, a number of programmes, specifically the Swedish Regional Advanced ATM Migration programme (Project 4) and the US GBAS TAP optimization programme (Project 5) seek to expand the use of CDA to higher traffic operations. These programmes, as well as the ECAC Advanced Mitigation Techniques programme (Project 1), will develop precision approach procedures along noise preferential routes.

4.5 Information was submitted on several international programmes, namely the ECAC Advanced Mitigation Techniques programme (Project 1), the Atlantic Interoperability Initiative to Reduce Emissions (AIRE, Project 6) and the Asia Pacific Interoperability Initiative to Reduce Emissions (ASPIRE, Project 7). These programmes will leverage the work of previous or existing research programmes to facilitate the wider implementation of best practices that have been developed.

Table 2. Summary of project descriptions

Project		*Project Coverage*				
No.	*Name*	*Flight Phase*	*Application*	*Targeted Improvement*	*Product/Deliverable*	*Time frame*
1	Advanced Mitigation Techniques (pending)	All	Terminal area aircraft operations	Noise, local air quality, climate	Guidance for local implementation of best practices and performance of environmental trade studies	2009-2011
2	German CDA	Arrival	Implementation of CDA	Noise, emissions and fuel burn		from 2009
3	NAP for Stockholm-Arlanda	Arrival	Implementation of CDA, adjustment of SIDs to avoid noise-sensitive areas, curved approaches	Noise	Development of SIDs and P-RNAV STARs	2004-2007
4	Regional Advanced ATM Migration Programme	Arrival	CDAs, green and curved approaches	Noise, emissions and fuel burn	P-RNAV STAR CDAs and green approaches to Arlanda, Landvetter and Umea; Radar-based CDA to Malmo; RNP AR (curved approaches) to Arlanda and Malmo	2007-2011
5	Optimizing Aircraft Sequencing and Spacing in the Terminal Area Airspace to Increase Airport Capacity, Reduce Fuel Burn and Emissions, and Reduce Noise on Developed Terminal Paths	Arrival	Terminal area path (TAP) procedures using ground-based augmentation systems (GBAS)	Noise, emissions, and fuel bum; aircraft sequencing and spacing	Optimized TAP procedures using existing technologies	2007-2009
6	Atlantic Interoperability Initiative to Reduce Emissions (AIRE)	All	ATM and terminal area procedures targeting worldwide interoperability	Noise, emissions, and fuel bum; aircraft sequencing and spacing	Proof-of-concept ATM system enhancements, quantification of "gate-to-gate" benefits, identification of implementation issues	from 2008
7	Asia Pacific Interoperability Initiative to Reduce Emissions (ASPIRE)	All	ATM and terminal area procedures targeting worldwide interoperability	Noise, emissions, and fuel burn; aircraft sequencing and spacing	Leveraging of existing initiatives to accrue environmental benefits; development of common environmental performance metrics	from 2008

Project		*Project Coverage*				
No.	*Name*	*Flight Phase*	*Application*	*Targeted Improvement*	*Product/Deliverable*	*Time frame*
8	Continuous Descent Arrival (CDA) at Louisville Int'l Airport (SDF) under the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) [update[	Arrival	Development and implementation of CDA procedures at US airports	Noise, emissions and fuel burn	Demonstration for night-time operations at SDF; ongoing demonstrations at Atlanta (ATL) and Los Angeles (LAX)	from 2004
9	Improved Quiet Climb	Departure	Automated FMS NADPs	Noise; reduced pilot workload and situational awareness	Working prototype, simulator trials, flight demo	2008-2012
10	Tailored Arrivals Demonstrations	Arrival	Dynamic routing	Noise and fuel burn; reduce throughput penalties; maximize capacity	Communication of tailored arrival path to minimize track distance and provide idle descent profile	
11	RNAV/RNP Procedures with Noise/Emission Elements	Arrival	Terminal area operations	Noise and fuel burn	Reduce track distances and avoid noise-sensitive areas	
12	Minimum CO_2 in TMA (MINT)	Arrival	Terminal area operations; approach procedures	Noise and fuel burn	Demonstration with current state-of-the-art airborne systems under high, medium and low traffic flows; incorporation of wind-data uplinks; reduce track distances and avoid noise-sensitive areas	January-November 2009
13	Environmentally Responsible Air Transport (ERAT)	Arrival Departure	Extended terminal area operations	Noise, emissions and fuel burn	Identify mature operational initiatives, develop concept elements, integrate them and validate a concept of operations that reduces the environmental impact of the air transport operation in all phases of flight in the (extended) terminal area	2008-2011; implementation 2015+
14	Optimized Procedures and Techniques for IMprovement of Approach and Landing (OPTIMAL)	Arrival	Advanced CDA (RNAV, FMS-managed vertical profile, advanced ATC tools)	Increase capacity, minimize noise, improve safety	Define and validate innovative air-ground cooperative procedures for the approach and landing phases of aircraft and rotorcraft in a pre-operational environment	2004-2008; implementation 2010+
15	CDAs in London TMA	Arrival	Implementation of CDA guidelines (Arrivals Code of Practice)	Noise	Promote and assist in the development or application of CDAs by NATS airport customers; train ATCOs in the benefits and techniques to enable CDAs; design airspace to improve CDA performance	Ongoing
16	Steeper Approaches	Arrival	Approach glide slope angle	Noise	Evaluation of noise benefits and flyability of steeper approaches	Ongoing
17	ACP Noise Assessments/ Population Exposure Analysis	Arrival Departure	Population noise exposure		Consultation documentation; analysis of LAQ contours, LDEN metrics, SEL footprints and sound quality for airspace change proposals	Ongoing

Project		*Project Coverage*				
No.	*Name*	*Flight Phase*	*Application*	*Targeted Improvement*	*Product/Deliverable*	*Time frame*
18	Departures Code of Practice	Departure	Develop Departures Code of Practice	Noise	Code to include: 1. use of fixed ground power and preconditioned air rather than aircraft APU 2. taxi with fewer than all engines running 3. continuous climb departures 4. collaborative decision making	Full Paper in 2010
19	Higher Holding	Arrival	Holding altitudes	Fuel burn	Investigation of higher holding opportunities	

4.6 The available quantified noise, emissions and fuel burn effects are summarized in Table 3. Note that the reported overall AIRE and ASPIRE benefits are for "gate-to-gate" operations. Details of the qualitative and quantitative benefits are provided in Attachment 1. For the sake of providing a common basis of comparison in Table 3, the quantitative benefits provided in the attachments have been converted to a common set of units (litres or kilograms of fuel, tonnes of CO_2).

4.7 While, qualitatively, improved operations such as wider implementation of CDA and development of procedures along noise preferential routes are generally accepted to accrue overall noise benefits, for almost all of the projects the quantification of noise benefits has not been provided. This can be attributed to the early stages of the programmes; however, a 6 dB reduction from 7.5 to 15 NM from the runway threshold has been reported for the CDA trials at Louisville completed in 2004. It should also be noted that the use of noise preferential routes, while reducing the number of people affected by significant aircraft noise, may lead to local increases in noise levels along those routes.

4.8 Additionally, available actual or estimated emission and fuel burn effects have been provided. These mostly show the accrual of benefits resulting from the use of the developed procedures.

Table 3. Summary of project benefits

Project		*Quantified Benefits ("+" = increase/disbenefit, "–" = decrease/benefit)*			
No.	*Name*	*Noise*	*Emissions*	*Fuel Burn*	*Estimated/Actual*
1	Advanced Mitigation Techniques (pending)	too early	too early	–20 to –50 kg per flight (relative to existing CDA goals) due to higher altitude initiation of CDAs	Estimated
2	German CDA	too early	too early	too early	tbd
3	NAP for Stockholm–Arlanda	tbd	tbd	–56 kg per flight (P-RNAV STAR with B737)	Actual
4	Regional Advanced ATM Migration Proqramme	too early	too early	too early	tbd
5	Optimizing Aircraft Sequencing and Spacing in the Terminal Area Airspace to Increase Airport Capacity, Reduce Fuel Burn and Emissions, and Reduce Noise on Developed Terminal Paths	too early	NO_X: +18% to –50% HC: +19% to –53% CO: +7% to –41% CO_2: +14% to –45% SO_2: +14% to –45%	+17% to –6.5%	Estimated

Project		*Quantified Benefits ("+" = increase/disbenefit, "–" = decrease/benefit)*			
No.	*Name*	*Noise*	*Emissions*	*Fuel Burn*	*Estimated/Actual*
6	Atlantic Interoperability Initiative to Reduce Emissions (AIRE)	tbd	CO_2: –1.4 t/flt (transatlantic, gate-to-gate)	–568 l/flt (transatlantic, gate-to-gate)	Actual and estimated
7	Asia Pacific Interoperability Initiative to Reduce Emissions (ASPIRE)	tbd	CO_2: –11.1 t/flt (transpacific, gate-to-gate)	–4 400 l/flt (transpacific, gate-to-gate)	Estimated
8	Continuous Descent Arrival (CDA) at Louisville Int'l Airport (SDF) under the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) [update]	–6 dB (@ 7.5–15 NM from runway threshold)	CO below 914 m: –12.7% (B767) / –20.1% (B757) HC below 914 m: –11.0% (B767) / –25.1% (B757) NO_x below 914 m: –34.3% (B767) / –34.4% (B757)	@ SDF: –159 kg (B767) / –45 kg (B757)	Actual
9	Improved Quiet Climb	–3 to –6 dB (cf. typical close-in NADP)			Estimated
10	Tailored Arrivals Demonstrations	tbd	tbd	tbd	tbd
11	RNAV/RNP Procedures with Noise/Emission Elements	tbd	tbd	tbd	tbd
12	Minimum CO_2 in TMA (MINT)	tbd	tbd	–150 kg compared to good traditional approach	Estimated
13	Environmentally Responsible Air Transport (ERAT)	tbd	tbd	tbd	tbd
14	Optimized Procedures and Techniques for IMprovement of Approach and Landing (OPTIMAL)	1. Single event, A320: "Nominal" CDA: –2 to –9 dBA from 45 up to 20 km from threshold, penalty of 4 dBA at 17 km from the threshold; "Optimized" CDA: additional – 4 dBA for low noise levels. Improvements dependent on aircraft type. 2. LDEN 48, Schipol: 20% reduction	n/a	n/a	Estimated
15	CDAs in London TMA				
16	Steeper Approaches				
17	ACP Noise Assessments/ Population Exposure Analysis				
18	Departures Code of Practice				
19	Higher Holding			–2% per 1 000 ft increase	Estimated

Implementation challenges

4.9 Overall, the primary prerequisites to implementation of the reported NAP procedures are personnel training and the provision of guidance material, furnishing aircraft with appropriate navigational equipment, and development of increased ATC capacity to use the advanced procedures. However, it should be noted that the US GBAS TAP programme does include efforts to incorporate aircraft without advanced FMS. The reported implementation prerequisites are summarized in Table 4.

Table 4. Summary of implementation prerequisites

	Project	*Implementation Prerequisites*
No.	*Name*	
1	Advanced Mitigation Techniques (pending)	Provision of ECAC guidance material for local authorities
2	German CDA	Training, publication and charting
3	NAP for Stockholm-Arlanda	P-RNAV equipped aircraft, RNAV procedures, initial experience in low traffic density, Pilot and ATC education and information
4	Regional Advanced ATM Migration Programme	P-RNAV equipped aircraft, RNAV procedures, Advanced Arrival Manager for high traffic density, RNP AR procedure design manual, RNP AR approved airlines
5	Optimizing Aircraft Sequencing and Spacing in the Terminal Area Airspace to Increase Airport Capacity, Reduce Fuel Burn and Emissions, and Reduce Noise on Developed Terminal Paths	No additional prerequisites
6	Atlantic Interoperability Initiative to Reduce Emissions (AIRE)	Demonstrations of operational integrity, safety and positive cost benefit
7	Asia Pacific Interoperability Initiative to Reduce Emissions (ASPIRE)	Demonstrations of operational integrity, safety and positive cost benefit
8	Continuous Descent Arrival (CDA) at Louisville Int'l Airport (SDF) under the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) [update]	FMS-equipped aircraft, low traffic density
9	Improved Quiet Climb	
10	Tailored Arrivals Demonstrations	
11	RNAV/RNP Procedures with Noise/Emission Elements	
12	Minimum CO_2 in TMA (MINT)	Airline implementation of “NowCast” system; For high traffic, sufficient ground system complexity to safety and efficiently manage mixed equipage
13	Environmentally Responsible Air Transport (ERAT)	ATM: RNAV routes, advanced AMAN, DMAN, ghosting tool for merging of traffic; Cockpit: display of configuration change points, FMS/engine control adaptation for NADP/CDA thrust management

	Project	*Implementation Prerequisites*
No.	*Name*	
14	Optimized Procedures and Techniques for IMprovement of Approach and Landing (OPTIMAL)	Equipment: – ATM: RNAV routes, improved Arrival Manager and ATC tools – Cockpit: FMS ACDA Method of introduction: – Start at low density (night-time operations), build up experience. Training: – Pilots and ATC Acceptance: – Nominal profile has the highest acceptability of both pilots and air traffic controllers.
15	CDAs in London TMA	
16	Steeper Approaches	tbd
17	ACP Noise Assessments/Population Exposure Analysis	
18	Departures Code of Practice	
19	Higher Holding	

Appendix A

A SURVEY OF AIR CARRIER NOISE ABATEMENT DEPARTURE PROCEDURES (NADPs) — PRESENTED TO CAEP/7

Background

1. Modelling the aero-profiles resulting from specific departure procedures produces the data necessary to assess departure noise and engine emissions. Accurate modelling of an aircraft departure begins with the selection of take-off weight, take-off thrust, flap setting, temperature and airport elevation. In addition, management of the aircraft configuration and thrust during the initial climb must be specified. The initial climb is characterized by segments of constant speed climb, acceleration and flap retraction along with an initial thrust reduction from take-off power.

2. The sequence of the initial climb segments is prescribed by the air carrier and can vary, not only by carrier, but also by airport and aircraft type. Having no single source of reference for the details of operational departure procedures has presented problems for similar modelling efforts, and the procedures provided by a few air carriers, while valid, could not be considered as representative of the industry. Additionally, the airlines may modify their procedures based on changes in aircraft types and performance or the cost of fuel.

3. To create a detailed reference source for departure procedures, a questionnaire was developed and forwarded to an extensive list of air carriers in 2006. To encourage a response, the air carriers were given an overview of the work being conducted by both CAEP WG2 and SAE A-21 citing the importance that the modelling be representative of actual operations.

Survey results

4. The remainder of this Appendix shows the results of the questionnaire forwarded to the air carriers requesting detailed information regarding reduced take-off thrust application, take-off flap selection, and a detailed description of their respective departure procedures. The following carriers responded to the questionnaire:

American Airlines	United Air Lines	Delta Air Lines	US Airways
Northwest Airlines	KLM	All Nippon	Qantas
Lufthansa	UPS	British Airways	Japan Air Lines
Alitalia	ABX Air	DAS Air	LuxAir
Monarch	Air France	Continental Airlines	

5. The number of aircraft represented in the survey is approximately 3 850.

Air carrier survey results

TAKE-OFF THRUST SUMMARY

The vast majority of survey participants reported the use of reduced thrust take-offs, applying either de-rated thrust or assumed temperature methodology.

TAKE-OFF FLAP SUMMARY

The following reflects the most common reported take-off flap settings:

AIRCRAFT	FLAP SETTING
A300	15
A310	15 and 20
A319	CONF 1+F and CONF 2
A320	CONF 1+F and CONF 2
A321	CONF 1+F and CONF 2
A330	CONF 1+F and CONF 2
A340	CONF 1+F and CONF 2
B737	05 and 01 and 15
B747	10 and 20
B757	15 and 05
B767	05 and 15
B777	05 and 15 and 20
MD11	25 and 20
MD80	11
MD90	11
DC8	15 and 18
DC9	05 and 01
DC10	20
EMB14	09
F100	05 and 15

DEPARTURE PROCEDURE SUMMARY

Notes:

– Target climb speeds are given as V2 plus; no attempt was made to specify the actual target speed as it is accepted that the segment is flown to the manufacturer's specified safety speed.

– The initial power reduction is simply given as climb power although some reported the use of de-rated climb power.

– Some air carriers publish more than one departure procedure for each fleet type.

Aircraft: A319, A320, B737, B747, B757, B767, B777
Profile 1

- Take-off power and flaps climbing at V2 plus to 800 ft AFE
- At 800 ft, set climb power
- Constant speed climb to 1 500 ft AFE
- At 1 500 ft, reduce pitch, accelerate and retract flaps on schedule
- Constant speed climb to 3 000 ft AFE
- At 3 000 ft, accelerate to 250 kts
- Constant speed climb to 10 000 ft.

Aircraft: B737, MD90
Profile 2

- Take-off power and flaps climbing at V2 plus to 800 ft AFE
- At 800 ft, set climb power
- Constant speed climb to 2 500 ft AFE
- At 2 500 ft, accelerate to 250 kts while retracting flaps on schedule
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: A319, A320, B737, B747, B757, B767, B777
Profile 3

- Take-off power and flaps climbing at V2 plus to 800 ft AFE
- At 800 ft, reduce pitch, accelerate and retract flaps on schedule, following initial flap retraction (B747 Flap 5; B777 Flap 1), set climb thrust
- Constant speed climb to 3 000 ft AFE
- At 3 000 ft, accelerate to 250 kts
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: B747, B767, B777
Profile 4

- Take-off power and flaps climbing at V2 plus to 800 ft AFE
- At 800 ft, reduce pitch, set climb power, accelerate and retract flaps on schedule
- Constant speed climb to 3 000 ft AFE
- At 3 000 ft, accelerate to 250 kts
- Constant speed climb to 10 000 ft.

Aircraft: A300, A319, A320, A321, A330, B737, B747, B757, B767, B777, MD80, MD90
Profile 5

- Take-off power and flaps climbing at V2 plus to 1 000 ft AFE
- At 1 000 ft AFE, set climb power, reduce pitch, accelerate and retract flaps on schedule
- Constant speed climb to 2 500 ft AFE
- At 2 500 ft AFE, accelerate to 250 kts
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: MD80, B737, B757, B767, B777
Profile 6

- Take-off power and flaps climbing at V2 plus to 1 000 ft AFE
- At 1 000 ft, set climb power
- Constant speed climb at V2 plus to 2 500 ft AFE
- At 2 500 ft, reduce pitch, accelerate and retract flaps on schedule
- Accelerate to 250 kts
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: B757, B767, B777
Profile 7

- Take-off power and flaps climbing at V2 plus to 1 000 ft AFE
- At 1 000 ft, reduce pitch, accelerate and retract flaps on schedule
- Set climb thrust
- At 3 000 ft, accelerate to 250 kts
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: B737
Profile 8

- Take-off power and flaps climbing at V2 plus to 1 000 ft AFE
- At 1 000 ft, reduce pitch, accelerate and retract flaps on schedule
- At clean speed, set minimum power (1.2 per cent gradient)
- Constant speed climb to 2 500 ft AFE
- At 2 500 ft, accelerate to 250 kts
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: B737
Profile 9

- Take-off power and flaps climbing at V2 plus to 1 000 ft AFE
- At 1 000 ft, set minimum power (1.2 per cent gradient)
- Constant speed climb to 2 500 ft AFE
- At 2 500 ft, reduce pitch, accelerate to 250 kts while retracting flaps on schedule.

Aircraft: A320, A321, B747, B767, B777
Profile 10

- Take-off power and flaps climbing at V2 plus to 1 000 ft AFE
- At 1 000 ft, accelerate and retract flaps on schedule
- At 1 500 ft AFE, set climb power, accelerate to 250 kts
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: A300, A319, A320, A321, A330, A340, B767, B777, MD11, MD80
Profile 11

- Take-off power and flaps climbing at V2 plus to 1 500 ft AFE
- At 1 500 ft, set climb power, reduce pitch, accelerate to greater of clean speed or 250 kts while retracting flaps on schedule
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: A300, A319, A320, A321, A330, A340, B737, B747, B757, B767, B777, DC10, MD11, MD80, EMB145
Profile 12

- Take-off power and flaps climbing at V2 plus to 1 500 ft AFE
- At 1 500 ft, set climb power
- Constant speed climb to 3 000 ft AFE
- At 3 000 ft, accelerate to 250 kts while retracting flaps on schedule
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: B777
Profile 13

- Take-off power and flaps climbing at V2 plus to 1 500 ft AFE
- At 1 000 ft, set climb power
- Constant speed climb to 3 000 ft AFE
- At 3 000 ft, accelerate to 250 kts while retracting flaps on schedule
- Constant speed climb at 250 kts to 10 000 ft.

Aircraft: B777
Profile 14

- Take-off power and flaps climbing at V2 plus to 1 000 ft AFE
- At 1 000 ft, set climb power, reduce pitch, accelerate to greater of clean speed or 250 kts while retracting flaps on schedule
- Constant speed climb at 250 kts to 10 000 ft.

Appendix B

A SURVEY COLLECTED FROM PRINCIPAL CONTACTS FOR NAP R&D — EUROPE, THE UNITED STATES AND JAPAN — PRESENTED TO CAEP/7

Survey results for NAP research and development

To collect information on NAP R&D and implementation projects, a questionnaire was developed and distributed to aviation industry coordinators and contact persons. Information and survey results obtained from Europe, the United States and Japan are contained in this appendix.

Attachment 1

SUMMARY CONTINUOUS DESCENT ARRIVAL AT LOUISVILLE INT'L AIRPORT (SDF) UNDER THE PARTNERSHIP FOR AIR TRANSPORTATION NOISE AND EMISSIONS REDUCTION (PARTNER)

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Project name: Project 4: Continuous Descent Arrival at Louisville Int'l Airport (SDF) under the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER), a Federal Aviation Administration Center of Excellence (COE) for Aircraft Noise and Aviation Emissions Mitigation.

Sponsoring organization(s): Federal Aviation Administration

Scope and Objectives of the project: (e.g. improving understanding, developing new techniques, enhancing implementation of existing capabilities, harmonization, etc?)

Comprehensive R&D demonstrations for the near-term implementation of CDA in the United States. Initial CDA (approval and) launch planned at SDF by Fall 2006. Other demonstration planning ongoing at LAX and ATL.

Summary description of project:
(Include i) Driver, if not noise/emissions, ii) Arrival or Departure Procedure)

Environmental mitigation of noise and emissions and fuel savings using Continuous Descent Arrival (CDA) procedures.

Project time frame, duration:

PARTNER Project since 2001 to present. Strategically, proposed for 2011, when COE becomes an independent entity.

Level of maturity and expected time frame/lifespan for implementation of procedure/solution:

Basic CDA is available for operators/users to pursue airport-specific design tailoring in order to demonstrate and file an FAA application for new procedure approval.

Order of magnitude of expected benefits (give scale of applicability — State, region, global):

Noise:	@ 7.5-15 nm: up to 6 dB noise reduction
	Lower per aircraft noise levels
	Impact concentrated in narrow corridors
Emissions:	CO below 3 000 ft reduced by 12.7 per cent (B-767) and 20.1 per cent (B-757)
	HC below 3 000 ft reduced by 11.0 per cent (B-767) and 25.1 per cent (B-757)
	NO_X below 3 000 ft reduced by 34.3 per cent (B-767) and 34.4 per cent (B-757)
Fuel burn:	@ SDF: (B767) 350 lbs/flt saved; (B757) 100 lbs/flt saved

Other (e.g. alternative mitigation cost reduction, constraint alleviation etc.): N/A

Disbenefits or other considerations:
(Capacity, etc.)

Demonstrated for night-time low traffic operations at Louisville airport for two aircraft types within UPS fleet.

Prerequisites:

Technical equipment (aircraft, airport, air-ground communication):
Low traffic condition airport, aircraft with FMS, operator to work voluntarily with PARTNER/FAA design team.
Method of introduction in existing fleet and airport operations:
Applicable as "Special" procedures with FAA.
Cost (development cost and/or total for implementation):
Interested operator shares cost with FAA.
Training (air traffic controllers, pilots):
Pilots and ATC.
Acceptance (air traffic controllers, pilots):
Must be demonstrated within the region locally.
Safety/risk assessment:
No risks encountered during demos.
Other:
N/A

How will the outcome be used or implemented (e.g., formal Agencies involved or specific regulatory implications):

CDA airport projects are being planned in collaboration with the FAA and the PARTNER COE-CDA Design Team.

Example of implementation:

PARTNER team collaboratively designed and demonstrated CDA and filed for "Special" procedure with FAA approval to utilize CDA at Louisville (SDF) airport. Anticipate FAA approval by Fall FY 2006.

Formal references:

J.-P. B. Clarke, N. T. Ho, L. Ren, J. A. Brown, K. R. Elmer, K.-O. Tong, and J. K. Wat, "Continuous Descent Arrival: Design and Flight Test for Louisville International Airport," AIAA Journal of Aircraft, Vol. 41, No. 5, pp. 1054-1066, September-October 2004.

J.-P. Clarke, D. Bennett, K. Elmer, J. Firth, R. Hilb, N. Ho, S. Johnson, S. Lau, L. Ren, D.Senechal, N. Sizov, R. Slattery, K.-O. Tong, J. Walton, A. Willgruber, and D. Williams, "Development, design, and flight test evaluation of a continuous descent arrival procedure for night-time operation at Louisville International Airport," PARTNER Center of Excellence Report PARTNER-COE-2006-002, 9 January 2006.

PARTNER website: http://web.mit.edu/aeroastro/www/partner/projects/proj4.htm

Attachment 2

ADVANCED ARRIVAL TECHNIQUES AT SCHIPHOL AMSTERDAM AIRPORT

Project name: Advanced Arrival Techniques at Schiphol Amsterdam Airport

Sponsoring organization(s): LVNL (Dutch Air Traffic Control), Boeing BCA, Boeing Phantom works

Scope and Objective of the research: Demonstrate capabilities of modern aeroplanes. The Advanced Arrival Techniques, as studied in the Advanced Arrival and Departure Techniques (AADT) project, focuses on the improvement of predictability in traffic behaviour during arrival for both pilots and controllers, by using aircraft-derived information from the flight deck in the ground ATM system. The predictability improvement is essential to allow continuous descent arrivals to be flown in peak hours. Today, continuous descent approaches can be flown by single flights accurately and efficiently, resulting in a significant reduction in noise and engine exhaust emissions, as well as fuel burn savings. As the number of continuously descending flights towards a landing runway increases, however, the Air Traffic Controller's job becomes increasingly more difficult because altitude separation is no longer available to ensure a safe, orderly and expeditious flow of traffic. In the current operation this problem is overcome by introducing a higher landing (time) interval between aircraft to account for the poor controller predictability of the aircraft flight path and speed. This in turn results in reduced airport capacity that forces CDA operations to be flown during night-time only. However, predictability for controllers can be significantly improved when using information available on board of the aircraft.

Summary description of project:
(Include: i) Driver, if not noise/emissions, ii) Approach or Departure Procedure)

Investigate ability of local Air Traffic Systems to communicate and predict aeroplane positioning.

The trial objectives that have been defined in preparation of the trial are defined and agreed. The trial objective is to:

Conduct an in-service operational trial repeatable Top Of Descent (TOD) Continuous Descent Arrival (CDA) procedure to support the following analyses in order to provide recommendations for strategy development:

- Assessment of use of aircraft-derived data to improve the predictability of the ATM system;
- Assessment of airlines' satisfaction with procedure and operating cost impact;
- Assessment of crew satisfaction with procedure and workload impact;
- Assessment of controllers' satisfaction with procedure workload; and
- Assessment of the environmental impact (fuel burn, noise and emissions).

Level of maturity or expected time frame for completion: April 2006 completed

Order of magnitude of expected benefits:

Noise:	6 to 12 dBA
Emissions:	Currently under study – Unknown
Fuel savings:	50-1 000 lbm of fuel

Disbenefits or other considerations:

Capacity impact:

The flight paths require precise flying through the Flight Management Computer (FMC) calculated routing. If the airplane crew is offered a different routing by ATC after the top of descent, the integrity of the CDA could be compromised because the FMC would be constrained to calculate a new optimal flight path. The pilot would take over at that point and could require changing speeds, adding engine power, or levelling off at lower altitudes. All these factors increase noise and fuel burn. Predicting airplane position and time is an absolute criterion for CDAs to be able to operate at times of high traffic volume. Using absolute standard arrival routes from top of descent is a critical element in pursuing CDAs for high traffic situations.

Prerequisites:

Technical equipment (aircraft and airport):
737NG, MD-11 aircraft participated in trial. Amsterdam Schiphol airport ATC

Method of introduction in existing fleet:

Cost:

Acceptance (controllers, pilots): Good

In the low-density, night environment, the modified procedures were successful in that they did not increase controller workload and they permitted aircraft to descend optimally. Further success was realized in the way that the new procedures were introduced to the controllers and to the pilots at minimum cost.

Safety/Risk assessment: Low risk

Example of implementation:

Formal references:

Research Report Advanced Arrival Techniques – Using aircraft capabilities to improve arrivals. D/R&D/005/026 version 1.0 dated 19 January 2006.

In-service Demonstration Test Plan Advanced Arrival Techniques. Version 0.4 dated 23 September 2005.

Attachment 3

LOUISVILLE (SDF) CONTINUOUS DESCENT ARRIVAL

Project name: SDF (Louisville) Continuous Descent Arrival

Sponsoring organization(s): Boeing, MIT, FAA, UPS, NASA, SDF (Noise Abatement Procedure Working Group)

Scope and Objective of the research: The primary objective of the design work was to come up with operational FMS-based CDA procedures for opposite facing runways, 17R and 35L, that begin at cruise altitude, may be used in daily operation, and did not have FMS issues identified in previous (2002) flight tests. The purpose of conducting the demonstration flight test was to validate new design tools, demonstrate the robustness and consistency of the procedure, affirm the acceptability from both pilots and controllers, and to further validate noise, emissions, fuel burn and time savings that previous analysis and testing have shown.

Summary description of project:
(Include: i) Driver, if not noise/emissions; ii) Approach or Departure Procedure):

The demonstration was conducted with the last 12 westerly arrivals between 1 to 2 AM local time. The flight tests were successfully completed with 125 aircraft participating over ten nights. 123 aircraft performed as (or close to) expected. Two aircraft were vectored (due to lower initial separation) and one aircraft unable to participate. Noise data were collected on nine of the ten nights; a late switch in direction of operation prevented the noise measurement team moving to the other side of the airport. Louisville TRACON successfully mixed CDA and non-CDA aircraft on one night. The noise measurements were generally of high quality and matched predicted levels made with the flight data that were collected. Five weeks worth of flight data were collected and used to make noise predictions for the CDA test flights and flights during the following three weeks.

Level of maturity or expected time frame for completion:

UPS is in the process of applying for special RNAV procedure for late night operations.

Order of magnitude of expected benefits:

Noise: Reduced noise contour area by up to 33 per cent.
Emissions: NO_X, CO, and HC emissions were also reduced by up to 35 per cent.
Fuel burn: Flight time savings of a few minutes and fuel savings of 100 to 300 lbs were realized.

Disbenefits or other considerations:
(capacity, etc.)

Capacity was not adversely affected, due to late night/single carrier, low cross traffic operations.

Prerequisites:

Technical equipment (aircraft and airport): 757 and 767 aircraft arriving at SDF.

Method of introduction in existing fleet:

UPS will modify RNAVs which will be more efficient for implementation for the same 12 westerly arrival flights at night. ADS-B may be used to improve initial separation requirement.

Cost:

Acceptance (controllers, pilots):

Pilot acceptance of procedure was overwhelmingly positive while the controllers saw no issues.

Safety/Risk assessment:

Example of implementation:

UPS has implemented this method for night-time arrival at Sacramento Mather airport (one to two flights per night).

Formal references:

"Development, Design, and Flight Test Evaluation of a Continuous Descent Approach Procedure for Night-time Operation at Louisville International Airport," FAA COE PARTNER CDA Development Team, 2005.

Attachment 4

SAN FRANCISCO (SFO) OCEANIC TAILORED ARRIVAL TRIAL

Project name: SFO Oceanic Tailored Arrival Trial

Sponsoring organization(s): NASA-Ames and Boeing

Scope and Objective of the research:

Phase 1. Basic Oceanic Tailored Arrival (OTA):

- Basic OTA is equivalent to a "Continuous Descent Approach" (CDA).
- Assess noise impact, fuel burn, and pilot and controller workload.
- If successful, basic OTA may become standard Bay Area approach procedure.

Phase 2. OTA with speed schedule:

- Basic OTA, with cruise and descent speeds modified by En-Route Descent Advisor (EDA).
- Assess ability to predictably modify an aircraft's trajectory using a clearance suggested by an advanced air traffic control tool.
- First step towards more efficient ATC operations.

Phase 3. OTA with "Required Time of Arrival" (RTA):

- Basic OTA, with aircraft assigned an arrival time at a low altitude waypoint.
- Assess effectiveness of aircraft adjusting speed to arrive at scheduled time.
- Aircraft technology may be useful for air-ground schedule coordination.

Summary description of project:
(Include: i) Driver, if not noise/emissions, ii) Approach or Departure Procedure)

There are a number of key components of the Tailored Arrivals end state system. They are:

1. Continuous Descent Approach Procedures — Fuel efficient, reduced noise flight profiles adaptable to a specific airspace.

2. ATC Flow Management Tool (NASA's Traffic Management Advisor, TMA) — Controls flows and sequencing into the terminal area to maximize throughput during high-density operations. The flow management tool specifies Required-Time-of-Arrival (RTA) for each aircraft at specified points (e.g., a meter fix) and specifies the necessary delay for each aircraft to reach the desired RTA.

3. ATC Descent Tool (NASA's EDA) — Derives precise, conflict-free "tailored" 4D trajectory for each aircraft to meet its RTA with the best possible descent profile for the aircraft.

4. CPDLC — Controller to Pilot Data Link to: (a) provide an efficient mechanism for uplinking complex trajectory data to the flight deck; (b) provide a mechanism for downlinking critical aircraft parameters to maximize accuracy of the TMA/EDA aircraft trajectory model; and (c) provide an efficient mechanism for uplinking critical data (e.g., up-to-date wind data) to support optimal precision in aircraft compliance with the desired 4D trajectory.

5. FMS — Aircraft automation to accurately guide the aircraft along the desired 4D trajectory.

Level of maturity or expected time frame for completion:

Phase 1 trial period is June – December 2006.

Order of magnitude of expected benefits:

Noise: 3 – 6 dB.
Emissions: Reduction due to reduced flight time.
Fuel burn: A few hundred pounds/flight.

Disbenefits or other considerations:
(Capacity, etc.)

The trial will be conducted during low-density operations.

Prerequisites:

Technical equipment (aircraft and airport); FANS-equipped aircraft (777, 747, and MD11) at SFO and OAK:

Method of introduction in existing fleet:
Cost:
Acceptance (controllers, pilots): Oakland Center, TRACON, United, and possibly Fedex are participating
Safety/Risk assessment:

Example of implementation:

Formal references:

Attachment 5

SANTA ANA (SNA)/LONG BEACH (LGB) TAILORED ARRIVALS

Project name: SNA/LGB Tailored Arrivals

Sponsoring organization(s): Boeing

Scope and Objective of the research: The purpose of this task is to work with airport operators and authorities to design and conduct an in-service flight demonstration of a tailored arrival/continuous descent arrival procedure for John Wayne and Long Beach airports.

Summary description of project:
(Include: i) Driver, if not noise/emissions, ii) Approach or Departure Procedure)

The goals for these procedures are to improve operational efficiency, save fuel, and reduce environmental impacts such as noise and emissions. The unique features of this particular project are to develop and test low-density daytime arrival procedures by flight demonstrations. These two airports have night-time curfews and have common initial arrival fixes. Identify problem areas and required ground tools necessary for future implementation in the complex blend of commercial, regional and general aviation traffic that exists in Southern California.

Level of maturity or expected time frame for completion:

Perform demonstrations on carrier revenue flights in 2006 and 2007.

Order of magnitude of expected benefits:

Noise: 3 – 6 dB
Emissions: Reduction due to reduced flight time
Fuel burn: A few hundred pounds/flight

Disbenefits or other considerations:
(capacity, etc.)

Capacity is not addressed in this demonstration**.**

Prerequisites:

Technical equipment (aircraft and airport); 737, 737NG, A320, 757, 767 arriving at SNA, LGB.

Method of introduction in existing fleet:
Cost:
Acceptance (controllers, pilots);
Safety/Risk assessment:

Example of implementation:

Formal references:

Attachment 6

SOURDINE II PROJECT

Contact details:
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Project name: SOURDINE-II Study on the optimization of procedures for decreasing the impact of noise II

Sponsoring organization(s): The Sourdine II consortium included Airbus France, Eurocontrol Experimental Centre, AENA, INECO, Isdefe, SICTA and NLR (Coordinator). The project was part of the European 5th framework programme, financed 50 per cent by DG-TREN.

The consortium was supported by an expert panel (not funded), which provided feedback during procedure definition and at intermediate phases of the assessments.

Scope and Objectives of the project: (e.g., improving understanding, developing new techniques, enhancing implementation of existing capabilities, harmonization, etc.?)

The Sourdine II project is the follow-up project of the 4th Framework Programme Sourdine. Sourdine provided an inventory of noise abatement procedures and associated noise reduction potential. It also identified operational and technical bottlenecks with regard to implementation, such as constraints of the current ATM system, current operating procedures and hands-on experience of experts as well as lack of enabling technology in this field.

The objectives of Sourdine II were set at the development of new procedures and supporting technology:

– Development of new advanced and innovative environmental friendly approach and departure procedures, based on the results from the Sourdine I project.

– An accepted implementation plan by all involved stakeholders to be able to migrate from the current situation to advanced environmentally friendly approach and departure procedures. This avoids the need to develop specific local solutions to a European problem.

– Development of enabling technology to achieve the successful introduction of the selected departure and approach procedures, such as ATC controller tools and cockpit monitoring tools.

– Achievements consist of quantified results for each procedure in terms of safety, capacity and environmental benefits, as well as associated costs or benefits. Objective evaluation of these issues is performed by comparing controller and pilot workloads during baseline scenarios, i.e. current day, with future procedures.

Summary description of project:
(Include: i) Driver, if not noise/emissions, ii) Arrival or Departure Procedure)

Five arrival procedures have been evaluated in the project:

– Procedure I: baseline stepped approach
– Procedure II: CDA with fixed 2-degree descent
– Procedure III: CDA combining a fixed 2-degree CDA descent with an increased (4 degree) final glide slope

– Procedures IV and V: CDA featuring steep constant speed segment at respective intermediate and landing configuration.

Three departure procedures were evaluated:

– Procedure I: Baseline ICAO A
– Procedure II: Optimized close-in procedure
– Procedure III: Optimized distant procedure

The Sourdine II terms of reference focused on procedures for medium- and long-term implementation. The conclusions of the initial Sourdine project clearly indicated that the introduction of new noise-friendly operating procedures can only be successful provided the current airport capacity and safety levels are not negatively affected. Therefore, the objectives of Sourdine II have been set at a broad assessment of newly developed procedures and supporting technology, with respect to noise, safety, capacity, user acceptance (both pilot and air traffic controller), emissions and cost benefit.

Project time frame, duration:

Project time frame: 2001 to 2005; duration 45 months.

Level of maturity and expected time frame/lifespan for implementation of procedure/solution:

The project has shown that the Sourdine II departure procedures are found to be currently implementable, while the arrivals should follow a stepped implementation. It is expected that procedure II can be implemented in large airports (in low traffic density situations), procedure V in medium airports and procedure III in small airports. Procedure IV should be further assessed for maintenance evaluation, feasibility and acceptance by the users. The implementation has been divided into three main steps characterized by defining an iterative improvement cycle:

1. The stepped approach begins with the current situation by taking full advantage of existing technology.

2. The less intrusive procedures can be implemented in the short term in a busy traffic ATM system.

3. The more intrusive procedures can be implemented in the short term in low-density traffic.

It is recommended to perform flight trials to get detailed feedback on aircraft performance as well as pilot and controller acceptability from hands-on experience. Results from these flight trials can support additional assessments as performed in this project to reach the ultimate goal: continuous descent approaches during peak-hour operations at major European airports while maintaining or even improving capacity and safety.

Order of magnitude of expected benefits:

Noise benefits have been assessed for the different procedures on airport scale for Paris CDG, Madrid Barajas, Amsterdam and Naples airports. Noise results were obtained in terms of 55, 60 and 65 Ldn contours. Comparisons between the baseline approach and different CDA procedures indicated contour reductions of up to 8 per cent (55 Ldn) for Procedure II and up to 36 per cent (60 Ldn) for Procedure III. During the assessment it was concluded that the baseline procedure selected for all airports was in fact significantly less noise than actual procedures at the different airports.

For departures, the optimized Close-in procedure provided a 23 per cent (maximum) reduction of the 65 Ldn contour compared to the ICAO A baseline whereas the Distant procedure resulted in 55 Ldn contour reductions of up to 42 per cent compared to baseline.

Preliminary emissions predictions were performed, be it at a limited scale, and can be found in the reference indicated below.

Disbenefits or other considerations:
(Capacity, etc.)
Capacity reduction; according to fast time results:

ARRIVAL CAPACITY					
Airport	Baseline	NAP II	NAP III	NAP IV	NAP V
Madrid	78-80	70-72	70-72	68-70	72-74
Paris-CDG	81-83	80-82	80-82	X	80-81
Amsterdam	72-74	69-71	X	59-61	66-68
Naples	31-33	30-32	X	28-30	30-32

In real-time simulations, controllers stated that this procedure could be used in real operation with an expected capacity of 30-32 arrivals per runway per hour, compared with today's peak-hour capacity of 33-36. This number could be increased once controllers get more hands-on experience concerning the "new" speed profiles and aircraft performance.
Departures: no disbenefits expected.

Prerequisites:

Technical equipment (aircraft, airport, air-ground communication):
ATM: RNAV routes, arrival manager and ghosting tool for the merging of traffic.
Cockpit: indication of configuration change points on navigation display, FMS/Engine control adaptation for NADP thrust management.

Method of introduction in existing fleet and airport operations:
Start at low density (night-time operations), build up experience.

Cost (development cost and/or total for implementation):
–

Training (air traffic controllers, pilots):
Pilots and ATC.

Acceptance (air traffic controllers, pilots):
Procedure II has the highest acceptability of both pilots and air traffic controllers.

Safety/Risk assessment:
An initial high-level safety evaluation identified some safety issues for the four approach procedures for which solutions are required. Possible speed excess situations were identified for the CDA procedures II and III. Concerning procedure III, the increased final glide slope is a non-standard operation and potentially leads to higher workload and in combination with CDA could have an accrued risk of speed excess. This operation requires special analysis in relation to acceptance and to obstacle clearance surfaces. Concerning procedures IV and V, the steep intermediate approach segment and glide slope interception from above were identified as safety issues (potential consequences of a glide slope undershoot and an unstabilized approach). Potential flight path control problems, which could lead to an increased workload and an unstabilized approach in case the path is too shallow, were also identified. With regard to the two departure procedures, speed control problems at low power setting at OEI climb thrust were identified.

Other:
N/A

How will the outcome be used or implemented (e.g. formal Agencies involved or specific regulatory implications)

Project results are widely communicated with airports, airlines and ANSPs and serve as a basis for procedures in European research projects like AWIATOR, SILENCER and OPTIMAL.

Example of implementation:

Formal references:

http://www.sourdine.org

Attachment 7

SUMMARY OF NOISE ABATEMENT OPERATING PROCEDURE IN JAPAN

Project name: Fundamental research on aircraft performance relevant to noise abatement departure procedures

Sponsoring organization(s): Japan Civil Aviation Bureau

Scope and Objective of the research: Define the difference with regard to noise and emission between NADPs in PANS-OPS and the noise abatement departure procedure mainly adopted in Japan, i.e. steepest climb.

Summary description of project:
(Include: i) Driver, if not noise/emissions, ii) Approach or Departure Procedure)

Steepest climb departure procedure is one of the variations of NADP-1 and is most effective to confine the noise impact within the small area around the airport. NADP-2 has a distant crossover point to become quieter than NADP-1 or steepest climb and is most effective to bring down fuel consumption.

Level of maturity or expected time frame for completion:

The research was completed.

Order of magnitude of expected benefits:

Noise: Difference of 2-9 dB was calculated between NADP-1,-2 and steepest climb at 6 km from brake release point depending on aircraft type.

Emissions: Difference of 90-630 kg (CO_2) per take-off was calculated between NADP-1,-2 and steepest climb depending on aircraft type.

Fuel burn: Difference of 60-440 lbs per take-off was calculated between NADP-1,-2 and steepest climb depending on aircraft type.

Disbenefits or other considerations:
(capacity, etc.)

In case of introducing NADP-2, noise affected area where noise counter measures are to be undertaken is possibly spread out.

In case of introducing NADP-2, many types of aircraft exceed the speed restriction of 200 kts in the airspace below 3 000 ft in the control zone as regulated in civil aeronautical law in Japan.

Prerequisites:

Technical equipment (aircraft and airport):
Performance and noise data of A320-200 calculated by ANA using Airbus tool, and data of B737-700, B747-400, B767-300, B777-200 and B777-300ER calculated by Boeing.

Method of introduction in existing fleet:
N/A

Cost:
N/A
Acceptance {controllers, pilots}:
N/A
Safety/Risk assessment:
N/A

Example of implementation:

N/A

Formal references:

AIP/JAPAN, as for steepest climb procedure.

Appendix C

A SURVEY COLLECTED FROM PRINCIPAL CONTACTS FOR NAP R&D — PRESENTED TO CAEP/8

Survey results for NAP Research and Development

To collect information on NAP R&D and implementation projects, a questionnaire was developed and distributed to aviation industry coordinators and contact persons. Information and survey results obtained are contained in this appendix.

Attachment 1

ADVANCED MITIGATION TECHNIQUES PROJECT

a) Name of project:

Advanced Mitigation Techniques (AMT)

b) Project lead:

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c) Sponsoring organization:

EUROCONTROL

d) Participating organizations:

Suppliers (TBD)
EUROCONTROL Stakeholders via working arrangements
Other organizations (TBD) EASA?, ICAO?

e) Scope and objectives:

Scope:
Impacts: Noise, local air quality, climate change
Operations: Initially — aircraft operations at and around airports (Terminal areas)
Geographic: For applicability in EUROCONTROL States (ECAC)

Objectives:
To fulfil (at least in part) SESAR IP1 requirement to *maximize the recognition and the use made of the environmental capabilities of Service Level 0 and 1 developments, while also developing specific environmental techniques, procedures and capabilities* (SESAR D5, page 52). The initiative will:

- reduce noise, fuel use and emissions at and around ECAC airports;
- optimize and harmonize present (and emerging) ATM capabilities for environmental mitigation purposes;
- foster best practice in environmental mitigation by providing guidance and practical resources to enable widespread harmonized deployment;
- avoid or limit duplication of effort, poor practice, abortive effort, and the proliferation of local rules, whilst maintaining local flexibility;
- seek to minimize the risk of adverse trade-offs.

f) Project summary/description:

To review established (underutilized), recent and emerging ATM[1] operational capabilities that will be delivered by end 2013 (or shortly after) including those of EUROCONTROL, ANSP, users, FAA et al. Identifying those with the potential for environmental mitigation and the extent to which environment is embedded/optimized/promulgated in the initiative.

To review operational stakeholder environmental practice and needs in terms of harmonization and potential mitigation techniques (or potential improvements on existing mitigation techniques), etc.

To review rapid deployment opportunities from existing research activities (e.g. inter alia, NUPII, ERAT, CAATSII, SOURDINE, ASPIRE). Identifying those potentials where development progress is underway in the 2013 (approximate) time frame — and how these will be exploited/delivered in ECAC in a harmonized way.

From the above, to identify those areas with greatest potential for rapid deployment where EUROCONTROL can take a leading role. This may include new related work, supporting existing initiatives to optimize their environmental performance, or combining operational techniques in new ways to meet environmental needs.

Subject to the business case (impact assessment), to progress those that:

– lie within EUROCONTROL's competence;
– require acceleration or improvement;
– offer the most worthwhile mitigation benefits.

The main products will be guidance material, practical resources (training, simple assessment tools, checklists, case studies, etc.), and marketing materials. Where appropriate, provision of limited expertise may be provided to help to establish and progress implementation.

Potential topics for consideration include, inter alia:

– more advanced methods of facilitating CDA (e.g. controller tools, point merge);
– continuous climb departures;
– navigational procedures and accuracy developments (e.g. SID/STAR design and noise route adherence acceptability parameters);
– noise dispersion and concentration techniques;
– ground noise and emissions (e.g. APU management, A-CDM);
– flow management;
– controller tools;
– curved and steeper approaches (pending ICAO activities);
– others to be determined.

Note.— The intention is not necessarily to develop new mitigation techniques, nor is it desirable to duplicate the development of operational improvements. The approach will be to ensure that existing work being undertaken for operational purposes is fully exploited for environmental purposes (in a harmonized way) and that inherent mitigation capability is taken into account by operational initiatives. The guidance (etc.) may therefore be developed separately as environmental materials or as an integral part of an operational initiative with mitigation potential. This may be as simple as accounting for (and publishing) the environmental benefit delivered naturally by operational improvements and capabilities (e.g. CDM).

1. ATM in this context could include any direct influence on aircraft operations (e.g. ground-based or airborne equipment, controller tools, techniques and procedures, infrastructure design, navigation standards).

g) Time frame:

Supplier (possibly consortium) appointed 2009
Review phase completed mid-2010
Scope agreed with stakeholders mid-2010
First deliverables from end 2010.

h) Estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

It is not certain which capabilities will be exploited and so it is too early to be precise about expected benefits. It will also be important not to double-account for benefits from the existing initiatives. However benefits could include:

– much tighter accuracy when following preferred noise route, reducing the number of people affected but increasing the noise impact on those overflown;
– most of the noise benefit will arise further out from most airports than the noise contours — that does not mean that this is unimportant;
– CDA could be extended to start at higher levels and to allow procedural CDA in busier periods perhaps 20-50 KGs per flight over present CDA goals (50 M Euro per annum in fuel);
– significant economies of scale in adoption of best practice.

The main benefit will be to allow any airport or terminal area to adopt the very best environmental practice, with minimal development cost, in confidence, and in a harmonized way.

The guidance is intended to cover a range of impacts, and advice on trade-offs will be given alongside each. However the relative significance of air quality, noise and climate change is a matter for local decisions. The project will therefore provide a framework for making these decisions correctly but will not impose choices.

i) Implementation prerequisites:

ECAC: Most (all?) aircraft operational mitigation techniques require Collaborative Environmental Management (SESAR IP1 requirement). Guidance on this has been recently published by EUROCONTROL and will be followed by supporting resources. An ECAC-wide roll-out programme is already underway.

Similarly the development of a web-based “one-stop-shop” for accessing such guidance (and much more) and enabling stakeholder communications will be developed by EUROCONTROL in parallel. A prototype “SOPHOS” exists and has been beta tested. EUROCONTROL is also developing an environmental information/data portal and various assessment tools and methods (in the international framework for some). These will be fundamental to local optioneering/decision making.

Local: The intention will be to develop mitigation techniques and resources that can be implemented now without additional prerequisites (other than to fill gaps in local knowledge, skills or resources).

j) Implementation experience:

The initial CDA project, which will deliver CDA to 100 ECAC airports by the end of 2013, was developed and progressed by the same team.

k) Formal references:

ECAC harmonization and SESAR IP1 requirements are within EUROCONTROL competence.

Attachment 2

CONTINUOUS DESCENT APPROACH (CDA) IMPLEMENTATION AT GERMAN AIRPORTS

a) Name of project:

Continuous Descent Approach (CDA) Implementation

b) Project lead:

Mr. Andre Biestmann, DFS HQ, Tel: 0049 6103 707 1040,
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c) Sponsoring organization:

DFS

d) Participating organizations:

e) Scope and objectives:

Implement CDA at German airports

f) Project summary/description:

CDA will reduce noise, fuel burn and emissions by keeping aircraft at higher altitudes with continuous descent profiles (avoiding frequent levelling-off).

g) Time frame: From February 2009 ongoing.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

Not quantifiable yet.

i) Implementation prerequisites:

No additional ground or airborne equipment needed, only training and publications, and charting.

j) Implementation experience:

Some trials with positive results have already been undertaken.

k) Formal references:

Attachment 3

NOISE ABATEMENT PROCEDURES FOR STOCKHOLM-ARLANDA AIRPORT

a) Name of project:

Noise Abatement Procedures for Stockholm-Arlanda Airport

b) Contact details:

Berit Gustavsson (LFV) berit.gustavsson@lfv.se +46 11 19 20 77

c) Participating organizations:

SAS, Falcon Air, Blue1

d) Scope and objectives:

Implementation of CDA to Stockholm-Arlanda, adjustments of SIDs to avoid noise-sensitive areas, trials with curved approach to avoid noise-sensitive areas.

e) Summary description of project:

From March 2006 until May 2008 there were three test periods using P-RNAV STARs with SAS, Falcon Air and Blue 1: SAS with all their aircraft types, Falcon Air AB with B737-300 and Blue 1 with RJ85, RJ100 and MD90. The P-RNAV STARs were developed and from 8 May 2008 the revised P-RNAV STARS can be used by all airlines which are capable of using P-RNAV procedures.

SIDs were adjusted in May 2006.

Five successful curved approaches took place the autumn 2005 with SAS B737.

f) Time frame: 2004-2007

g) Actual/estimated benefits and trade-offs: Reduction of noise

h) Implementation prerequisites:

In general

- Permission from the county administrative board
- Safety assessment

CDA

- P-RNAV equipment in aircraft (procedural-based CDA)
- RNAV procedures (procedural-based CDA)
- Build up experience by starting in low traffic density. Increase the amount at a pace suitable for ATC.
- Pilots and ATC education and information.

i) Implementation experience:

Cooperation between airlines, ATC, airport, procedure designer, environmental experts, safety engineers has been a success factor.

k) Formal references:

www.lfv.se

Attachment 4

RAMP/GREEN FLIGHTS/GREEN APPROACHES (RAMP = REGIONAL ADVANCED ATM MIGRATION PROGRAMME)

a) Name of project:

RAMP/Green Flights/Green Approaches (RAMP = Regional Advanced ATM Migration Programme)

b) Contact details:

Berit Gustavsson (LFV) berit.gustavsson@lfv.se +46 11 19 20 77

c) Participating organizations:

SAS, Norwegian, Malmö Aviation, City Airline

d) Scope and objectives:

One charge of this project is to introduce procedures and systems necessary to implement or increase the number of Continuous Descent Approaches (CDA) and Green Approaches* to the Swedish airports Arlanda, Landvetter, Malmö and Umeå. Another charge is to introduce a “curved approach” (RNP AR-procedure) to Stockholm-Arlanda to avoid the urban area of Upplands Väsby. The purpose is to reduce noise and emissions.

*A Green Approach is defined as a CDA from Top of Descent.

e) Summary description of project:

Stockholm-Arlanda Airport
Implementation of radar vectored CDA and a RNP AR-procedure.

– To Arlanda, radar-based CDA was implemented on a regular basis 31 July 2008, as a complement to procedural-based CDA, to be used when the traffic density is too high to use P-RNAV STARs. From July to December 2008 the CDA success rate was 48 per cent (those following P-RNAV STARs included). In numbers there were 49 369 CDAs in total during 2008. For noise monitoring purposes, an arrival is classified as a CDA if it contains a maximum one phase of level flight, not longer than 2 NM, below an altitude of 5 000 ft.

– To avoid flying over the urban area of Upplands Väsby, which will be forbidden from 2018, LFV has developed an RNP AR-procedure with three turns (RF-legs). An application has been sent to the Swedish SCAA to get permission for a trial period of six months with SAS and Norwegian starting in August 2009.

– Follow-up of Green Approaches (P-RNAV STARs implemented by project “Noise Abatement Procedures for Stockholm-Arlanda Airport”). From September 2008 to February 2009, there were 54 green approaches every day on average, which corresponds to 21 per cent.

There is a problem with aircraft not following the altitude restrictions. So far the altitude restrictions are not being used to keep separation from other aircraft but the problem has to be solved before P-RNAV STARs can be used in high-traffic density.

Göteborg-Landvetter Airport

In January 2009 Göteborg-Landvetter Airport introduced a new SID/STAR system based on P-RNAV. The P-RNAV STARs are designed to facilitate CDA.

The regular use of radar-based CDA was published in the AIP in November 2008.

Umeå Airport

The regular use of radar-based CDA was published in the AIP in December 2008.
P-RNAV STARs with CDA vertical profile are planned to take effect in November 2009. The navigation will be based on GNSS.
A RNP AR-procedure is going to be designed and is planned to take effect in the AIP in 2010 (on condition that the RNP AR procedure to Arlanda airport has been approved).

Malmö Airport

The regular use of radar-based CDA is planned to be published in the AIP in November 2009.
P-RNAV STARs with CDA vertical profile will not be designed into Malmö Airport as planned. There is no need for this at the moment.

Green approaches in high traffic volumes

To be able to do green approaches in high traffic volumes to Arlanda and Landvetter there is a need for an advanced Arrival Manager (AMAN). Within the project Green Approaches a study has been done which points out what information an AMAN at the least needs to take into account when predicting the most appropriate and stable traffic sequence of arrivals to enter the TMA. The steering group (RAMP) is about to take a decision about how to go on with an AMAN.

f) Time frame: 2007-2011. (New activities can be decided to be included in this project.)

g) Actual/estimated benefits and trade-offs:

Reduction of noise and emissions. Reduction of fuel. To Arlanda the fuel reduction for B737 following P-RNAV STAR is 56 kg on average.

h) Implementation prerequisites:

In general

Safety assessment
Build up experience by starting in low traffic density. Increase the amount at a pace suitable for ATC.
Pilots and ATC education and information.

P-RNAV STAR

1. P-RNAV equipment in aircraft
2. RNAV procedures
3. Advanced AMAN for high-traffic density

RNP AR

RNP AR procedure design manual

4. RNP AR approved airlines (for every specific procedure)

i) Implementation experience:

Cooperation between airlines, ATC, airport, procedure designer, environmental experts, safety engineers has been a success factor.

To give information to all involved (even outside the project) is a challenge. Information is very important but sometimes hard to live up to.

j) Formal references:

www.lfv.se

Attachment 5

OPTIMIZING AIRCRAFT SEQUENCING AND SPACING IN THE TERMINAL AREA AIRSPACE TO INCREASE AIRPORT CAPACITY, REDUCE FUEL BURN AND EMISSIONS, AND REDUCE NOISE ON DEVELOPED TERMINAL PATHS

a) Name of project:

Optimizing Aircraft Sequencing and Spacing in the Terminal Area Airspace to Increase Airport Capacity, Reduce Fuel Burn and Emissions, and Reduce Noise on Developed Terminal Paths

b) Project lead:

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c) Sponsoring organization:

U.S. Joint Planning and Development Office, NextGen Institute.

d) Participating organizations:

FedEx
United States Air Force
NAVCanada

e) Scope and objectives:

The project is to plan, develop and test a prototype procedure using the emerging technologies of the Ground Based Augmentation System (GBAS) Terminal Area Path (TAP) Procedures, real-time two-way data exchange, and dynamic sequencing application software. The project will illustrate the following benefits in the terminal area: decreased fuel burn and emissions, reduction in noise, increased approach availability, decreased minima where possible, optimized aircraft sequencing in real time, stable arrival/approach procedures to terminal area operations, constant rate of descent throughout arrival and approach, minimized flight time in terminal area, minimized impact to ATC.

f) Project summary/description:

Using existing technologies to reduce noise, emissions and fuel burn by having aircraft follow a TAP procedure in the terminal area. In addition, work was undertaken in the en route airspace to sequence and space aircraft to optimize the number of operations that can use the TAP procedures.

g) Time frame:

Project began in August 2007. Phase I ended August 2008 and Phase II started directly after Phase I ended. The flight demonstrations are still being planned, but it is hoped they will be completed in May 2009.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

A small modelling analysis has been completed for this effort. The modelling effort shows mixed results for the noise, fuel burn and emissions savings. TAP procedures were created for the four arrival corner posts at MEM. The designed procedures are longer than the average length of the current procedures.

- Fuel burn ranged from a 6.5 per cent savings to an increase of over 17 per cent;
- NO_X ranged from a 18 per cent increase to over a 50 per cent decrease;
- HC ranged from a 19 per cent increase to over a 53 per cent decrease;
- CO ranged from a 7 per cent increase to over a 41 per cent decrease;
- CO_2 ranged from a 14 per cent increase to over a 45 per cent decrease;
- SO_2 ranged from a 14 per cent increase to over a 45 per cent decrease.

Noise: A single aircraft was modelled using the LAMax metric. Overall, a decrease in the 65 dB and above is seen and a decrease in the 40 dB-65 dB range is seen. A more detailed analysis will need to be performed before the true benefits can be quantified.

i) Implementation prerequisites:

Existing technology is being used for the flight demo. Though not all aircraft are equipped with the same technology, the project is designed to take multiple levels of equipage on the aircraft.

j) Implementation experience:

None at this point.

k) Formal references:

Project Reports:

ISI, GATech, “Formulations and Cognitive Engineering Models” June 2008.
ISI, GATech, “Methodology for Integration of Decision Support Tools with Two-way Communications, Surveillance, and Flight Operations”, July 2008.
ISI, GATech, “Feasibility Concepts for Optimizing the Sequencing and Timing of Aircraft in Terminal Area Airspace (TAA)” July 2008.
ISI, GATech, “Design of Terminal Area Path Procedures and Integrated Two-way Communications”, August 2008.
ISI, GATech, “Environmental Modelling of Feasible Concepts for Optimizing the Sequencing and Timing of Aircraft in the Terminal Area Airspace (TAA)”, January 2009.
ISI, GATech, “Draft Flight Test and Analysis Plan”, January 2009.

Attachment 6

ATLANTIC INTEROPERABILITY INITIATIVE TO REDUCE EMISSIONS (AIRE) PROGRAMME — USA EFFORT

a) Name of project:

Atlantic Interoperability Initiative to Reduce Emissions (AIRE)

b) Project lead:

FAA AIRE

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Tailored Arrivals —	Marc Buntin	(202) 493-4990	charles.buntin@faa.gov
Metrics —	Sandy R. Liu	(202) 493-4864	sandy.liu@faa.gov

c) Sponsoring organization:

Federal Aviation Administration and European Union (EU)/European Commission (EC).

d) Participating organizations:

Air Navigation Service Providers (ANSPs): FAA, DSNA France, IAA (Ireland), LFV Sweden, NAV Portugal.
Airlines: Delta Air Lines, Air France, KLM, SAS, Virgin Atlantic, FedEx.
Industry: Boeing, Airbus, United Parcel Service.

Participants 2007-2008**:** FAA, American Airlines, Delta Airlines, United Airlines, AirEuropa Airlines, Nav Portugal, and Georgia Institute of Technology.

e) Scope and objectives:

- Hasten development of operational procedures to reduce aviation's environmental footprint on a "gate-to-gate" basis;
- Quantify environmental benefits to aid in formulation of potential business cases;
- Accelerate incorporation and worldwide interoperability of environmentally friendly procedures/standards;
- Capitalize on existing technology on either side of Atlantic; and
- Identify implementation issues, obstacles, choke points, metrics and solutions, and work with our European partners.

f) Project summary/description:

AIRE demonstrations are proof-of-concept ATM system enhancements that have shown to offer major environmental benefits as well as improved operational efficiency.
For each AIRE domain technology/technique, statistically significant levels of fuel savings and emissions and noise reductions will be quantified for the participating trans-Atlantic flights.

The cumulative measures will identify the overall potential "gate-to-gate" environmental mitigation possible for trans-Atlantic flights.

g) Time frame:

AIRE cooperative agreement signed at June 2007 Paris Air Show by FAA and EU/ EC**.** FAA Technical programme launched in 2008 and planned to support NextGen developments into the mid-term.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

FY 2008 AIRE Findings

FY2008 Activities	Demonstration	AIRE Benefits	Cost Saving@ $3.08/gal (1013/08)
Oceanic TBO	May Demo- Completed	– 47 gals/flt	–$145/flt
CDAs @ ATL/ MIA	May Demo- Completed	– 38-50 gals/flt	–$150/flt
ASD-X@MEM/JFK	Recently activated	est – 50 gals/flt	–$150/flt
Current Spain to Caribbean Islands	AIRE Cumulative Total:	Est. 150 gals/flt x 40 flts/wk	$960K/annually

ENVIRONMENTALLY:

For an annual CO_2 Emissions Savings Equivalency based on the AIRE Demo:
It can potentially save 3K metric tons CO_2 = (40 flt ops/wk).

Annual greenhouse gas emissions from 500 passenger vehicles.

Energy:
CO_2 emissions from 312 000 gallons or 6 400 barrels of oil consumed.
CO_2 emissions from the electricity use of 365 homes for one year.

Off-set mitigation:
Carbon sequestered by 70 500 tree seedlings grown for 10 years.

Relative to nature's cycle:
Carbon sequestered annually by 625 acres of pine or fir forests.

Conservation:
CO_2 emissions avoided by recycling 1 000 tons of waste instead of sending it to the landfill.

i) Implementation prerequisites:

Demonstrations of operational integrity, safety and positive cost benefit are prerequisite to national airspace implementation.

j) Implementation experience:

Implementation experience is being gained under the AIRE Programme demonstrations.

k) Formal references:

A "Gate-to-Gate" Approach to Reducing Aviation's Environmental Footprint, 2007 Paris Airshow, FAA Brochure.

Atlantic Interoperability Initiative to Reduce Emissions (AIRE) FY 2008 Proposed (Technical) Programme Plan, 2007 Industry Kickoff Meeting, FAA Programme Plan.

October 2007 Briefing:
http://www.faa.gov/about/office_org/headquarters_offices/ato/publications/071024%20A_AIRE_Partners_Briefing.pdf

Attachment 7

ASIA PACIFIC INTEROPERABILITY INITIATIVE TO REDUCE EMISSIONS (ASPIRE) PROGRAMME

a) Name of project:

Asia Pacific Interoperability Initiative to Reduce Emissions (ASPIRE)

b) Project lead:

FAA ASPIRE

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Metrics —	Sandy R. Liu	(202) 493-4864	sandy.liu@faa.gov

c) Sponsoring organization:

Federal Aviation Administration and Asian Pacific Rim Partners

d) Participating organizations:

Air Navigation Service Providers (ANSP):
FAA
AirServices Australia
Airways New Zealand
Japan Civil Aviation Bureau
Airports Fiji
CAA French Polynesia (Tahiti)

Airlines:
United, American, Continental, Delta, Air New Zealand, Qantas, Japan Airlines,
FedEx, UPS, Northwest, Nippon Cargo, All Nippon, Singapore Airlines, Cathay Pacific

Industry:
Boeing, Airbus, ARINC, SITA, Honeywell

e) Scope and objectives:

Partners under ASPIRE are committed to work closely with airlines and other stakeholders in the region in order to:

– accelerate the development and implementation of operational procedures to reduce the environmental footprint for all phases of flight on an operation-by-operation basis, from gate to gate;
– facilitate worldwide interoperability of environmentally friendly procedures and standards;
– capitalize on existing technology and best practices;
– develop shared performance metrics to measure improvements in the environmental performance of the air transport system;
– provide a systematic approach to ensure appropriate mitigation actions with short-, medium- and long-term results; and

- communicate and publicize ASPIRE environmental initiatives, goals, progress and performance to the global aviation community, the press and the general public.

ASPIRE Supports ICAO Strategic Objectives for 2005-2010:

- Strategic Objective C: Environmental Protection — Minimize the adverse effect of global civil aviation on the environment.
- Strategic Objective D: Efficiency — Enhance the efficiency of aviation operations.
- Consolidated Vision and Mission Statement – 17 December 2004.

ASPIRE Supports the Civil Air Navigation Services Organisation (CANSO) Work Programme, such as the Environmental Work Plan 2008 to 2010:

- defining and advancing best practice;
- influencing environmental policy to balance safety, capacity, efficiency and the environment;
- developing metrics and targets for reduction;
- enhancing the understanding of ATM's impact on the environment; and
- communicating the benefits and actions throughout the industry and beyond.

f) Project summary/description:

- This Asia Pacific programme will leverage the efforts of existing North and South Pacific workgroups and encourage a focus on environmental benefits.
- Beyond SFO, primary focus of ASPIRE will be on oceanic and offshore programmes.
- Partnership opportunities involve several regional ANSPs and multiple airlines equipped with the world's most modern aircraft fleet.

ASPIRE will leverage existing initiatives:

- Pacific ATS Route Realignment
- User Preferred Route Expansion
- Dynamic Airborne Reroute Programmes (DARP)
- ADS-C In-Trail Procedures
- Tailored Arrivals
- Pre-Departure OTM-4D.

g) Time frame:

On 18 February 2008, the multilateral partnership known as the Asia and South Pacific Initiative to Reduce Emissions (ASPIRE) was created in Singapore. The first ANSPs to sign the ASPIRE joint statement were Airservices Australia, Airways New Zealand, and the Federal Aviation Administration. FAA continues to support ASPIRE to supplement NextGen development activities into the mid-term.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

Projected estimates of fuel savings (gals) and CO_2 emissions reduced (lbs) by the mitigation strategies used are as follows:

Flight Phase 1, Pre-flight, taxi and take-off		
Fuel saved by	Quantity (gals)	CO_2 reduced (lbs)
APU use	60	1 262
“Just in time” refuelling	68	1 430
Reduced taxi time/minute	1	21
Flight Phase 2, Departure and Climb		
Use of Maximum climb power	40	841
Flight Phase 3, En route Cruise		
Use UPR-User Preferred Routes (avg)	420	8 834
DARP-Dynamic Airborne Reroute Procedure (avg)	70	1 472
Operating at optimum altitude (average)	135	2 639
Slower Cost Index	90	1 893
Flight Phase 4, Descent and Approach		
Use of Tailored Arrival	200	4 207
“Delayed flap”	80	1 683
Total Savings		
Cumulative Savings	1163	24 482

i) Implementation prerequisites:

Demonstrations of operational integrity, safety and positive cost benefit are prerequisite to national airspace implementation.

j) Implementation experience:

Implementation experience is being gained under the AIRE Programme demonstrations.

k) Formal references:

ASPIRE Website: http://www.airways.co.nz/ASPIRE/index.asp

Attachment 8

SUMMARY CONTINUOUS DESCENT ARRIVAL (CDA) AT LOUISVILLE INT'L AIRPORT (SDF) UNDER THE PARTNERSHIP FOR AIR TRANSPORTATION NOISE AND EMISSIONS REDUCTION (PARTNER)

a) Name of project:

Summary Continuous Descent Arrival (CDA) at Louisville Int'l Airport (SDF) under the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER)

b) Project lead:

Contacts:
Jim Walton (UPS)

Dr. John-Paul Clarke (Ga Tech)	john-paul.clarke@ae.gatech.edu	(404) 894-2760
Jim Brooks (Ga Tech)	jim.brooks@ae.gatech.edu	(404) 385-2770
Sandy Liu (FAA)	sandy.liu@faa.gov	(202) 493-4864

c) Sponsoring organization:

Federal Aviation Administration through the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) Centre of Excellence (COE).

d) Participating organizations:

Massachusetts Institute of Technology
Boeing Company
Federal Aviation Administration
National Aeronautics and Space Administration
Louisville Regional Airport (SDF) Authority
United Parcel Service (UPS)

e) Scope and objectives:

Environmental mitigation of noise and emissions and fuel savings using Continuous Descent Arrival (CDA) procedures. An environmentally ideal arrival procedure is one where the aircraft descends continually at idle thrust (or ~economy power) from cruise to landing.

Objectives:

- Design CDA procedure for SDF TRACON.
- Measure "real-world" benefits of CDA procedure.
- Identify FMS issues that limit benefits or introduction.

f) Project summary/description:

Comprehensive R&D demonstrations for the near-term implementation of CDA in the USA. Initial success of the CDA demonstrations launched at SDF have lead to other CDA demonstrations at LAX and ATL.

g) Time frame:

A PARTNER project since 2004.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

The basic CDA technique has proven to offer the following:

Noise:	@ 7.5-15 nm: up to 6dB noise reduction
	Lower per aircraft noise levels
	Impact concentrated in narrow corridors
Emissions:	CO below 3 000 ft reduced by 12.7 per cent (B-767) and 20.1 per cent (B-757)
	HC below 3 000 ft reduced by 11.0 per cent (B-767) and 25.1 per cent (B-757)
	NO_X below 3 000 ft reduced by 34.3 per cent (B-767) and 34.4 per cent (B-757)
Fuel burn:	@ SDF: (B767) 350lbs/flt saved; (B757) 100 lbs/flt saved

i) Implementation prerequisites:

Low traffic condition airport, aircraft with FMS, operator to work voluntarily with PARTNER/FAA design team.

j) Implementation experience:

Demonstrated for night-time low traffic operations at Louisville airport for two aircraft types within UPS fleet.

k) Formal references:

J.-P. B. Clarke, N. T. Ho, L. Ren, J. A. Brown, K. R. Elmer, K.-O. Tong, and J. K. Wat, “Continuous Descent Arrival: Design and Flight Test for Louisville International Airport,” AIAA Journal of Aircraft, Vol. 41, No. 5, pp. 1054-1066, September-October 2004.

J.-P. Clarke, D. Bennett, K. Elmer, J. Firth, R. Hilb, N. Ho, S. Johnson, S. Lau, L. Ren, D.Senechal, N. Sizov, R. Slattery, K.-O. Tong, J. Walton, A. Willgruber, and D. Williams, “Development, design, and flight test evaluation of a continuous descent arrival procedure for night-time operation at Louisville International Airport,” PARTNER Center of Excellence Report PARTNER-COE-2006-002, 9 January 2006.

PARTNER website: http://web.mit.edu/aeroastro/www/partner/projects/proj4.htm

Attachment 9

IMPROVED QUIET CLIMB

a) Name of project:

Improved Quiet Climb

b) Project lead:

Kevin Burnside (kevin.a.burnside@boeing.com)

c) Sponsoring organization:

Boeing Phantom Works

d) Participating organizations:

Boeing Phantom Works
GE Aviation Systems

e) Scope and objectives:

Improved departure noise reduction.
Reduced workload during noise abatement departure procedure.
Improved situational awareness during noise abatement departure procedure.

f) Project summary/description:

Modify existing Boeing close-in NADP procedure automation functionality in 737NG flight management system. Introduce location-based thrust triggers, cues on navigation display, and thrust triggers into departure procedure stored in onboard navigation database.

g) Time frame: Working prototype in 2008. Simulator trials in 2008-2009. Flight demo in 2010-2012.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

Noise benefits on the order of 3-6 dBA depending on location and aircraft operating parameters, relative to a typical close-in departure procedure.

i) Implementation prerequisites:

j) Implementation experience:

Simulator trials

k) Formal references:

ICAO PANS-OPS;
FAA Advisory Circular 91-53A.

Attachment 10

TAILORED ARRIVALS DEMONSTRATIONS

a) Name of project:

Tailored Arrivals Demonstrations

b) Project lead:

Rob Mead (rob.mead@boeing.com)

c) Sponsoring organization:

Boeing Phantom Works

d) Participating organizations:

Airlines
Airports
FAA

e) Scope and objectives:

Reduced fuel burn during descent
Dynamic routing to maximize airspace capacity
Reduced noise from routing and vertical profile

f) Project summary/description:

Communicate a tailored vertical and lateral arrival path to arriving aircraft that can minimize track distance and provide an idle descent vertical profile within the current airspace, air traffic and aircraft operating constraints.

g) Time frame:

SFO demo
MIA demo

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

Reduced noise
Improved fuel burn
Reduced throughput penalties by improving prediction and increasing flexibility by dynamic routing.

i) Implementation prerequisites:

j) Implementation experience: San Francisco Airport, Miami Airport

k) Formal references:

Attachment 11

RNAV/RNP PROCEDURES WITH NOISE/EMISSION ELEMENTS

a) Name of project:

RNAV/RNP Procedures with Noise/Emission Elements

b) Project lead:

Joe Wat
Kevin Elmer
Dan McGregor
Kevin Burnside

c) Sponsoring organization:

Boeing Commercial Aeroplanes Navigation Services
Boeing Commercial Aircraft Services

d) Participating organizations:

Airlines
Airports
FAA

e) Scope and objectives:

Reduce track distances to provide fuel savings
Avoid noise-sensitive areas via precision navigation

f) Project summary/description:

g) Time frame:

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

Reduced noise
Improved fuel burn

i) Implementation prerequisites:

j) Implementation experience:

SeaTac Airport, Luxembourg Findel Airport, London Heathrow Airport

k) Formal references:

Attachment 12

MINT — MINIMUM CO_2 IN TMA

a) Name of project:

MINT — Minimum CO_2 in TMA

b) Project lead:

Christer Forsberg (AVTECH Sweden)
christer.forsberg@avtech.aero
+4 685 441 0485

c) Sponsoring organization:

SESAR JU/AIRE (50 per cent), consortium partners (50 per cent)

d) Participating organizations:

AVTECH Sweden
Airbus
LFV Group
Novair
Egis Avia

e) Scope and objectives:

The objective of this project is to demonstrate minimum CO_2 operation in the TMA with current state-of-art airborne system capabilities and to analyse the actual performance of the aircraft in two typical conditions:

– optimum performance in an unconstrained environment, which is representative for low to medium traffic situations (regional airports or hubs during off-peak hours);

– optimum performance in a constrained environment where ATC uses Controlled Time of Arrival (CTA) instructions, representative for higher traffic situations with sequencing of incoming traffic.

f) Project summary/description:

The project will combine different ongoing initiatives to show the most efficient flight seen from the aircraft performance perspective. The project will build on the initiated RNP procedure development that is done by LFV to address reduction of track miles inside the TMA while avoiding noise-sensitive areas. For the vertical optimization the project will use the AVTECH-developed AVENTUS NowCast System which uplinks the most important winds after analysing the entire vertical segment that the aircraft will fly through. The NowCast System is updated with accurate forecast information from the UK Met Office that receives measured and downlinked wind information from previously arriving aircraft. During flight in low traffic density periods the aircraft will be able to approach the airport with minimum fuel, and thus minimum CO_2. The analysis will be made based on comparison to a reference fuel consumption based on an average of data from ordinary earlier flights.

g) Time frame: January-November 2009

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

Reduction of fuel and noise. Simulations have indicated savings of 150 kg of fuel compared to a good traditional approach, gaining from both the continuous descent and the reduction of track miles benefits.

i) Implementation prerequisites:

For low-density traffic periods the RNP procedure will go into operation starting as of August 2009 for SAS and Norwegian (see RAMP project). Implementing the NowCast system will be on the initiative of the airlines but should come naturally once CDA clearances get more commonly assigned. For high-traffic density periods RNP clearances cannot be expected until the ground system gets sufficient system support to manage the mixed equipage safely and without affecting capacity.

j) Implementation experience:

Cooperation between ATC, airline, airport, industry and the regulatory body is extremely important. Regarding noise, dialogue with the community is also important.

k) Formal references:

http://www.avtech.aero/projects.php?projects_id=45&start=
http://www.sesarju.eu/public/subsite_homepage/homepage.html

Attachment 13

ENVIRONMENTALLY RESPONSIBLE AIR TRANSPORT (ERAT)

a) Name of project:

ERAT/Environmentally Responsible Air Transport (part of the 4th call of the 6th FP)

b) Project lead:

Michael Portier (To70)
Michael.Portier@To70.nl
+31 (0)70 392 23 22

c) Sponsoring organization:

The ERAT project receives approximately 50 per cent funding from the European Commission, DG Energy and Transport (DG TREN). The participants raise the other 50 per cent individually.

d) Participating organizations:

ERAT project consortium includes a major European airline, an aircraft manufacturer, an engine manufacturer, three European research institutes, two ANSPs, two airport authorities and two SMEs:

To70	SME
Lufthansa (DLH)	Airline
Airbus France (AIF)	Aircraft manufacturer
SNECMA	Engine manufacturer
NLR	Research establishment
DLR	Research establishment
Eurocontrol Experimental Centre (EEC)	Research establishment
NATS	ANSP
LFV	ANSP and airport authority
BHCIA (Bucharest International Airport)	Airport authority
ENVISA	SME

This composition ensures on-board availability of operational expertise required to evaluate the maturity and acceptability of the proposed optimized operations.

e) Scope and objectives:

Purpose

The ERAT project aims to identify operational initiatives, develop concept elements, integrate them and validate a concept of operations that reduces the environmental impact of air transport operation in all phases of flight in the extended terminal area. With a target time frame of operational implementation of the proposed concept of operations in 2015 and beyond, it is set to contribute to the high-level SESAR environmental target for 2020 of achieving a 10 per cent reduction in environmental impact per flight (on average).

Scope

As part of the EC 4th call of the 6th FP, the original purpose of the Environmentally Responsible Air Transport (ERAT) set in 2005 was to develop and validate a Concept of Operations to reduce the environmental impacts of air transport at airports, in phases of flight in the terminal area and during the en-route flight phase. At that time, the ERAT consortium considered this to be an extremely wide scope that requires in-depth investigations in very different areas.

The consortium regarded the quest for noise and emission reductions in the extended terminal area (eTMA) airspace as important as the en-route emission problem, but having a more immediate impact on the communities surrounding airports. A reduction in en-route emissions is regarded as having a direct relation to allowing aircraft to fly great-circle routes at optimal altitudes, minimizing track miles or routing close to this great-circle route while taking into account weather conditions.

It is for these reasons that the consortium has chosen to investigate the aircraft operations in the eTMA. The potential benefits of several initiatives are known from earlier research such as the Sourdine-I and II projects, Optimal, NUP2+ and C-ATM. Subsequently came a focus on the investigation of operational initiatives for reduction of noise and emissions within the extended terminal area airspace of airports. An integrated approach has been selected to develop concept elements which, in addition to minimizing environmental impact, can be safely implemented without loss of capacity.

The development of a Concept of Operations in ERAT will closely follow the SESAR Concept Story Board, supporting the first step called Time-Based Operations of the SESAR 2020 Concept. Given the above-mentioned focus on eTMA, the concept elements will contribute to the development of the following ATM services: descent, climb and runway services. A full deployment of the ERAT Concept of Operations falls outside the scope of the project.

Approach

The ERAT project aims to identify mature operational initiatives, develop concept elements, integrate them and validate a concept of operations that reduces the environmental impact of the air transport operation in all phases of flight in the (extended) terminal area. The inclusion of operational partners in the ERAT consortium ensures an implementation-driven process that is adapted to ATC practice.

Therefore the consortium has chosen the following step-by-step approach:

1. Identifying operational initiatives and developing concept elements reducing the environmental impact;

2. Selecting the best operational concept element while taking into account the maturity of the concept and any trade-off between noise, emissions and capacity while maintaining the same level of safety;

3. Embedding those concept elements within a total concept of operations for two airports (one with medium-density and one with high-density traffic) and their surrounding airspace, with clear links to the SESAR concept story board;

4. Providing quantified benefits of the concept of operations by making use of a tailored E-OCVM and conforming to the SESAR Overall validation and verification strategy;

5. Establishing an understanding of the issues involved with implementation by ensuring user acceptance of the concept of operations.

f) Project summary/description:

The environmental impact of air transport is getting more public attention and becoming an increasing problem. The ERAT project aims to identify operational initiatives, develop concept elements, integrate them and validate a concept of operations that reduces the environmental impact of the air transport operation in all phases of flight in the extended terminal area. After establishing the key areas and purpose, the project will identify and further develop operational initiatives into concept elements. Enabling technologies, required for particular concept elements, will also be identified. The concept elements contribute to the development of ATM services in the SESAR 2020 concept: descent, climb and runway services. These elements are subsequently the cornerstones for building the concept of operations for two European airports, Stockholm Arlanda and London Heathrow. The concept of operations supports the first step of Time-Based Operations in the SESAR concept story board. The target time frame for the operational implementation of the proposed concept of operations by the ERAT project is 2015 and beyond. The environmental benefits of ERAT are aimed at contributing to the environmental targets of SESAR. ERAT will also follow a top-down structured approach to validation and verification. The environmentally optimized operations will be simulated using fast-time and real-time simulations, in order to perform an operational validation including an assessment of capacity, safety, environmental impact and user acceptance. These activities are in support of future operational deployment and performance benefit. The results of the assessment activities will be presented through workshops to stakeholders such as airlines and ANSPs.

g) Time frame:

The ERAT project started on 1 November 2008 and will finish 1 May 2011. The target time frame for the operational implementation of the proposed concept of operations by the ERAT project is 2015 and beyond.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

ERAT shows how the environmental impact can be reduced in the extended TMA area after implementing a different concept of operations for Stockholm Arlanda and Heathrow Airport. Noise and emissions benefits (CO_2 and local air quality) are expected due to the introduction of Noise Abatement Procedures at departure and approach (optimized NADP, CDA with a constant slope of –2 degrees or with deceleration in energy sharing), combined with advanced arrival and/or departure managers on the ground side.

i) Implementation prerequisites:

The prerequisites for implementation are a combination of infrastructure, commitment, hardware and software. Some of these are:

Air Traffic Management: (RNAV routes, advanced AMAN, DMAN, Ghosting tool for merging of traffic)

Cockpit (indication of configuration change points on navigation display, FMS/Engine control adaptation for NADP/CDA thrust management).

j) Implementation experience:

The concepts of operations will be used in a real-time simulation (RTS) and fast-time simulations (FTS) for Heathrow and Arlanda airports. The real-time simulation facilitates the operational evaluation of the proposed Concept of Operations and any other implementation issues.

k) Formal references:

More detailed information can be found on http://www.erat.aero/. On this website the intermediate public deliverables and progress of the project can be found.

Attachment 14

OPTIMAL PROJECT

a) Name of project:

OPTIMAL: Optimized Procedures and Techniques for IMprovement of Approach and Landing

b) Project lead:

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+33567196054

c) Sponsoring organization:

The project as part of the European 6th framework programme, is partly funded by European Commission.
Coordinator: Airbus France
Consortium: AIRBUS France, DLR, INECO, EUROCOPTER, THALES Air Systems, ISDEFE, NLR, AENA, EUROCONTROL, THALES Avionics, EUROCOPTER Deutschland, ONERA, University of Liverpool, General Electric (Smiths Aerospace), Augusta, DFS, SENASA, LVNL, Davidson Ltd, GMV, Sperry Marine, ENAV, AIRBUS Central Entity, SICTA.

d) Participating organizations:

See Consortium list above.

e) Scope and objectives:

OPTIMAL (Optimized Procedures and Techniques for the IMprovement of Approach and Landing) is an air-ground cooperative project, which is aiming at defining and validating innovative procedures for the approach and landing phases of aircraft and rotorcraft in a pre-operational environment. The objective is to increase airport capacity while minimizing noise nuisance and improving operational safety. Those achievements will be enabled by today's available precision approach landing aids (ILS, MLS), as well as new satellite-based guidance systems (ABAS, SBAS, GBAS), etc., more accurate navigation means (low RNP), enhanced airborne systems, and enhanced ground functions to support air traffic control. The target time frame for the operational implementation of the OPTIMAL proposed operational concept is 2010 and beyond.

f) Project summary/description:

In OPTIMAL, the following approach procedures and operations have been studied:

- Advanced Continuous Descent Approach (ACDA)
- GNSS-based procedures (GBAS, LPV SBAS and ABAS)
- Enhanced Vision System (EVS)
- Dual/displaced threshold operations
- RNP AR APCH procedures with RNP<0.3
- Rotorcraft specific IFR procedures (Simultaneous Non Interfering and steep approaches)
- MLS procedures.

The two studied procedures, which are related to environment, are Advanced Continuous Descent Approach (ACDA) and steep approaches for rotorcraft operations. The ACDA is detailed hereafter. The concept studied in OPTIMAL is Advanced CDA in the sense it is not radar-vectored but based on RNAV and with use of FMS. The objective is to have repeatable noise-friendly operations with higher automation; this is possible thanks to available onboard function like RNAV operations and FMS-managed vertical profile, and thanks to improved ATC support tools such as accurate planning and additional monitoring. OPTIMAL focused on the improvement of the approach phase of ACDA operations. Continuing the work started in earlier projects like SOURDINE 2, OPTIMAL studied two compatible variants of ACDA: nominal and optimized profiles. The "nominal" CDA consists of a fixed earth referenced descent path of 2 degrees initially from the start of the CDA, changing to a 3-degree path below an altitude of 3 000 ft for the final segment; the CDA descent profile transitions into a conventional instrument final approach. Due to the fact that the 2-degree profile is more shallow than an idle clean descent, this profile provides some deceleration control capability with respect to the deceleration profile to the ATC controller. The deceleration profile can either be flown with idle thrust, optimized by using the FMS for determining the configuration changes, or the profile can also be flown more conservatively for ATC sequencing reasons. Under circumstances imposed by other traffic, it may be necessary to initiate an earlier than optimum deceleration to a lower speed and perform a constant speed descent along the 2-degree gradient. The "optimized" CDA provides even more environmental protection as it is flown at relatively low speeds while maintaining the cleanest possible configuration and considering actual wind conditions. The vertical profile will be variable depending on actual wind conditions until transition to the fixed 2/3-degree approach is made. OPTIMAL covered the entire chain from the definition of the operational concepts and the design of new approach procedures, the development of new airborne functions and ground functions which enable to fly these new approach procedures, up to manned simulations and flight trials to assess the performance and operational benefits.

For CDA, several developments have been performed:

– Development of ACDA airborne function on Airbus A320 and validation and evaluation through flight simulations and flight trials.

– Evaluation of ACDA integration at Schiphol airport with development of some improved ATC tools (AMAN, CORADA) and evaluations through environment study, capacity simulations, safety analysis and whole ATM manned simulations.

– Development of 4D ACDA airborne function and evaluation on ATTAS flight test aircraft.

g) **Time frame:** 2004 to 2008; duration 57 months.

Level of maturity and expected time frame/lifespan for implementation of procedure/solution:

The OPTIMAL research programme allowed to successfully achieve many experiments and tests which demonstrate the flyablilty of the ACDA procedures and the benefits brought by the ACDA. It allowed also assessing the implementation of ACDA in a busy ATC environment and demonstrated the flyability of future ACDA with high accuracy RTA capability. But several points need to be further studied by future research projects such as ERAT, Clean Sky, SESAR.

Following these OPTIMAL achievements and conclusions, some recommendations can be drawn up for the implementation of ACDA and for future research projects:

– The operational implementation of day-to-day CDA operations will be encouraged by the availability of RNAV procedures which will allow to fly repeatable and noise-efficient CDAs.

– Although ACDA procedures will require the airborne capacity (FMS capacity) to fly the CDA profile, it is recommended to use the current FMS profiles which are already noise-efficient compared to the standard vectorized approach.

– The acoustic results have shown that very large noise benefits can be obtained with advanced FMS CDA functions able to optimize and adapt CDA profiles to the aircraft performance of the day. However, it is important to mention that acoustic benefits and optimized profiles strongly depend on aircraft type. It is therefore recommended to design the CDA procedures to take into account the aircraft performances in order to avoid non-flyable CDAs for aerodynamically efficient aircraft and to avoid sub-efficient CDAs in terms of noise reduction.

– Acoustic analyses have shown the importance of the management of configuration extensions; that is why it is recommended to delay the configuration extensions as much as possible during the approach. This will be managed by the CDA-capable FMS but it is recommended that flight crews should be made better aware of the main sources of aircraft noise during the approach as well as flight techniques that could be safely applied to minimize noise.

– When operating ACDA procedures in a busy environment, ATC will need sufficient means to allow the operation of CDA approaches with minimum need to act on the sequence after starting the CDA descent. Depending on the amount of traffic, this will require accurate arrival planning (i.e. advanced AMAN, enhanced air-ground datalink of aircraft data), arrival sequencing and monitoring tools, 4D capacity (ATC capacity, airborne RTA capacity, air-ground datalink). Moreover it would be very beneficial for both ATC and aircraft to get access, through data link, to several CDA related data (aircraft speed, RTA, etc.).

– A standardized mode of CDA operation has not yet been internationally defined. It is recommended that international bodies develop guidance material for drawing and coding CDA approaches in order to promote the implementation of ACDA procedures.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

A320 CDA function design and tests

The airborne development phase consisted in providing the ACDA capacity on Airbus A320 aircraft with the objective to assess the flyability of the studied CDA profiles, to assess the technical feasibility of the cockpit changes, to assess the pilot operational acceptance and to check the acoustic benefits. The aim was to provide noise-efficient strategies, ensure repetitive noise benefits, lower pilot workload and avoid over-energy situations. The main airborne evolution consisted in developing a FMS capable of computation of acoustic efficient profiles for intermediate approach (no change was made on current descent logics) and in developing an adapted CDA HMI. This FMS allows noise optimization while managing the energy; it computes speed/altitude predictions in flight plan for configuration pseudo waypoints, provides the crew with some cues for configuration extension and provides automated request for more drag if speed/altitude are predicted to be too high at the pseudo waypoints. The tests consisted of validation and operational evaluation on an Airbus A320 simulator and flight trials on Airbus A320 flight test aircraft. The flown procedures were experimental CDA procedures at Toulouse Blagnac. The simulations and flight trials campaigns have demonstrated the flyability of the CDA profiles; they have also demonstrated the feasibility of the cockpit changes required to fly these new profiles. The crew workload was not increased compared to current operations; the guidance performance was satisfactory and no over-energy situation was encountered when testing the CDA approaches. The nominal profile has been judged operationally acceptable by the pilots; it has been considered simple and intuitive and worth being further studied whereas the optimized profile has been judged complex. The concept of the optimized profile is more difficult to understand and requires decelerating very early, which induces a longer deceleration and an increase of the flight time compared to classic approaches.

Regarding the acoustic benefits, the flight tests have confirmed the expected results from the preliminary analyses. The CDA profiles have been here compared to current FMS profiles without altitude/speed constraints; it shall be noted that these FMS profiles are already acoustically efficient profiles compared to radar-vectored profiles.

Figure 1 shows that CDA profiles are largely quieter than current FMS profiles far from the airport and provide a significant gain between 2 dBA and 9 dBA from 45 km up to 20 km of the runway threshold. This noise alleviation is mainly due to higher profile and slower speed. As a setback, there is a local noise penalty of 4 dBA for this aircraft at 17 km from the threshold due to the earlier slats extension on the CDA profile, but this penalty is minimized thanks to OPTIMAL configuration extension cues. The optimized profile provides significant additional acoustic gains (-4 dBA) for low noise levels.

As a conclusion, these tests show significant acoustic gains with the CDA profiles but it is important to note that the acoustic gains are strongly dependent on the aircraft type.

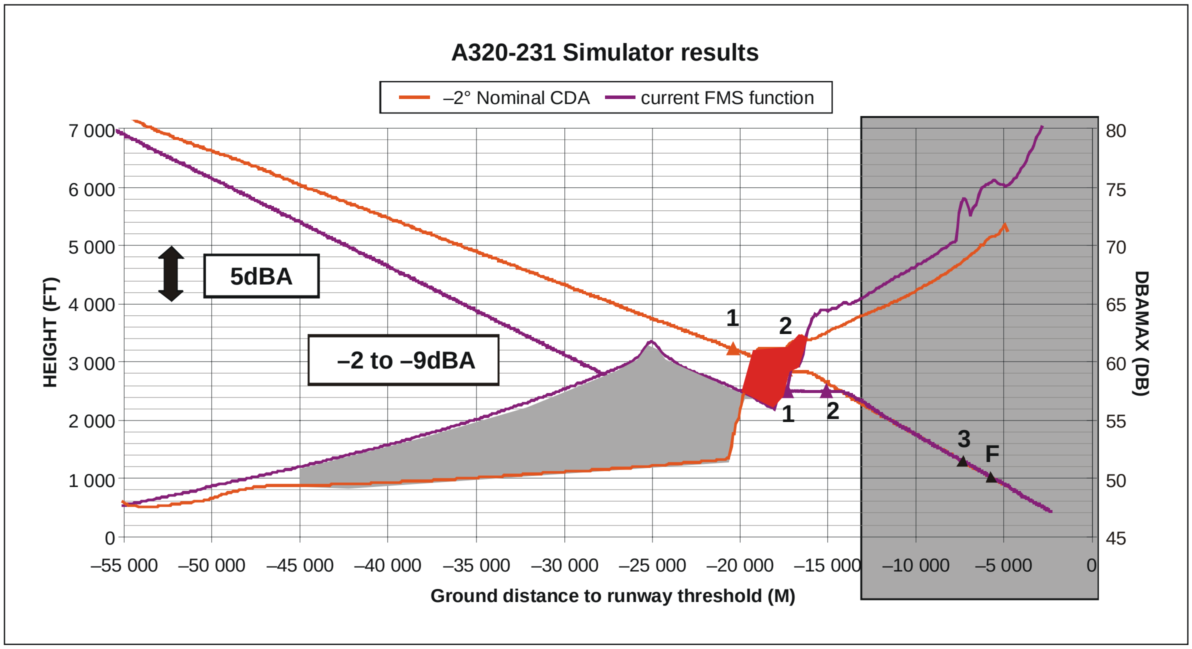

Figure 1. A320-231 Simulator results

ATM integration tests

One of the main challenges of the ACDA is the integration into ATM. Indeed, ACDA procedures are usually less controllable for ATC than conventional approaches and that is why current CDAs are especially applicable in low-density traffic.

The NLR has assessed the integration of ACDA approaches at Schiphol airport: the concept relies on an evolution of the airspace management with an extended TMA with RNAV routes and various combinations of enablers as time-based operations (RTA and datalink), advanced AMAN and ATC control tool, ASAS. Several complementary analyses and simulations testing the various combinations of enablers have been carried out.

The environmental analysis showed clear environmental benefits in terms of noise and gas emissions; for example, at Schiphol airport, the LDEN 48 could be reduced by 20 per cent.

The capacity analysis has shown that the introduction of ACDA could limit the maximum throughput to 33 arrivals per hour per runway and may increase the delay, but the 2015 traffic can be handled with an adjusted airport operating schedule.

An airborne manned simulation campaign took place on an NLR GRACE A330 flight simulator in order to assess a specific CDA HMI and the combination with ASAS and RTA capacity.

A safety analysis has been done in order to assess the required CDA separation at IAF and threshold compared to current operations; this was used as input to the overall ATM manned simulations. Some ATC tools have been also developed in order to support ACDA operations and have been assessed during the ATC simulations. These tools consist of an advanced AMAN and an ATC tactical tool called CORADA.

The overall ATM simulations took place on an NLR NARSIM simulator; several phases were conducted in order to test the various combinations of enablers. The results vary according to the tested combinations but it has been shown that ACDA operations could be flown with provided enablers; the obtained maximum throughput depends largely on chosen RNAV route structure (early merging), traffic mix, applied separation criteria, etc. The AMAN and CORADA are helpful for controllers but need further improvements.

4D ACDA ATTAS flight trials

One of the main drawbacks of the ACDA is the potential loss of the runway capacity as the aircraft are flying at different speeds and altitudes optimized to reduce their noise impact. In order to mitigate this drawback, the late-merging-point concept can be applied; it consists of delaying the merging as close as possible to the threshold in order to allow aircraft to fly different vertical and speed profiles.

This concept has been assessed by the DLR thanks to some flight trials carried out on the ATTAS flight test aircraft equipped with an advanced FMS capable of 4D ACDA. The flight tests took place at Bremen airport with various wind conditions.

The results show that the ACDAs can be flown by the FMS to meet RTA with a very good accuracy on G/S intercept or even on runway threshold. The lateral precision as well as the temporal precision was excellent as long as the wind forecast was accurate. In general, the time accuracy for all flights was also within a margin of about ±5 seconds. But it has been shown that accurate wind forecast is required; indeed inaccurate (weather) wind forecast will either affect RTA accuracy or reduce noise benefits of ACDAs (e.g. if earlier flap settings are required). The improvement of wind forecast quality can be expected in near future thanks to research activities on weather forecast improvement and air-to-air communication to exchange actual wind measurements.

i) Implementation prerequisites:

Technical equipment (aircraft, airport, air-ground communication):
- ATM: RNAV routes, improved Arrival Manager and ATC tools.
- Cockpit: FMS ACDA.

Method of introduction in existing fleet and airport operations:
- Start at low density (night-time operations), build up experience.

Training (air traffic controllers, pilots):
- Pilots and ATC.

Acceptance (air traffic controllers, pilots):
- Nominal profile has the highest acceptability of both pilots and air traffic controllers.

j) Implementation experience:

Project results are widely communicated with airports, airlines and ANSPs and serve as a basis for procedures in European research projects such as ERAT, Clean Sky, SESAR.

k) Formal references:

http://www.optimal.isdefe.es

Attachment 15

CDAS IN LTMA

a) Name of project:

CDAs in LTMA (London Terminal Manoeuvring Area)

b) Project lead:

Carrie Harris

c) Sponsoring organization:

National Air Traffic Services (NATS) – UK
Eurocontrol
Sustainable Aviation Noise Abatement Working Group:

Air Navigation Service Providers (ANSP):
NATS

Airports:
British Airports Authority
Manchester Airport Group
London City Airport

Airlines:
British Airways
Virgin Atlantic

Manufacturers / Other Industry:
Airbus
Rolls Royce
Society of British Aerospace Companies

d) Participating organizations:

NATS
Eurocontrol
Sustainable Aviation Noise Abatement Working Group

e) Scope and objectives:

CDAs are a noise abatement technique for arriving aircraft in which the pilot, when given descent clearance below the transition altitude by ATC, will descend at the rate he judges will be best suited to the achievement of continuous descent, whilst meeting ATC speed control requirements, the objective being to join the glide path at the appropriate height for the distance without recourse to level flight. Heathrow, Gatwick and Stansted airports have adopted working definitions for monitoring CDA at night; no precise definition of CDA approach has been given by ICAO nor in the UK AIP. The theoretical “ideal” CDA profile is a descent at 3 degrees from 6 000 ft.

f) Project summary/description:

During 1994-1999 the UK Government considered the feasibility of setting noise limits on arriving aircraft. A December 1999 ANMAC report was published recommending an Arrivals Code of Practice. The document was produced to try to identify steps which could reduce noise generated by arriving aircraft. CDAs were highlighted as the principle method of reducing arrivals noise. A Work Group was set up in 2000 comprising BAA, NATS, CAA, DLTR (now DfT), British Airways and Airtours (now MyTravel). A Code was published in February 2002. Although written for the three London airports, the Code provides broad base guidelines that can be modelled for any airport.

g) Time frame:

This work is ongoing. NATS has continued to work with its airport customers to promote and assist in the development or application of CDAs. NATS maintains high performance at the main London airports. NATS continues to train ATCOs in the benefits and techniques to enable CDAs and has completed a review of performance on CDA across the UK airports where NATS provides a service. NATS has enhanced the environmental performance criteria for airspace design so that new airspace will, wherever possible, be designed to improve CDA performance.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

Reduced noise.

i) Implementation prerequisites:

NATS has experience of high capacity airspace.

j) Implementation experience:

NATS is a major contributor to the Implementation Guidance.

k) Formal references:

CDA code of Practice V2 published November 2006
CDA Implementation Guidance Published 2008.

Attachment 16

STEEPER APPROACHES

a) Name of project:

Steeper Approaches

b) Project lead:

Carrie Harris

c) Sponsoring organization:

NATS
Sustainable Aviation Noise Abatement Working Group

d) Participating organizations:

NATS
Sustainable Aviation Noise Abatement Working Group

e) Scope and objectives:

NATS chairs the Sustainable Aviation Steeper Approaches Group which was established in 2007. The group's objective is to answer two questions:

1. What, if any, noise and emissions benefits can be derived from aircraft flying steeper approaches?
2. Can large aircraft fly approaches steeper than the standard 3 degrees?

f) Project summary/description:

An initial literature review revealed useful documents prepared by CAA, Eurocontrol and CAEP and drew out a list of airports with glide paths ranging from 2 degrees up to 6.65 degrees. The review revealed reasons to rule out steeper approaches on the grounds of safety, complexity, capacity and cost. However, it was agreed both within the SA steeper Approaches Group and with members of CAEP that the basic questions on environmental benefits and flyability were still valid and should be addressed in order to enable steeper approaches to be ruled in or out as a potential environmental mitigation option. Answers could inform future aircraft and airspace design, and implementation could enable quieter, more fuel-efficient operations.

g) Time frame:

In June 2008 simulations were carried out using Virgin Atlantic equipment at CAE simulation, Burgess Hill. The results were informative but not conclusive. The findings are to be communicated to CAEP and the next steps to progress understanding of this topic need to be agreed.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

Reduced noise.

i) Implementation prerequisites:

j) Implementation experience:

k) Formal references:

Attachment 17

ACP NOISE ASSESSMENTS/POPULATION EXPOSURE ANALYSIS

a) Name of project:

ACP (Airspace Change Proposal) Noise Assessments/Population Exposure Analysis

b) Project lead:

Carrie Harris

c) Sponsoring organization:

NATS

d) Participating organizations:

NATS
UK CAA Directorate of Airspace Policy (DAP)

e) Scope and objectives:

ACP Noise analysis includes LAQ contours, LDen Metrics and SEL footprints. Population exposure is analysed, and a comparison is made of expected noise with daily sounds to put it into context.

f) Project summary/description:

g) Time frame: This work is ongoing.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

i) Implementation prerequisites:

j) Implementation experience:

NATS has experience of ACPs in high-capacity airspace and has been innovative when presenting consultation documentation.

k) Formal references:

Attachment 18

DEPARTURES CODE OF PRACTICE

a) Name of project:

Departures Code of Practice

b) Project lead:

Carrie Harris

c) Sponsoring organization:

Sustainable Aviation Noise Abatement Working Group

d) Participating organizations:

Sustainable Aviation Noise Abatement Working Group

e) Scope and objectives:

Following the success of the "Arrivals Code of Practice" it was felt it would be beneficial to carry out a similar exercise for departing aircraft. The Departures Code of Practice Group met in late 2007 including representatives from British Airways, BAA, easyjet, NATS and Virgin Atlantic. Manchester Airports Group, bmi, CAA (ERCD) and SBAC are also becoming involved as the exercise progresses.

f) Project summary/description:

Four primary mitigation techniques for the environmental aspects of departing aircraft have been identified and will form the basis of the Code. These are:

1. the use of fixed ground power and preconditioned air rather than running the aircraft's APU
2. taxi with fewer than all engines running
3. continuous climb departures
4. collaborative decision making.

g) Time frame: The Full Paper is due to be delivered January 2010. An interim paper covering engine out taxiing was due in August 2009.

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

Noise Reduction
Reduced Emissions

i) Implementation prerequisites:

j) Implementation experience:

NATS has experience of ACPs in high-capacity airspace and has been innovative when presenting consultation documentation.

k) Formal references:

Attachment 19

HIGHER HOLDING

a) Name of project:

Higher Holding

b) Project lead:

Carrie Harris

c) Sponsoring organization:

NATS

d) Participating organizations:

NATS

e) Scope and objectives:

Investigation of higher holding opportunities; analysis shows each 1 000 ft higher could deliver two per cent saving in fuel.

f) Project summary/description:

g) Time frame:

h) Actual/estimated benefits and trade-offs (noise, emissions, operating efficiency, fuel burn):

i) Implementation prerequisites:

j) Implementation experience:

k) Formal references:

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