Atlantic Interoperability Initiative to Reduce Emissions (AIRE)

Summary of results 2010/2011
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From testing to proof

Following the success of the first AIRE cycle in 2009, the SESAR Joint Undertaking further extended this green activity portfolio of the SESAR programme. A good decision in the light of significant results from more than 9,000 trial flights involving some 40 partners in Europe and beyond.

Results show that a significant reduction of fuel burn and therefore CO\textsubscript{2} emissions can be achieved today through a partnership approach. The financial benefits of all the projects combined are estimated to amount in potential yearly savings of more than €20 million, representing a five times return on investment. We are particularly proud to see that most of the solutions demonstrated are now available for day to day operations or will be implemented shortly. Feedback from AIRE partners confirms that their participation is a clear “win-win” for them, allowing them to strengthen their capability of implementing environmentally friendly operations with a step by step approach. Insights built in AIRE feed into the overall SESAR programme where we are focussing on the subsequent introduction of new technologies and procedures as of 2013.

Background to the AIRE initiative

The AIRE programme was launched in 2007 by the European Commission and the United States Federal Aviation Administration to improve energy efficiency and lower engine emissions and aircraft noise.

The SESAR Joint Undertaking (SESAR JU) has been managing the programme from an European perspective since 2008 by means of collaborative contracts for projects involving one or more ANSPs, airlines and other ATM stakeholders.

AIRE initially focused in optimising oceanic operations, but has been extended to include all phases of flight. AIRE projects are structured through a validation plan organised around one or several ATM domains – surface, terminal and oceanic/en route operations and “gate-to- gate”. Within each domain, a given project envisages several specific operational areas where trials can be conducted to improve fuel and airspace usage, reduce CO\textsubscript{2} emissions, and sometimes noise.
Executive Summary

In July 2010, 18 projects involving 40 airlines, airports, ANSPs and industry partners were selected for the 2010/2011 cycle of the AIRE programme, in which surface, terminal, oceanic and gate-to-gate operations were tackled. In comparison to the first round of AIRE projects in 2008/2009, this cycle was significantly expanded, with more ambitious projects, many additional locations and partners, and more than 9,000 flight trials completed. Another new feature in this cycle was closer integration within the context of the SESAR programme which is now fully ramped-up.

Partners

**Airlines:** Air Europa, Air France, Austrian Airlines, Brussels Airlines, Czech Airlines, Germanwings, Iberia, KLM Royal Dutch Airlines, Lufthansa, Novair, SAS, SWISS, TAP Portugal;

**Air Navigation Service Providers:** Aena, Air Navigation Services of the Czech Republic, Austro Control, Belgocontrol, DFS, DSNA, DGAC, NATS, NAV Portugal, ONDA, LFV, LVNL, Skyguide, NAV CANADA;

**Airport Operators:** Aéroports de Paris, Brussels Airport, Flughafen Zürich AG, Swedavia;

**Industry Partners:** Adacel, Airbus, CRIDA A.I.E, GE aviation, INECO, National Aerospace Laboratory (NLR), Pildo labs, Quovadis, Rockwell Collins, SENASA.

In addition, the FAA directly supported some of the oceanic and gate-to-gate projects as well as a number of other partners such as ANSPs and airlines that participated on an informal basis.

“"The experience gained by each partner will be transferred to daily actions and will significantly improve our industry’s environmental performance“

“"We are revolutionising the way we do business in the North Atlantic“

“"It has been a really exciting and positive project for us, and has created a lot of interest throughout our respective businesses. ... I have always been impressed with the commitment each partner has shown to the project and the support they have shown towards each other across the AIRE projects. We have remained as a team and dealt pragmatically and professionally with any and all issues that have arisen. Brilliant!“

Selected quotes from AIRE projects managers
Surface
Operational improvements for surface pass by better planning and involvement of all actors. This allows for the minimisation of aircraft holdings and distance rolling on the ground. Such improvements will also lead to the reduction of taxi-out and taxi-in times, single engine taxiing out to absorb potential delays at the parking stand, and minimum usage of the aircraft APU.

Two projects addressed surface optimisations – a French consortium studied operational situations in adverse conditions, caused by bad weather or other factors that constrain runway use optimising capacity and reducing delays. An Austrian project conducted an evaluation of issuing Target-Off Block time (TOBT), the calculation of a variable taxi out time and issuing a Target-Start-up Approval Time (TSAT) to reduce taxi operations enabled by better take-off time predictability, the first steps towards the implementation of a CDM (Collaborative Decision Making) system at the airport.

Terminal
Accomplishing more fuel-efficient climbs and descents are operational improvements made within the Terminal Manoeuvring Area (TMA) of a given airport. Optimisations include better lateral and vertical profiles; including the use of techniques like Continuous Descent Operations (CDOs) and Continuous Climb Departures (CCDs). Three AIRE projects focused on green approaches optimising the descent vertical profiles where possible from the optimum Top of Descent (ToD), allowing aircraft operators to fly as close as possible to their preferred vertical trajectory. Green approach trials were conducted at Brussels, Paris and Prague airports. A German project, for Cologne-Bonn and Dusseldorf airports, focused on airspace re-design, with the development of a new procedure to couple the arrival flows at both airports, enabling greener approaches into Cologne. In Madrid the adherence and deviations to the published CDO was investigated.

Oceanic
Four projects were carried out, including major North Atlantic Flight Information Regions (FIRs) such as Santa Maria, New York Oceanic, Shanwick, and Gander. One Portuguese lead project, with active FAA support, targeted horizontal and lateral oceanic trajectory optimisations, taking advantage of the full exploitation of present datalink communication capabilities between the Airline Operation Centre (AOC) and the aircraft and between the aircraft and the Area Control Centre (ACC).

Flights between Lisbon and Casablanca and crossing traffic were optimised in the Lisbon and Casablanca FIRs using the free route concept. Two additional projects, under the leadership of NATS and NAV CANADA respectively demonstrated the benefit of implementing a new longitudinal separation standard and the optimisation of flight profiles (allowing variable altitude and speed), taking advantage of the implementation of ADS-B surveillance capabilities.

Gate-to-gate
The ultimate goal of AIRE is to have a full optimisation of all phases of flight and seven projects successfully covered more than one domain, two of them with direct and active FAA involvement. City pairs included Paris – Point-a-Pitre; New York JFK – Paris; Paris – Toulouse, several destinations departing and arriving from/at Gothenburg, and several destinations arriving in Amsterdam and Stockholm. Improvements covered reduction of taxi-out time and reduced engine taxi in; oceanic and en-route vertical and lateral optimisation; military airspace coordination; direct routing; idle reverse thrust on approach; CDOs and optimised arrivals through RNP AR procedures; and better sequencing and traffic synchronisation using advanced DMAN.
AIRE 2010/11 technical and procedural solutions

- Using collaborative Decision Making (CDM) initiation and/or enhancement of pre-departure sequencing system and Departure Manager systems (GDL/DMAN) to issue optimised Target-Off Block times and predictable green taxi out times at Paris, Vienna and New York JFK airports;

- Continuous Descent Operations (CDOs) procedure developments in Amsterdam, Brussels, Cologne, Madrid, Gothenburg, Prague and Toulouse;

- Improved approach procedures including airspace reconfiguration, removing altitude and other constraints and designing green standard arrival combined, with green initial approaches in Paris and Cologne/Dusseldorf Terminal Areas TMAs;

- Design and use of RNP procedures in Gothenburg and Stockholm;

- Vertical, Lateral and longitudinal optimisations in the main North Atlantic Oceanic FIRs;

- Shorter flights from a combination of free route air space in Lisbon FIR and direct route creation in Casablanca FIR;

- New reduced longitudinal separation minimum of five minutes on the North Atlantic Organised Track System (OTS) between pairs of GNSS-equipped aircraft;

- Full use of ADS-B surveillance capabilities on Shanwick and Gander for altitude and speed optimisations;

- Implementation of basic Arrival Management (AMAN) capabilities for improving arrival sequencing at airports in Zurich and Amsterdam.
Summary of environmental benefits per domain and project

<table>
<thead>
<tr>
<th>Domain</th>
<th>Project</th>
<th>Location</th>
<th>Number of trials</th>
<th>CO₂ benefit per flight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Greener airport operations under adverse conditions</td>
<td>Paris/CDG</td>
<td>1800</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Airport CDM</td>
<td>Vienna</td>
<td>208</td>
<td>54</td>
</tr>
<tr>
<td>Terminal</td>
<td>B3</td>
<td>Brussels</td>
<td>3094</td>
<td>160-315</td>
</tr>
<tr>
<td></td>
<td>DoWo – Down Wind Optimisation</td>
<td>Paris/CDG</td>
<td>219</td>
<td>158-315</td>
</tr>
<tr>
<td></td>
<td>REACT-CR</td>
<td>Prague</td>
<td>204</td>
<td>205-302</td>
</tr>
<tr>
<td></td>
<td>Flight trials for less CO₂ emission during transition from en-route to final approach in a multi-airport environment</td>
<td>Cologne Dusseldorf</td>
<td>362</td>
<td>110-650</td>
</tr>
<tr>
<td></td>
<td>RETA-CDA2</td>
<td>Madrid</td>
<td>210</td>
<td>250-800</td>
</tr>
<tr>
<td>Oceanic</td>
<td>DORIS</td>
<td>St Maria FIR, NY FIR</td>
<td>110</td>
<td>3134</td>
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<tr>
<td></td>
<td>ONATAP</td>
<td>Free Route Airspace Lisbon Casablanca FIR</td>
<td>999</td>
<td>526</td>
</tr>
<tr>
<td></td>
<td>ENGAGE</td>
<td>Shanwick FIR, Gander FIR</td>
<td>23</td>
<td>1310</td>
</tr>
<tr>
<td></td>
<td>RlongSM</td>
<td>Shanwick FIR, Gander FIR</td>
<td>53*</td>
<td>441</td>
</tr>
<tr>
<td>Gate to gate</td>
<td>Green Shuttle</td>
<td>Paris Orly, Toulouse</td>
<td>60</td>
<td>221 / 788</td>
</tr>
<tr>
<td></td>
<td>Transatlantic A 380 Green Flights</td>
<td>New York JFK, Gander OCA, Shanwick OCA</td>
<td>15+4*</td>
<td>1200+1900</td>
</tr>
<tr>
<td></td>
<td>Transatlantic green flight PPTP</td>
<td>Paris/Orly, Point-à-Pitre, Shanwick FIR, Santa Maria FIR, New York OCA</td>
<td>1+8+8*</td>
<td>(no significant trend)+2090+1050</td>
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<tr>
<td></td>
<td>Greener Wave</td>
<td>Zurich</td>
<td>1700</td>
<td>504</td>
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<tr>
<td></td>
<td>VINGA</td>
<td>Gothenburg</td>
<td>189</td>
<td>70-285</td>
</tr>
<tr>
<td></td>
<td>AIRE Green Connections</td>
<td>Gothenburg Stockholm/Arland</td>
<td>25</td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>Trajectory based night time CDA’s at Schiphol airport</td>
<td>Amsterdam/Schiphol</td>
<td>124</td>
<td>Tbc</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>9416</td>
<td></td>
</tr>
</tbody>
</table>

1 This table is indicative for high level communication purposes as the definition of trial is variable per project meaning in some cases the commercial flights participating in the evaluation (solution already in service)

2 Some of the savings are incremental - in addition to savings demonstrated earlier

3 53 flights analysed in detail - 433-665 RlongSM scenarios observed resulting in the involvement of 2196 flights

4 Results given per optimisation domain

5 Estimated values - Projects not concluded when brochure went to press
Conclusions

The AIRE initiative has been recognised as providing early green benefits, with airlines, ANSPs, airports and other stakeholders showing increasing interest in participating.

The mechanism for transforming a successfully trialled technique into routine daily usage is very much project-dependent. However, experience shows that implementation is the natural/obvious next step because it is a win-win situation. The AIRE partners, together with the SESAR JU, are making sure that the best practices are well known and presented in relevant operational fora.

To find out more read the reports on our website and previous AIRE project summaries at www.sesarju.eu\aire.

Full AIRE reports can be found at www.sesarju.eu\aire
### Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>4D</td>
<td>Four-dimensional</td>
</tr>
<tr>
<td>ACARS</td>
<td>Aircraft Communications Addressing and Reporting System</td>
</tr>
<tr>
<td>ACC</td>
<td>Area Control Centre</td>
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<tr>
<td>ADS-B</td>
<td>Automatic Dependent Surveillance-Broadcast</td>
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<tr>
<td>AIRE</td>
<td>Atlantic Interoperability Initiative to Reduce Emissions</td>
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<tr>
<td>AMAN</td>
<td>Arrival Management</td>
</tr>
<tr>
<td>ANSPs</td>
<td>Air Navigation Service Providers</td>
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<tr>
<td>AOC</td>
<td>Airline Operations Centre</td>
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<tr>
<td>ATCo</td>
<td>Air Traffic Controller</td>
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<tr>
<td>ATM</td>
<td>Air Traffic Management</td>
</tr>
<tr>
<td>CDA</td>
<td>Continuous Descent Approach/Arrival</td>
</tr>
<tr>
<td>CDM</td>
<td>Collaborative Decision Making</td>
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<tr>
<td>CDO</td>
<td>Continuous Descent Operations</td>
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<tr>
<td>CFMU</td>
<td>Central Flow Management Unit</td>
</tr>
<tr>
<td>C02</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>CPLDC</td>
<td>Controller-Pilot Datalink Communications</td>
</tr>
<tr>
<td>CTOT</td>
<td>Calculated take-off time</td>
</tr>
<tr>
<td>DMAN</td>
<td>Departure Management</td>
</tr>
<tr>
<td>FANS</td>
<td>Future Air Navigation System</td>
</tr>
<tr>
<td>FIR</td>
<td>Flight Information Region</td>
</tr>
<tr>
<td>GSNSS</td>
<td>Global Navigation Satellite System</td>
</tr>
<tr>
<td>INA</td>
<td>Initial Approach</td>
</tr>
<tr>
<td>OTS</td>
<td>Organised Track System</td>
</tr>
<tr>
<td>RNP</td>
<td>Required Navigation Performance</td>
</tr>
<tr>
<td>RNP AR</td>
<td>Required Navigation Performance Authorisation Required</td>
</tr>
<tr>
<td>STAR</td>
<td>Standard Terminal Arrival Route</td>
</tr>
<tr>
<td>TMA</td>
<td>Terminal Manoeuvring Area</td>
</tr>
<tr>
<td>TOBT</td>
<td>Target-Off Block time</td>
</tr>
<tr>
<td>ToD</td>
<td>Top of Descent</td>
</tr>
<tr>
<td>TSAT</td>
<td>Target-Start-up Approval Time</td>
</tr>
</tbody>
</table>
**De-icing conditions**

- Adherence to CFMU slots in December 2010 at Paris CDG airport was improved compared to December 2009 (71% against 66%).
- Considering 18 occurrences where more than 100 de-icing operations per day occurred, minimum annual CO2 reductions is estimated at 220 tons (70 tons of fuel).

**Collaborative Decision Making (CDM) at Vienna Airport**

**Project members**

Austrian Airlines, Austro Control

**Main project objectives**

Evaluation of procedures to reduce taxi times and therefore fuel burn and emissions. Austrian Airlines and Austro Control demonstrated possible savings by applying pre-departure sequencing procedures that require investment in new IT systems as well as a scaled-down approach that could be implemented without investments in new IT systems, but yields less benefits.

**Number and duration of trials**

Validation exercises were conducted on three days from May to October 2011, covering the peak periods from 09:40 to 11:00 and from 12:30 to 13:40. A total of 208 flights were part of the evaluation.

**Results**

- Reduction of taxi-out time compared to Austrian Airlines fleet average taxi out time in 2010: approximately 2 minutes per flight departing from Vienna
- Fuel savings through efficient taxiing: approximately 17kg/flight
- Reduction of CO2 emissions: around 54kg/flight
Terminal

B3 project

**Project members**
Brussels Airlines, Belgocontrol, Brussels Airport Company

**Other airlines participating (not part of the Consortium)**
Jetairfly, Thomas Cook, DHL, and Singapore Airlines Cargo

**Main project objectives**
The project aimed to perform continuous descent flight trials in a complex radar-vectoring environment. The trials main objectives were to test the operational concept and to quantify the fuel, CO\(_2\) and noise benefits.

**Number and duration of trials**
A total of 5,407 CDO flights have been carried out since July 2009, including 3,094 in the first ten months of 2011 [AIRE project duration], corresponding to nine percent of the total number of flights participating in the trials arriving on runways 25R/25L.

**Results**

Airbus 319s used an average of 50 kg less fuel per CDO flight, producing 160 kg less CO\(_2\), and Airbus 330s 100kg, corresponding to 315 kg of CO\(_2\).

Maximum noise levels on the ground were reduced by 2 dB(A) for Airbus 319s and 3 dB(A) for Airbus 330s between 10 and 25 nautical miles from touchdown.

Down Wind Optimisation at Paris CDG (DOWO)

**Project members**
DSNA, Air France

**Main project objectives**
DSNA and Air France proposed developing the concept of Green STAR (Standard Arrival) combined with Green INA (Initial Approach), evaluating the possibility of improved vertical profiles in a busy TMA and ACC.

**Number and duration of trials**
Altogether more than 200 commercial flights participated. The evaluations took place between 16 November and 3 December 2010.

**Results**

40-50 kg fuel savings for twin-engined medium haul aircraft (A320)

90-100kg fuel savings for a twin-engined long-haul aircraft (B777)

Reduction of Emissions using CDAs in TMA in Czech Republic (REACT-CR)

**Project members**
Air Navigation Services of the Czech Republic, Czech Airlines, Pildo Labs

**Main project objectives**
REACT-CR started in October 2010 with the aim of introducing more efficient flight profiles in Prague Ruzyně Airport

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*Benefits were obtained in low/medium traffic conditions and cannot be extended to peak periods where demand is close to or exceeds capacity.*
Flight Trials for lower CO$_2$ emissions during transition from en-route to final approach

Project members
Deutsche Lufthansa AG, DFS Deutsche Flugsicherung GmbH, Germanwings GmbH

Main project objectives
The main objective was the optimisation of the vertical profile of arrivals to Cologne from the southeast in a high-density traffic area. Cologne, Dusseldorf and Frankfurt airports account for more than a third of total aircraft movements at Germany’s main airports, but are located within 100n.m. of each other.

Number and duration of trials
Since 14 April 2011, when an Airbus 319 performed the company’s first ever CDA at Prague, more than 200 CDAs have been performed during CSA regular operations. Data from a total of 668 flights was analysed to learn about the environmental benefits that these operations will have in the future.

Results
Benefits have been estimated to be about 65 kg of fuel savings per A319/A320 flight, and about 96 kg of fuel savings per A321 flight. Annual extrapolations of CO$_2$ savings for CSA are potentially about 2,080 tons (approximately €500,000). The potential savings for all the A319, A320 and A321 approaches performed at Prague have been estimated to be more than 1,400 tons of fuel and 4,600 tons of CO$_2$ annually.

Terminal area. The overall objective was to pre-operationally implement Continuous Descent Approaches at Prague airport and perform validation trials during Czech Airlines (CSA) regular operations.

Number and duration of trials
Since 14 April 2011, when an Airbus 319 performed the company’s first ever CDA at Prague, more than 200 CDAs have been performed during CSA regular operations. Data from a total of 668 flights was analysed to learn about the environmental benefits that these operations will have in the future.

Results
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The very ambitious preparation trial in 2010 saved up to 650kg CO$_2$ (200kg fuel) per flight, but led to potential conflicts with other traffic streams. In 2011 a different solution was tested with a shallower profile, which gave potential cuts in CO$_2$ emissions of about 110kg (35kg fuel) per flight. Reductions of up to 3,700kg CO$_2$ (1,200 kg fuel) could be achieved per day.
Reduction of Emissions in Terminal Areas using Continuous Descent Approaches – 2 (RETA-CDA 2)

**Project members**
INECO, Crida, Aena, Iberia, Air Europa, Vueling

**Main project objectives**
The RETA-CDA project in AIRE 2009 demonstrated that CDA flights done by commercial flights deliver positive average savings in fuel burn along with CO₂ reductions. The purpose of RETA-CDA 2 was to demonstrate the repeatability and predictability of CDOs by:
- analysing their performance on commercial flights from a wider scope i.e. from ToD
- assessing the time deviation between the flights’ estimated and real profiles and the impact of the major influencing parameters;
- evaluating the link between lost opportunities for CDO with the time deviation (if it exists).

**Number and duration of trials**
Flights were performed between February and September 2011 by three airlines resulting in the monitoring of 3,039 potential flights of which 210 were eligible for deviation assessment.

**Results**
CO₂ benefits per flight of CDO in Madrid have been estimated to be 250 to 800 kg representing 25% less fuel used on the descent phase.

CDOs have been performed daily for the last six months with no major difficulty for the pilots or the ATCO.

En-route / oceanic

**Dynamic Optimisation of the Route In flight (DORIS)**

**Project members**
NAV Portugal, Air Europa, Iberia, INECO, AESA, SENASA, FAA

**Main project objectives**
Implementing a real time flight monitoring procedure looking for optimised flight routes in the transatlantic environment.

**Number and duration of trials**
The project flights trials phase took a four month period, from March to June 2011, with more than 100 flight candidates from each of the airlines on which 110 flight optimisations for both airlines where found.

The project showed that it is possible to achieve environmental benefits with available operational and technical optimisation, such as ATM flexibility in the North Atlantic random route airspace as well as full exploitation of datalink communications between the airline HQ and the aircraft, via ACARS, and between the aircraft and the ACCs, via FANS CPDLC.

The DORIS optimisation process improved the flexibility to change flight routes in flight without introducing a significant workload for either the ATC or the flight crew. The results suggest updating airlines should update policy to enforce the use of these optimisation procedures in every day operations.

**Results**
The results assessed from 44 flights (detailed data available) showed that the optimised routes achieved an average 995kg reduction in fuel consumption per flight, with CO₂ emissions reduced by 3,134 kg, representing 2.5% of both total fuel used and CO₂ emissions for the entire flight.

ONATAP

**Project members**
NAV Portugal, Office National Des Aéroports, TAP Portugal

**Main project objectives**
The consortium implemented shorter flight routes from a combination of free route airspace at Lisbon FIR and direct route creation at Casablanca FIR.

**Number and duration of trials**
The demonstrations were performed with TAP Portugal A320s, A330s and A340s, operating across Lisbon and Casablanca FIRs, departing from Portugal (Lisbon) to Africa (Dakar, Bissau, Bamako, Accra, Luanda and Maputo). The project
Trial phase was a culmination of one year of collaboration between the different partners, with a flight trial period of five months, from June to October 2011, including 999 flights.

**Results**

New flight paths led to an average time saving of 2:32 minutes per flight and a reduction of 167 kg in fuel consumption, leading to a decrease of 526 kg in CO$_2$ emissions.

The stakeholders also agreed that the increased regional collaboration and exchange of information improved the common situational awareness of traffic and may foster future developments on flight operations.

The Europe and North America Go ADS-B for a Greener Environment (ENGAGE) Corridor

**Main Project Objectives**

Evaluation of the potential for reduction of aircraft emissions in the North Atlantic Oceanic airspace (NAT) corridor by varying aircraft altitude and/or Mach Number. Key elements were to minimise the impact on overall system safety and not affect other NAT flights.

**Number and Duration of Trials**

The trials followed two “proof of concept flights” flown on United Nations World Environment Day in June 2010 and ran from July to November 2011 and included 23 flights between Europe and North America. Altitudes varied from FL320 to FL400, with the largest range for a single flight being 3,200ft. Each of the flights varied their altitude during the oceanic portion. Mach number for all trials was between 0.770 and 0.846, with the largest variation for a single flight being 0.025. 16 of the 23 optimised flights varied their Mach number during the Oceanic portion of their flight.

**Results**

An average of around 416 Kg of fuel and around 1,310 kg of CO$_2$ were saved per flight, representing approximately 1.9% of the planned oceanic fuel burn. Given procedure and system modifications, up to 7,300 flights per year could achieve benefits from ENGAGE-like operations, yielding CO$_2$ reductions of over 9 million kg.
Reduced Longitudinal Separation Minimum in the North Atlantic

**Project members**
NATS, NAV CANADA, Air France

**Other airlines participating:**
British Airways and United Airlines

**Main project objectives**
The North Atlantic has one of the busiest oceanic traffic flows in the global ATM system, with up to 1,200 movements daily between Europe and North America. The purpose of the AIRE RLongSM project was to assess the benefits of RLongSM with regard to the efficiency of flights within the Shanwick and Gander Oceanic Control Areas. The new reduced longitudinal separation minimum of five minutes (the normal standard is ten minutes) was introduced in March 2011 on the North Atlantic Organised Track System (OTS) between pairs of aircraft that are GNSS equipped.

**Number and duration of trials**
During the project, flights from 41 different operators were involved in scenarios in which RLongSM was applied, resulting in 433 applications of the separation standard in Shanwick and 665 applications in Gander. Air France conducted a fuel burn analysis on 53 occasions in which the reduced minimum was applied to their flights as a means of enabling oceanic step climbs when they would have otherwise not been possible. British Airways and United Airlines also provided data on the benefits achieved.

A safety assessment also found that RLongSM had no detrimental impact on safety. There was no increase in the reporting rate of safety events nor any variation in the factors that contribute to risk in the NAT.

**Results**
The assessment concluded that up to 140Kg of fuel could be saved with each application of RLongSM, leading to a direct yearly reduction in greenhouse gas emissions in the NAT of approximately 1.2 million kg, based on the current application rate of the separation standard. These savings are predicted to grow with the expected increase in use of ADS-C. The assessment also illustrated the importance of meteorological conditions when optimising oceanic flights for optimum fuel consumption.
Gate-to-gate

Green Shuttle

**Project members**
Airbus, Air France, DSNA

**Main project objectives**
The main objective of this trial was the optimization of the flight trajectory between Paris-Orly and Toulouse and Toulouse-Paris Orly both laterally and vertically. Significant differences could be observed during the trial depending on the flight direction (i.e. descent optimisation at Toulouse airport).

**Number and duration of trials**
60 flights between 15 November and 3 December 2010.

**Results**
**Improvement solutions from Paris-Orly to Toulouse (19 optimised flights):**
- Continuous Descent from TOD to runway 14 and runway 32

Fuel savings: 70 kg/flight, 650 kg CO₂/day

**Improvement solutions from Toulouse to Paris-Orly (41 optimised flights):**
- User preferred profile - vertical: cruising at optimised FL340
- Continuous Descent from TOD to IAF
- CDA from IAF to runway

Fuel savings: 200-250 kg/flight, 2,850 kg CO₂/day

A380 Transatlantic Green Flights

**Project members**
Airbus, Air France, NATS, NAV CANADA, FAA

**Main project objectives**
The project looked at two aspects of optimising Air France transatlantic flights with the Airbus A380 between New York JFK airport and Paris CDG airport: two-engine taxi-out and optimised en-route transatlantic trajectory:
- Taxi optimisation at New-York JFK airport in high density environment

Between December 2010 and April 2011 fifteen two-engine taxi-outs were performed in 38 flights.

**Results**
The average fuel saving was 360 kg (1,2 tons of CO₂)

- En-route trajectory optimisation in high density North Atlantic region

Taking advantage of the high optimum cruise level of the A380 (FL 390 and above) the control centres for the oceanic airspace of Gander (NAV CANADA) and Shanwick (NATS) facilitated the flight to leave the Oceanic Track System in order to take best advantage of actual wind conditions.

Four North-Atlantic trajectory optimisations were performed on 22 flights between December 2010 and April 2011.

**Results**
Average fuel saving was 600 kg (1,9 tons of CO₂), or 1% of the average fuel consumption for the oceanic cruise segment.

Paris-Point à Pitre Transatlantic Green Flights (TGF)

**Project members**
DSNA, NATS, NAV Portugal, Adacel, Air France, FAA

**Main project objectives**
Evaluation of the potential benefits of implementing Transatlantic Green Flights for Paris-Orly to Point à Pitre Airports.

This project was based on three types of optimisation:
- oceanic optimisation in the lateral domain
- oceanic optimisation in the vertical domain
- optimisation in the approach
Number and duration of trials
Evaluations for each type of optimisation were performed separately and carried out between February and July 2011 with the intention of transition into standard operations.
• Lateral domain: 6 potential, 1 optimised
• Vertical domain: 12 potential, 8 optimised flights
• Approach: 15 potential, 8 optimised flights

Results

Lateral domain
• The TGF lateral trial did not permit to gather enough results to measure environmental benefits

Vertical domain
• The average CO₂ emissions reduction measured is between 660kg and 2090kg per flight.

Approach
• Average CO₂ emissions reduction of 1050 kg per flight.

Greener Wave

Project members
SWISS, Zurich Airport, Skyguide

Main project objectives
The GREENER WAVE project demonstrated the feasibility of reducing carbon dioxide emissions during the first arrival wave of long-haul flights in to Zurich by addressing efficiency considerations. The prevailing ATC concept of "first come, first served" had the drawback of queuing aircraft at the arrival route entries just before the end of the night ban at Zurich Airport. GREENER WAVE attempted to improve the situation by assigning a 4D slot prior to starting the approaches of all SWISS aircraft in the early-morning arrival wave. As a result of its overall success, the principles of GREENER WAVE remain operational. A total of 1700 flight trials were part of the evaluation.

Results

Evaluation of 15,000 flights throughout the project revealed a 75% decrease in holding time. The cruise phase was flown closer to optimum speed and the punctuality of the arriving flights increased. Overall, the savings in CO₂ emissions amounted to 160kg of fuel per flight, or 1,800 tons a year.
Validation and Implementation of Next Generation Airspace (VINGA)

**Project members**
LFV, Göteborg Landvetter Airport (Swedavia), Quovadis, Novair

**Main project objectives**
The VINGA project aimed to demonstrate the potential for reduced CO\(_2\) emissions and noise from the en-route phase of the arriving flight into Göteborg Airport, Sweden, through the approach, landing, and surface phase, to parking. Validation activities continued until the aircraft left Swedish airspace. The project therefore contained all components included in the traditional gate-to-gate concept, but in a slightly different order. 178 flights trials were performed using RNP approaches and 11 flight trials using RNP transition to ILS.

**Results**
The implementation of RNP STARs and RNP AR approaches has the potential to save up to 22-90 kg of fuel (70-285 kg CO\(_2\)) per flight, depending on the runway in use. This corresponds to fuel savings of up to 11% per flight in the later part of the flight (measured from a given distance (radius) of 200 NM from the airport reference point). The savings were achieved by flight path shortening and by allowing the aircraft to leave the en-route phase at an optimum ToD, followed by an unconstrained CDO.

Analysis of speed constraint removal in the departure phase showed that 55 kg of fuel (165 kg CO\(_2\)) per flight could be saved with negligible changes to the noise contours with respect to Swedish environmental legislation.

Green Connections

**Project members**
LFV, Swedavia, SAS, Rockwell Collins France and GE Aviation

**Main project objectives**
The overall aim was to generate a green connection between the Gothenburg and Stockholm city pair, by using existing technologies such as performance-based navigation and data-link communication to reduce the environmental impact on every flight segment.

Green Connection flights also performed a 4DT exercise, where the aircraft’s trajectory was downlinked every three minutes throughout the entire flight mission. The aim was to validate how the quality of the input data affected the FMS-generated trajectory and how long before departure the aircraft’s trajectory ideally could be shared.

**Number and duration of trials**
The project performed trial flights during a four-month time window, starting on 15 December 2011. A total of 100 flights where performed using the new designed RNP AR approach into Stockholm Arlanda Airport, of which 25 was performed as full gate-to-gate validations.

**Results**
Early calculation indicates that approximately 70 kg of fuel and 220 kg of CO\(_2\) could be saved per flight. Noise exposure is expected to be reduced, but an estimate cannot be given at this early stage. These calculations are based on simulated flights – more detailed calculations will take place when the 100 flights have been executed.
Trajectory Based Night-time CDA’s at Schiphol Airport

**Project members**
KLM, LVNL, NLR

**Main project objectives**
The goal was to reduce emissions by increasing the percentage of top-of-descent CDA’s into Schiphol airport at night by applying the SESAR concept. The trial used an experimental pre-planning system to optimise the handling of arriving traffic.

**Number and duration of trials**
The trials were progressively executed between May 2011 and November 2011. In October and November a test week was executed in which all inbound traffic participated. About 50% of the test nights were hampered by respectively storm (October) and dense fog (November). A total of 124 flights received a planned time of arrival and were part of the trial execution.

**Results**
- Important demonstration of CDA implementation at Schiphol airport
- Improvement of night operations, in particular the effectiveness and workload of controllers
- Potential 80 tons of CO$_2$ savings during the trials.