AMBER Project

Arrival Modernization for Better Efficiency in Riga

Demonstration Report

Document information	
Project Title	AMBER
Project Number	01.03
Project Manager	Air Baltic
Deliverable Name	Demonstration Report (B1)
Edition	01.01.002

Task contributors
Air Baltic Airbus Prosky Latvijas Gaisa Satiksme

Abstract

This document provides the Demonstration Report for the AMBER Project, describes how the project demonstrations have been conducted, and provides the results of the demonstration activity.

It presents the solution that has been subject to the proof-of-concept and the assessment and methodology for the data collection processing and demonstration flights.

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	Position & Title	Date
[redacted] Airbus Prosky	[redacted]	11/06/2014
[redacted] AIR BALTIC		01/07/2014

Reviewed By - *Reviewers internal to the project.*		
Name & Company	Position & Title	Date
[redacted] LGS	[redacted]	04/07/2014

Approved for submission to the SJU By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
[redacted] AIR BALTIC	[redacted]	04/07/2014

Rejected By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
N/A	N/A	N/A

Rational for rejection
None.

Document History

Edition	Date	Status	Author	Justification
01.01.001	03/07/2014	Final	[redacted] *(Airbus Prosky)* [redacted] *(Air Baltic)*	First edition
01.01.002	12/09/2014	Final	[redacted] *(Airbus Prosky)* [redacted] *(Air Baltic)*	Revision to include SESAR comments on Edition 001

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

Table of Contents

Executive summary

The AMBER project stands for "Arrival Modernization for Better Efficiency in Riga". This project was led by a consortium formed by Air Baltic, Quovadis (who later was renamed Airbus Prosky) and Latvia's traffic service provider LGS (Latvijas Gaisa Satiksme).

The objectives of the AMBER project were:

- To demonstrate regional turboprop aircraft capability of flying tailored RNP AR procedures, in order to reduce CO2 emissions by achieving track mile savings together with Continuous Descent Operations (CDO), compared to conventional procedures;
- To optimize the arrival routes into Riga International Airport's RWY 18 using PBN technology;
- To reduce the noise impact, where possible, over populated areas using vertical profiles.

The AMBER initiative introduced in Latvia a proven advanced form of GNSS-based precision operation. It takes full advantage of RNP AR capabilities for a variety of aircraft including jetliners (such as Airbus, Boeing and Bombardier aircraft), as well as turboprop aircraft such as the Q400 Dash 8, by designing and validating through approximately 100 revenue flight demonstrations, RNAV (RNP) STARs and RNP-AR approaches for the arrival to runway 18 of Riga International airport. This project also foresees the training of local Air Traffic Control personnel to handle efficiently and without disruption the mix of RNP and non-RNP capable aircraft during the flight demonstrations and prior to full implementation.

The project has been divided into seven work packages and distributed in three phases to be completed within 24 months of the project start. Phase 1 addressed the design, testing and validation of the procedures; Phase 2 encompassed the flight demonstration activities and analysis of results; and Phase 3 addresses the communications and public relations activities.

Two approaches have been designed. The first one, called RNAV(RNP) approach Z RWY 18, is a slightly longer track ensuring a comfortable 2 NM straight-in final segment. The second one, called RNAV(RNP) approach Y RWY 18 has been designed in order to increase track mile savings, by designing a shorter track with a slightly more challenging last turn and only 1 NM straight-in final segment.

The demonstration flights have been carried out under Visual Meteorological Conditions (VMC), in block periods spanning approximately 9 months between Mid-September 2013 and end of May 2014. 371 flights were dispatched as trials flights; 124 of them performed a successful AMBER arrival, either 18Z or 18Y. The other flights did not start the approach or had to cancel the approach mainly due to weather issue, RWY 36 in use or ATC rejection.

The implementation of Flight Data Monitoring (FDM) during the flight trials also allowed the Consortium to compare specific measurements such as fuel burn/CO2 emissions, air distance flown, flight time or level-offs during approach, between conventional approaches under radar vectors and AMBER approaches to Riga Airport's runway 18. As expected, results show that the use of RNP AR procedures can lead to savings up to over 15 NM of flight distance / 60Kg of fuel per approach.

The AMBER project is part of the Atlantic Interoperability Initiative to Reduce Emissions (AIRE) programme, aiming to reduce CO2 emissions, capitalise on today's aircraft technology, and accelerate the uptake of ATM best practices. AMBER thus demonstrates measurable immediate benefits at hand that can be used to improve operations efficiency and trigger a rapid deployment across Europe.

1 Introduction

1.1 Purpose of the document

This document provides the Demonstration report for the AMBER project at Riga airport. It describes the results of demonstration exercises defined in the demonstration plan (Project Number 01.03, Edition 01.00.002) and how they have been conducted.

1.2 Intended readership

The SESAR Joint Undertaking (SJU) and, specifically, the SJU's points of contact and reviewers assigned for AMBER will find this document particularly interesting as it provides a detailed analysis regarding use of RNP AR in Riga International Airport RW18.

Secondly, this document shall be a very useful tool for all members of the project as it contains clear descriptions of all technical and operational concepts, details and tools used during the project.

Finally, the document might provide remarkable inputs to other projects dealing with the introduction of RNP AR procedures in terminal airspaces, as well as introducing RNP AR procedures for regional turboprop aircraft.

1.3 Structure of the document

The document is organized as follows:

- Section 1 is the introduction;
- Section 2 presents how this project and the demonstrations contained in it are related with the SESAR program and the near-future objectives of the ANSP;
- Section 3 explains the project management;
- Section 4 provides an overview of the exercise execution and planning;
- Section 5 provides information regarding exercise results but also the project's conclusion and recommendations.
- Section 6 summarizes the project's communication activities ;
- Section 7 presents the last steps to be conducted in order to finalize the project;
- Section 8 provides the list of applicable and reference documents.

1.4 Glossary of terms

Continuous Descent Approach (CDA). An approach, enabled by airspace design, procedure design and ATC facilitation, in which an arriving aircraft descends continuously, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, until the final approach fix /final approach point.

1.5 Acronyms and Terminology

Term	Definition
ACC	Area Control Center
AIRE	Atlantic Interoperability Initiative to Reduce Emissions
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
CAA	Civil Aviation Authority
CAT	Category
CDA	Continuous Descent Approach
CTR	Control Zone
DFDR	Digital Flight Data Recorder
DMU	Data Management Unit
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology
ESSIP	European Single Sky Implementation Plan
FAP	Final Approach point
FIR	Flight Information Region
FL	Flight Level
FMS	Flight Management System
GNSS	Global Navigation Satellite System
IAF	Initial Approach Fix

Term	Definition
ILS	Instrument Landing System
KPA	Key Performance Area
KPI	Key Performance Indicator
LoA	Letter of Agreement
MSL	Mean Sea Level
OFA	Operational Focus Areas
PBN	Performance Based Navigation
P-RNAV	Precision RNAV
QAR	Quick Access Recorder
RNAV	Area Navigation
RNP	Required Navigation Performance
RNP APCH	Required Navigation Performance Approach
RNP-AR	Required Navigation Performance with Authorization Required
RWY	Runway
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
STAR	Standard Arrival Route
ToD	Top of Descent
TWR	Tower
WP	Work Package

Table 1: Summary of the scope for Riga RNP AR procedures

2 Context of the Demonstrations

2.1 Scope of the demonstration and complementarity with the SESAR Programme

The scope of the AMBER project was to design, validate and test RNAV (RNP) STARs and RNP-AR approaches for arrivals to runway 18 of Riga International Airport (RIX-EVRA). The objectives were to demonstrate a reduction of track miles, reduction of fuel consumption (therefore CO_2 emissions) due to optimized vertical and horizontal paths, and reduction of noise (where possible) compared with conventional arrival procedures.

Other expected benefits of the project include improvement to airport access, and optimization of the TMA airspace by taking full advantage of RNP capabilities and reduction of ATC workload.

The CAA of Latvia has approved the use of GNSS as a valid sensor for RNAV/RNP operations, which establishes the framework for the use of GNSS systems for navigation application in Latvia. This very important step, in line with ICAO recommendations to promote the deployment of PBN procedures, paves the way and perfectly embeds the AMBER project within the international program for the reduction of aircraft emissions, AIRE.

AMBER has demonstrated the value of PBN and the benefits of optimized tracks in combination to navigation accuracy, in line with AIRE's objectives to produce constant step-based improvements to be implemented as quickly as possible after the projects conclusion in order to contribute to the achievement of environmental savings.

Demonstration Exercise ID and Title	EXE-01.01-D-001 : RNP AR Operations at Riga
Leading organization	Air Baltic / Airbus Prosky
Demonstration exercise objectives	Design and validate RNP STARs and RNP AR approaches to Runway 18 at Riga International Airport (EVRA)
OFA addressed	02.01.01 Optimized RNP Structures 02.02.01 CDA
Applicable Operational Context	Riga Airport Riga TMA Riga FIR
Demonstration Technique	Flight trials Aircraft data capture
Number of trials	≥ 100

Table 2: Exercises overview

3 Programme management

3.1 Organisation

The Consortium of the AMBER project is composed by three partners: Air Baltic (the national airline carrier of Latvia), Airbus Prosky (formally named Quovadis), and LGS ("Latvijas Gaisa Satiksme" the Latvia agency for air traffic management).
Per the SESAR Integrated Flight Trials and Demonstrations Activities Agreement for the AMBER Project [5], Air Baltic will be acting as project leader, while Airbus Prosky and LGS will be acting as "Consortium Members". Finally, the CAA of Latvia and the Riga Airport authority will participate in the project, with their respective duties, and regulatory implication on the envisaged activities for the project.

Figure 1 below displays an overview of the project organization:

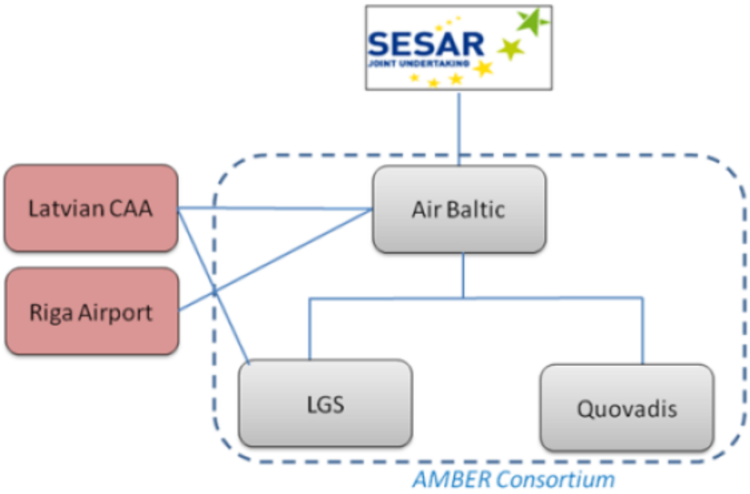


Figure 1: Project organization chart

Table 3 below provides the focal points assigned by each Consortium Member:

	Project Focal Point	Technical Focal Point	Financial Focal Point
Air Baltic	[redacted]	[redacted]	[redacted]
Airbus Prosky	[redacted]	[redacted]	[redacted]
LGS	[redacted]	[redacted]	[redacted]

Table 3: AMBER Project Focal Points

3.2 Work Breakdown Structure

The AMBER project is formed by seven (7) work packages (refer to Figure 2). Each work package is led by a Consortium Member with the contribution of other project members and participants.

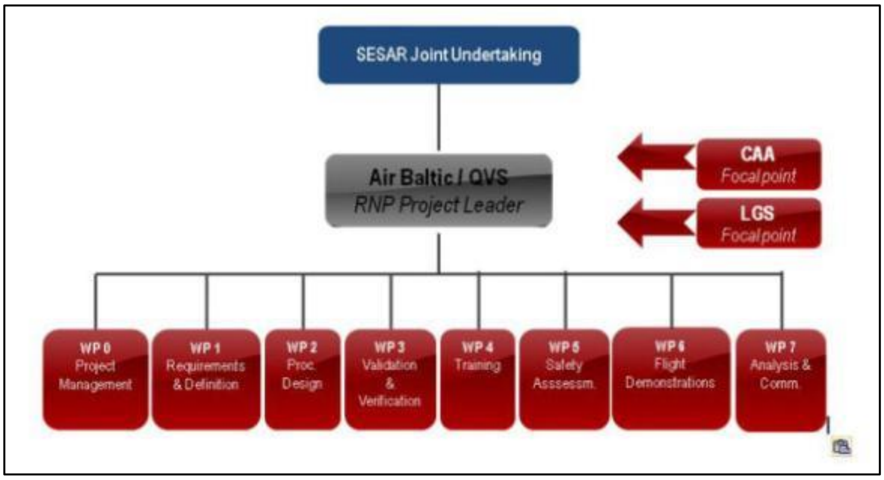


Figure 2 : Work breakdown structure of AMBER

The work packages are distributed into three (3) distinct project phases as shown in Figure 3.

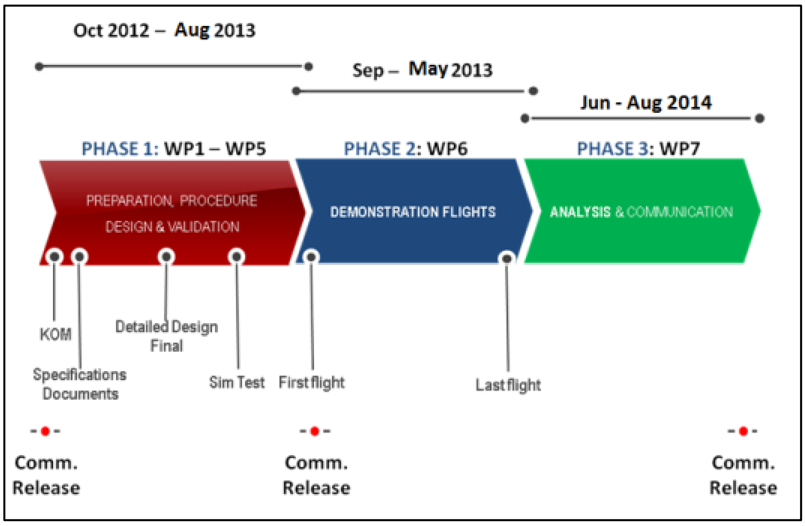


Figure 3 : Work package distribution of AMBER Project

Phase 1 of the project encompasses WP0 to WP5, which includes overall project management, procedures design work, safety assessments, and development of operational procedures prior to commencement of the flight demonstration activities. Figure 4 next page displays the work development that will take place during Phase 1 of the project.

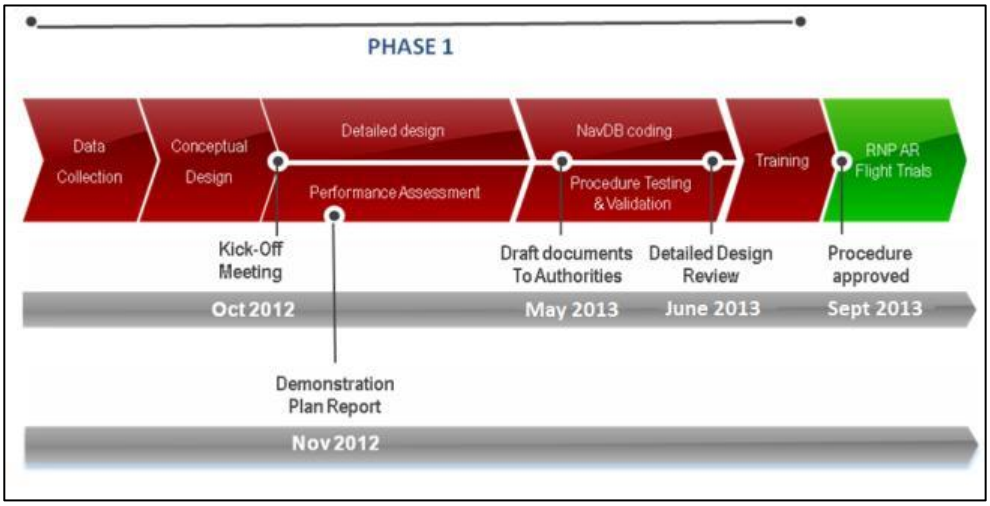


Figure 4: Phase 1 activities for AMBER

WP0 (Project Management) concentrated on the overall management and coordination activities of the project, most importantly interfacing with the SJU on behalf of the Consortium Members. Control of the project deadlines, milestones and accomplishments, budget actions, risk management, communications activities and deliverables submission is included as part of this WP.

✓ Air Baltic, as project coordinator, led WP0.

WP1 (Operations requirements specifications) defined the ANSP and the airlines operational needs, assessment of local RNP AR regulations, and the requirements for the flight demonstration activities. The main deliverable for this work package is a Project Specifications document detailing the factors and criteria agreed between all project parties for the design of the procedures at Riga airport.

✓ Air Baltic and Airbus Prosky both led WP1;
✓ LGS validated the conclusions reached during WP1 and approved the project specification.

WP2 (Procedure design) addressed the design of the flight procedures. The conceptual design has been discussed during the kick-off meeting in October 2012, and has been frozen prior to starting the detailed design. The deliverables of this work package include procedure technical reports, production of navigation database coding and charts resulting from the detailed design work. The resulting material has been analyzed, validated and accepted by the Consortium Members prior to start the ground and flight simulation tests.

✓ Air Baltic and Airbus Prosky both led WP2;
✓ LGS participated to the detailed design definition throughout the process, and then accepted the flight procedures when they were designed

WP3 (Validation and verification) encompassed the ground validation, flight simulator, and aircraft performance tests required as inputs for the Flight Operations Safety Assessment (FOSA) document of WP5. These tests also ensure that the designed procedures are flyable under agreed parameters. The deliverables of this work package are the simulator validation test results.

✓ Airbus Prosky led WP3 in close collaboration with Air Baltic

WP4 (Training) defined the flight crew and ATCOs training requirements prior to commencing the demonstration flight trials. This includes the review and dissemination of training guidelines and syllabus for aircrews to adopt, and ATC training on the developed procedures to ensure efficient clearances during the demonstration activities. Deliverables of this work package include training syllabus for both operators and ATC.

- ✓ Airbus Prosky led WP4, to define the training requirements and propose the training plan and materials for both flight crews and air traffic controllers
- ✓ Air Baltic was involved in organizing and coordinating the flight crew training activity
- ✓ LGS was involved in organizing and coordinating the air traffic controllers training activity

WP5 (Safety Assessment) encompassed the activities required to produce the Flight Operation Safety Assessment and ATC Safety Assessment document deliverables for the TMA and the aircraft types participating in the demonstration flights.

- ✓ Airbus Prosky and LGS led WP5
- ✓ Air Baltic coordinated the development and validation of these assessments.

WP6 (Flight Demonstrations and Evaluation) was part of Phase 2 of the AMBER project. In this phase the Consortium accomplished exactly 124 successful demonstration flights at Riga. The aircraft equipment utilized on these flights was based on operator's availability, trained crews and ATCOs present for the demonstrations. The deliverable of this work package are initial reports resulting from the Flight Data Monitoring outputs and radar tracks obtained from the flights, in addition to other statistical information that can be obtained during the time these operations take place.

- ✓ Air Baltic led WP6.
- ✓ Contributors included Airbus Prosky and LGS.

WP7 (Analysis and Communication) was part of Phase 3 of the AMBER project and dedicated to the Awareness & Dissemination activities also outlined in the Communications Plan described in Section 7 of this document. Figure 5 below provides a high level view of the timing expected for the communications activities related to major project milestones:

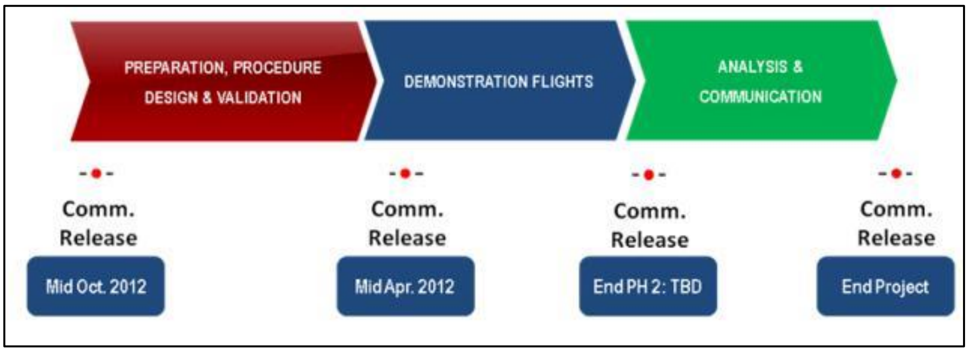


Figure 5 : Milestone Comm. Releases of AMBER

- ✓ Air Baltic and Airbus Prosky both led WP7.
- ✓ LGS provided support by providing some data and analysis on the recorded flight trials.

3.3 Deliverables

The AMBER Kick-Off meeting took place on 4 October 2012 at Air Baltic Training Centre in Riga.

The following dates were met for the various deliverables.

Deliverable Name	Date
Demonstration Plan (A1)	November 2012
KOM Minutes of meeting	October 2012
Technical Review	October 2013
Start of flight trials	September 2013
Final Review	July 2014
Demonstration Report (B1)	September 2014

Table 4 Formal deliverables dates

3.4 Risk Management

A risk is any foreseeable circumstance that might affect the project in a negative way, and which shall be identified as early as possible in order to plan mitigation actions. A responsible entity has been assigned to each risk. Below is the initially identified risk table.

WP	ID	Risk description	Probability assessment (Low/Medium/ High/ Very high)	Severity assessment (Low/Medium/ High/ Very high)	Mitigation actions	Owner
WP1	1.1	The members of the Consortium do not agree on the project planning and execution	Low	Medium	Re-discuss planning, and deployment plan	Air Baltic
WP 2	2.1	The CAA of Latvia / LGS does not agree on the conceptual design / necessary mitigations to design criteria.	Low	High	Provide suitable justifications in documentation / or change design	Air Baltic
WP 2	2.2	The members of the consortium do not agree on the conceptual design / request a change of procedure.	Low	High	Change the conceptual design in the specification	Air Baltic
WP 2	2.3	The CAA of Latvia / LGS do not approve/sign the detailed design of the RNP procedure.	Low	High	Define a change request that all members accept	Air Baltic
WP 6	6.1	The aircraft operated by the Air Baltic are not equipped / capable to fly RNP AR procedures.	Medium	High	Find acceptable mitigation means, by procedure change or adapted crew training	Air Baltic
WP 6	6.2	Operations requirements by the CAA of Latvia for the demo flights cannot be met by Air Baltic.	Low	High	Find acceptable mitigation means, by procedure change or adapted crew training	Air Baltic
WP 6	6.3	ATC personnel do not give the required RNP AR approach clearances during demo flight period.	Low	High	Analyze the reasons for restrictions, and find adapted training and procedures to allow the trials	LGS
WP 7	7.1	Figures retrieved from Flight Data captured by Air Baltic during the RNP AR demo flights are not comparable to Flight Data captured for conventional procedures.	Low	Medium	Find adapted figures to allow for meaningful comparison	Air Baltic

Table 5 - Potential project risks

Each risk has been properly mitigated during the entire project, thus none of described risks have occurred.

4 Execution of Demonstration Exercise

4.1 Exercise Preparation

The preparation activities included all necessary activities, in order to prepare the design, validation and implementation of the RNP procedures.
This included:
- Determining the operational needs and considerations of Air Baltic, in order to choose optimal solutions to design the RNP flight tracks;
- Assessing ATC constraints and needs, in order to define an optimal solution that fits in today's traffic management strategies, as well as enable capacity increase when using the RNP arrival tracks. Main risks from ATC perspective were identified, namely discontinuation of the RNP arrival at different altitudes as well as increased workload for the ATC controllers due to mixed traffic;
- Assessing the local regulation, in order to mutually agree on acceptable regulatory baselines with the CAA before approval of the procedure;
- Assessing all constraints and local requirements in order to ensure that the procedures are easily implemented in the local environment of Riga airport operations (eg: obstacles, noise-sensitive areas, airspace constraints).

4.2 Exercise Execution

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise analysis start date	Actual Exercise end date
EXE-01.01-001	RNP STARs and RNP AR approach demonstrations into RWY 18 of Riga airport.	4 Oct 2012	May 2014	April 2014	July 2014

Table 6: Exercises execution/analysis dates

The AMBER project was launched on 4 October 2012 in Riga with the participation of the Consortium Members, with a maximum duration of 24 months. The demonstration flights into Riga were performed between September 2013 and May 2014. A total of 124 demonstration flights were performed, of those 122 were recorded for the data analysis. For 2 flights no data was recorded due to technical error in the used data recording process.

Due to operational requirements and external factors to the project (i.e. weather), the flight demonstrations lasted longer than expected (9 months instead of 4). Considerations to keep in mind include: available scheduled flights on the aircraft type, qualified aircraft and qualified crew, adequate runway in use, arrival in possibly not-limiting traffic situation, availability of Visual Meteorological Conditions for at least the final part below MSA, with trained crews operating RNP equipped aircraft, and trained ATC available at Riga approach control center. Thus a tight planning and optimal cooperation between the Consortium Members were required to successfully execute the flight demonstrations and retrieve appropriate data for analysis.

In order to have a wide picture of the activities that needed to be completed before, during and after the demonstration flights, it is necessary to understand the step by step process of the procedure design, and the geographical context (and area limits) in which these procedures shall be implemented. The intended way in which data will be captured to meet the objectives of the project are explained within each exercise section.

The procedure design process is composed of the conceptual design and the detailed design. When tasked to design procedures, a conceptual design is performed for each airport taking into account the environmental constraints together with the ANSP's and operator's requirements. Items such as the aircraft models, speeds, ATC procedures, AIP information, and operational constraints are all factors taken into consideration during the conceptual design. These design(s) are then presented and discussed during the Kick-Off Meeting.

After presentations and discussions between the interested parties, the conceptual design, project objectives, project planning, applicable regulations were summarized and included in a Project Specifications document, that shall be validated formally by all stakeholders prior to the start of the detailed design.

During the detailed design of the procedures, the project managers and procedure designers ensure that the intended trajectories take into consideration all constraints identified in the conceptual design, ensure paths are flyable and comply with the performance of the aircraft types intended for the procedures. Each flight leg of the procedure is checked to ensure that the aircraft is capable to fly the different constraints (altitude, speeds, and turn radius). If there are significant changes between the conceptual design and the detailed design, changes must be approved by all stakeholders prior to implementation.

Each RNP AR instrument procedure is thoroughly evaluated in a representative simulator to:

- Verify the flyability of new designed instrument procedure;
- Define adequate normal and abnormal flight crew procedures;
- Validate the FMS navigation database coding; and
- Evaluate the absence of TAWS warning when the aircraft is on the nominal flight path.

During this evaluation, the effect of the aircraft design had to be taken into consideration and evaluated in variable conditions such as normal or rare wind and temperature conditions. As necessary wind and/or temperature limitations may have to be defined in addition to the temperature limitation, which may be mandated by the design criteria of RNP AR approach procedures.

Due to inadequate Q400 simulator configuration in Stockholm, Air Baltic used a DH-8 Q400 simulator in Toronto training center to test the flyability of the procedures on DH-8 Q400 aircrafts. Due to its unique relationship to Airbus, Airbus Prosky used the A320 simulators of Toulouse Training Center to test the flyability of the procedures on one jetliner model.

A detailed design review meeting was set by all involved parties on 4th June 2013 to freeze the final design and procedure trajectories prior to final coding and charting. In addition a technical report and a flight operation safety assessment were produced providing pertinent information for the ANSP and operator to prepare training items for crews and ATCOs, and for the authorities (when involved) to deliver any authorizations required by the interested parties upon successful completion of a flight (FFS or live) demonstration. The up to date Navigation Database with RNP AR approaches coded was provided to Air Baltic on June 2013.

To ensure achieving the objectives of the project, a significant quantity of flight data related to present conventional procedures available for Riga airport were captured. These processed results were then compared to the data captured during the RNP AR demonstration flights.

4.3 Deviations from the planned activities

During the testing phase in simulator, it appeared that the RNP AR trajectory agreed during the kick off meeting was restrictive and not enough efficient regarding the design specs for flights coming from West / North West. Therefore, a new RNP approach has been designed for flight coming from the West – North West and has then been connected to all the entry points existing for the first approach.

This led to design two different RNP AR approaches:

- The **RNAV (RNP) Y RWY 18**: This approach is the one initially planned for the project, during the project's definition and kick-off meeting in 2012. It provides the shortest possible track from South/South West arrivals to land on RWY 18, and leads to maximum efficiency and avoidance of nuisance for populations. However, this approach was eventually found to be trickier depending on the meteorological conditions (e.g strong winds). In particular the final turn leads to stabilizing the aircraft rather late in final at 300 ft AAL, and with challenging winds such as westerly crosswind, this may be a challenge for pilots to handle.

  It was decided to keep this approach available for project trials, but to restrict its use to fair weather conditions (good VMC conditions, light wind, absence of crosswind).

- The **RNAV (RNP) Z RWY 18**: refer to 5.1.2.3. This approach provides a longer and more comfortable stabilization segment in final to RWY 18.

Due to operational requirements, external factors to the project (i.e. weather) and late approval (obtained in September 2013), the flight trials began later and lasted longer than expected in the initial project's scope. Indeed, the flight demonstration occurred in August 2013 and the flight trials took place from September 2013 to May 2014. One of the main issues encountered was to be able to combine:

- RNP AR approved aircraft (all the Air Baltic fleet was not capable of RNP AR),
- Trained flight crew for RNP AR operations,
- Adequate runway in use (RWY 18),
- Weather and wind suitable for a VMC approach,
- Light traffic period of day, and ability for ATC to issue the clearance for AMBER approach.

However, more than 100 flights have been performed an AMBER approach at the end of May 2014 and the comparison exercise between conventional approaches and AMBER approaches has then been successfully completed.

5 Demonstration Exercise report

5.1 Demonstration Exercise Report

5.1.1 Exercise Scope

5.1.1.1 Exercise Level

The demonstration exercise of AMBER project covers RNP STARs and RNP AR approach demonstrations into RWY 18 of Riga airport.

5.1.1.2 Description of the Operational concept being addressed

The introduction of PBN is a proven-concept that allows many operational benefits for all aviation stakeholders: airlines, air traffic management organisations, airport and local communities.
Riga Airport is rapidly growing, and therefore, the implementation of modern technologies is a natural step to accompany this growth whilst keeping the environmental-friendly objectives of Latvian aviation development a priority.
In line with this development, Air Baltic is rapidly renewing its aircraft fleet to more modern, more fuel-efficient aircraft, such as Bombardier Q400 NextGen (2013) and Bombardier CS300 jetliner (2015). All these new aircraft are capable of handling modern PBN solutions such as RNP AR approaches.
Therefore, the AMBER project is a trigger to introduce innovative solutions in order to enhance the traffic flow on approach and lower fuel cost and environment footprint.

Procedural and operational improvements within busy TMAs as expected in the AMBER project, are covered by SESAR Traffic Synchronization Priority Business Needs, more precisely by OFA 02.01.01, OFA 02.02.0.

5.1.1.3 Demonstration objectives and hypothesis

The **first objective (OBJ-01.01-1)** of this demonstration exercise is to design optimized lateral/vertical paths and RNP operations. Then, on top of this lateral path reduction, the objective is to provide an approach design that allows no intermediate level offs from entry in Riga FIR to the interception of the final approach path (Continuous Descent Arrival concept) which will further contribute to optimizing the approach path.

The **second objective (OBJ-01.01-2)** of this demonstration exercise is to actually execute flight trials, to demonstrate the successful implementation of these RNP procedures in Riga. This implies carrying out a validation and approval exercise with the CAA of Latvia, in order to grant authorization for these passenger flight trials, properly training and briefing the required personnel including flight crews and ATC, and then capturing the required data, in order to perform a study that will show achievements of introducing new procedures compared to conventional ones.

The **third objective (OBJ-01.01-3)** is Fuel savings and CO_2 emissions reduction on RNP STARs and RNP AR Approach.

This objective is a direct result of the successful completion of OBJ-01.01.01-1. By creating an approach path that allows track miles reduction and optimized flight profile, significant fuel savings can be achieved. This has a direct consequence on CO2 emissions reduction, since CO2 emissions are proportional to fuel burn.

The **fourth objective (OBJ-01.01-4)** is Noise reduction using green trajectories.

Finally, environment concerns in Riga airspace very much include noise –sensitive areas in any study aiming at optimizing flight tracks. In particular, in the case of Riga approaches to RW18, it is essential to avoid overflying the touristic and very noise sensitive area of Jurmala city on the coastline of the Baltic Sea.

5.1.2 Conduct of Demonstration Exercise EXE-01.01-001

5.1.2.1 Approach Design

5.1.2.1.1 Optimization of lateral flight track:

RNP AR approaches allow to design optimized curved paths, to join the required entry points (in Riga: the transfer points at the FIR boundary) to arrive on the final axis. Because the aircraft is stabilized at the FAP on a lateral and vertical guidance and because it is possible to design curved paths after the FAP, it is not required to design an approach with a long straight-in segment of 5-10 nm, as it is the case for an ILS approach for example.

Taking benefit of this, the concept was to design a lateral profile that joins a right-hand “base leg”, just South of Jurmala city, and then turns right to line up in short final of runway 18, with RNP levels set to:

- RNP 1.0 until initial approach fix
- RNP 0.3 during approach
- Gradual increase to RNP 1.0 on missed approach

Below is the corresponding approach chart:

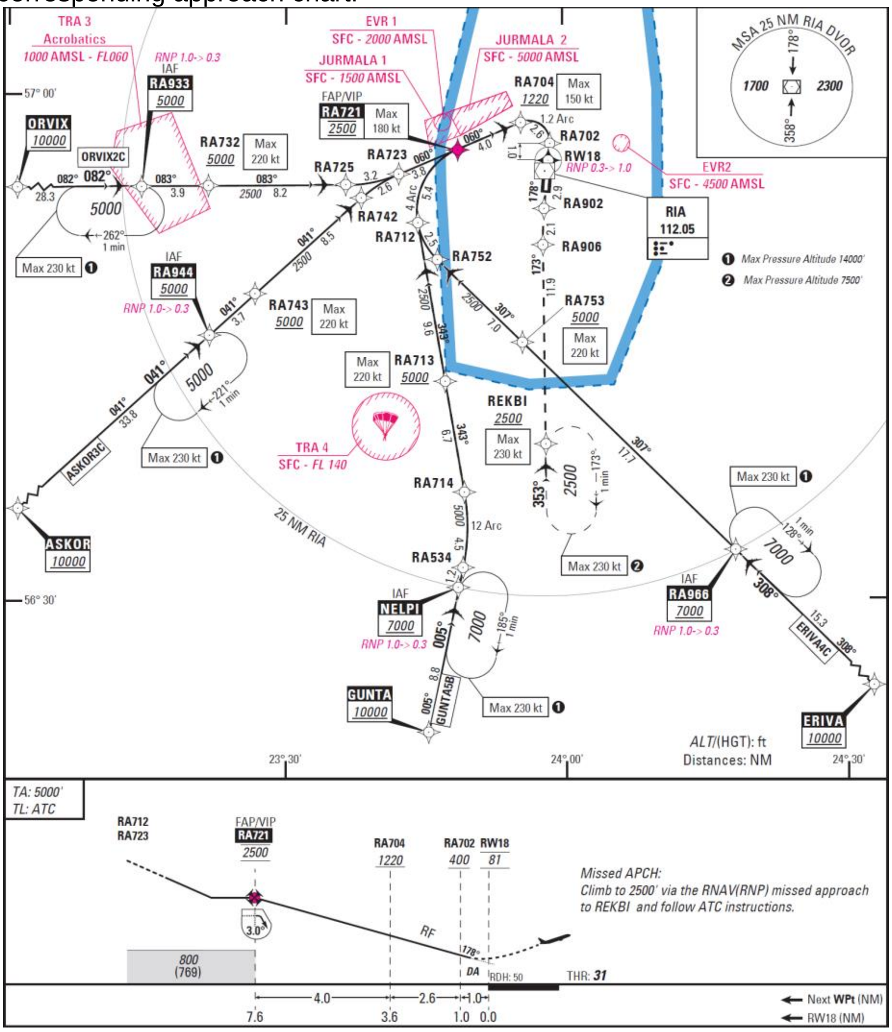


Figure 6: RNAV (RNP) Y RWY 18 lateral track

This is the shortest possible lateral track to connect entry points such as GUNTA or ASKOR to the final approach of RWY 18, taking into account the environmental constraints:

- Not to overfly the populated area of Jurmala City and coastline
- Not to overfly the City of Riga (east of the airport)

For the other entry points, the concept was to join the final part of the approach at the same waypoint (RA721) in order to have a common final approach track. This led to a slightly sub-optimal lateral track for the ERIVA arrivals, which could be shorter if designed east of the airport.

As mentioned in Section 4.3, an additional RNP AR approach has been designed in order to take full benefits of RNP AR capabilities.

The new trajectory allows first to take benefit from RNP AR for flight coming from the West / north-West, but also to increase the last radius, as it is flown over the Gulf of Riga, which was the difficult point of the first RNP AR approach.

The submitted design is the following:

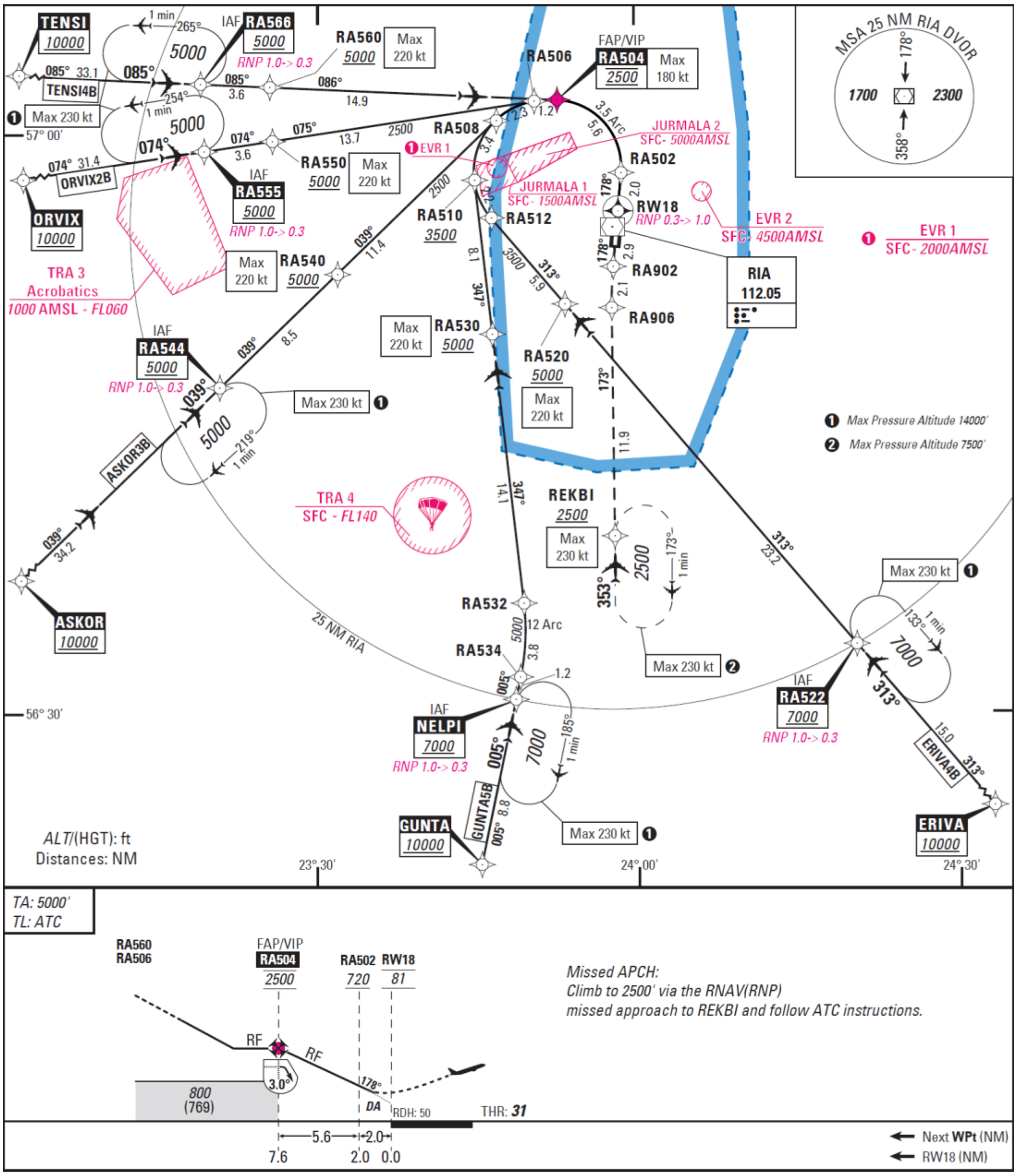


Figure 7: RNAV (RNP) Z RWY 18

The development of this second approach has been conducted in parallel with the other one. Therefore, the design specifications, safety and environmental aspects and methodology used are the same as for RNAV (RNP) approach Y RWY18 (refer to 5.1.2.2).

This second approach (renamed "Z") became the reference track to be used for the trials, having the more challenging "Y" one as a second option to be use in the good conditions after initial RNP AR experience is gained by using the "Z" approach.

5.1.2.1.2 Optimization of vertical profile:

On top of optimizing the lateral track, it is essential that the RNP AR design includes vertical profile optimization. This is achieved by allowing the various aircraft to fly the procedure whilst descending on their optimized descent profile, which is the one calculated by their on-board FMC. This includes:

- Descending at or close to the aircraft's optimal calculated TOD (Top of Descent)
- Avoiding unnecessary altitude constraints that would force the aircraft to descend too low, or stay too high, and then have either an unnecessary level-off or on the other hand an excessive energy level to cope with (use of speed brake, increase of fuel burn).
- Avoiding unnecessary speed constraints that would result in aircraft's early speed reduction increase of overall flight time, and therefore decrease in fuel burn efficiency.

This was achieved by observing the FMC-predicted optimal vertical path (with no constraints) and then adding altitude constraints (for ATC purposes) which were non-restrictive for the aircraft's optimal path. As an example, "at or above 5000ft" constraints were added, where the aircraft is really between 6000 and 8000ft on its optimal descent path.
To ensure compatibility with all aircraft types, a standard jetliner (A320) was used as a reference. The ideal (unconstrained) profile for the A320 was computed using its FMS, and then altitude constraints were added, that are below the optimal profile. Then checks were made in order to verify that the Q400 would be on or close to its ideal profile.

5.1.2.2 Design validation

Once the detailed design frozen and agreed by all the stakeholders, the two approaches have been coded and tested on simulator.

Full flight simulator tests have been conducted on both DH-8 Q400 and jetliner model (A320).

The DH-8 Q400 simulator session took place in Toronto (Bombardier training centre). During the session in a few cases unexpected disconnection of the autopilot near the VIP was observed, resulting in inability to further keep the AP for approach. This was eventually understood as an issue of flight phase transitioning in the FMS. To clear the issue, Air Baltic developed an internal procedure to include a small level-off of 2 NM before the VIP, and ensure the aircraft intercepts the final path in level flight.

The simulation session conducted on the A320 full flight simulator did not raise any concern related to the aircraft.

5.1.2.3 Training

A specific RNP AR training has been provided for both Air Baltic personal and ATC personnel.

5.1.2.4 Safety assessment

Safety assessments have been prepared from perspectives of different participants, with any risks respectively addressed.

- Airbus Prosky prepared a Flight Operational Safety assessment (FOSA).
- Air Baltic prepared a Safety Assessment, based on the FOSA and internal considerations.
- Airbus Prosky and LGS also prepared a safety assessment regarding ATC clearance and monitoring of RNP AR operations.

5.1.2.5 Approval

After providing the full project documentation to CAA for review and demonstrating - through a non-revenue flight demonstrating of all five “Z” arrivals (*) - the navigation system capabilities, aircraft flyability, ATC procedure and communication efficiency as well as operator procedures and crew preparation, Air Baltic received on 13th September 2013 the approval to start flight trials.

(*) The Y approach was approved and introduced later.

5.1.2.6 Flight trials

The first flight trial was flown mid-September, after having being approved by the CAA. Between September 2013 and May 2014, 124 successful AMBER flights were completed. Results are provided in section 5.1.3 of this report.

5.1.3 Exercise Results

5.1.3.1 General

Below is provided the AMBER trial status, for flight trials conducted between September 2013 and May 2014:

	Count of flights		RWY 36 in use	ATC rejected	Weather	Status not reported	RNP APCH problem
Total dispatched trial flights:	371						
Trial dispatched, AMBER approach not started	237	reason:	125	25	85	2	
AMBER arrival started but discontinued	10	reason:		1	6		3
AMBER arrival successfully completed	124						
AMBER arrival completed, no data stored	2						

The key results are provided in the following tables:

Average results on conventional arrivals:

Entry	*Conventional flights count*	*Time*	*Fuel*	*Air dist*	*Level-off*	*Level-off time*	*Flights with level-off*
		min	*kg*	*NM*	*NM*	*min*	*%*
ASKOR	72	20.5	209	91.9	5.1	1.6	29%
ERIVA	125	23.0	262	99.2	5.2	1.7	41%
GUNTA	40	22.9	249	101.8	5.4	1.6	55%
ORVIX	23	18.9	188	86.4	4.1	1.5	26%

Average results on AMBER RNP arrivals:

Entry	AMBER flights count	Time	Fuel	Air dist	Level-off	Level-off time	Flights with level-off
		min	kg	NM	NM	min	%
ASKOR Z	29	20.1	187	84.3	0	0	0%
ERIVA Z	49	23.8	256	100.6	0	0	0%
GUNTA Z	17	20.9	208	91.5	0	0	0%
ORVIX Z	10	19.5	183	82.3	0	0	0%
ASKOR Y	7	18.6	167	77.9	0	0	0%
ERIVA Y	6	21.4	225	91.8	0	0	0%
GUNTA Y	3	19.9	175	82.3	1.6	0.4	33%
ORVIX Y	1	19.1	156	74.8	0	0	0%

Differences:

Entry	Time	Fuel	Air dist	Level-off	Level-off time	Flights with level-off
	min	kg	NM	NM	min	%
ASKOR Z	-0.4	-22	-7.6	-5.1	-1.6	-29%
ERIVA Z	0.8	-6	1.4	-5.2	-1.7	-41%
GUNTA Z	-2.0	-41	-10.3	-5.4	-1.6	-55%
ORVIX Z	0.6	-4	-4.1	-4.1	-1.5	-26%
Average difference AMBER Z vs conventional	**-0.3**	**-18.3**	**-5.2**	**-5.0**	**-1.6**	**-38%**
ASKOR Y	-1.9	-42	-14.0	-5.1	-1.6	-29%
ERIVA Y	-1.6	-38	-7.3	-5.2	-1.7	-41%
GUNTA Y	-2.9	-74	-19.5	-3.8	-1.2	-22%
ORVIX Y	0.1	-31	-11.6	-4.1	-1.5	-26%
Average difference AMBER Y vs conventional	**-1.6**	**-46.3**	**-13.1**	**-4.6**	**-1.5**	**-30%**

Detailed results per KPA are provided in section 5.1.3.3 of this document.

During the AMBER project trials phase a continuous observation process was implemented over trials operational execution from both pilot and air traffic controller perspectives. No outstanding operational observations were received from pilot side, with three cases reported of RNP technical discontinuation as described in 5.1.2.1.2., and one case of slight overspeed. No reports on outstanding operational problems were received from air traffic controllers. Based on both the aircraft recorded and air traffic control radar recorded data AMBER RNP arrivals have shown precise execution and following of the prescribed flight track.

Additional operational advantage associated with execution of RNP AR approach trials is the observed reduction of pilot – air traffic controller communication. Number of communication transmissions is reduced, and the remaining transmissions are standardised and simple.

A related noise measurement and assessment session was realised by Riga International airport in parallel with AMBER trial flights execution. Due to unfavourable location of stationary noise level measuring equipment, it was only possible to measure noise levels of AMBER Z arrivals during the trial. The measured average noise level for AMBER Z approach was 1.2 dBA lower than average of conventional approaches. When calculated for possible measurement errors, it was concluded that the noise level reduction is at least 0.6 dBA. As both Z and Y arrivals imply a very similar aircraft handling concept, it is presumed that also AMBER Y approaches will provide at least equal reduction in noise level, through reduction in noise level could be even higher, due to lower speed restrictions prescribed in the Y arrival procedure. On the other hand, trajectories of the AMBER arrivals are overflying homes of more residents than the current conventional arrivals, where final turns are executed over Baltic Sea. When comparing the positive effect of noise level reductions (minimum 0.6 dBA, measured 1.2 dBA) against the negative effect of more residents affected (equivalent of 0.1 dBA for Z approaches and 0.7 dBA for Y approaches), the positive effect is considered more significant, thus introduction of AMBER RNP AR approach procedures is considered desirable from airport noise management perspective. A scanned copy of the prepared noise assessment report has been attached to this document in Appendix A.

5.1.3.2 Data capture methodology

For all of performed trial approaches, several indicators have been stored and analysed. For data recording the existing Flight Data Monitoring system was used, consisting of on-board quick access recorder and computer infrastructure in Air Baltic offices. Such solution provides the most exact and reliable figures, without workload increase for the participating flight crews. Readings of the fuel flow metres were used for fuel consumption calculation. In figure 1 the used data acquisition model is described.

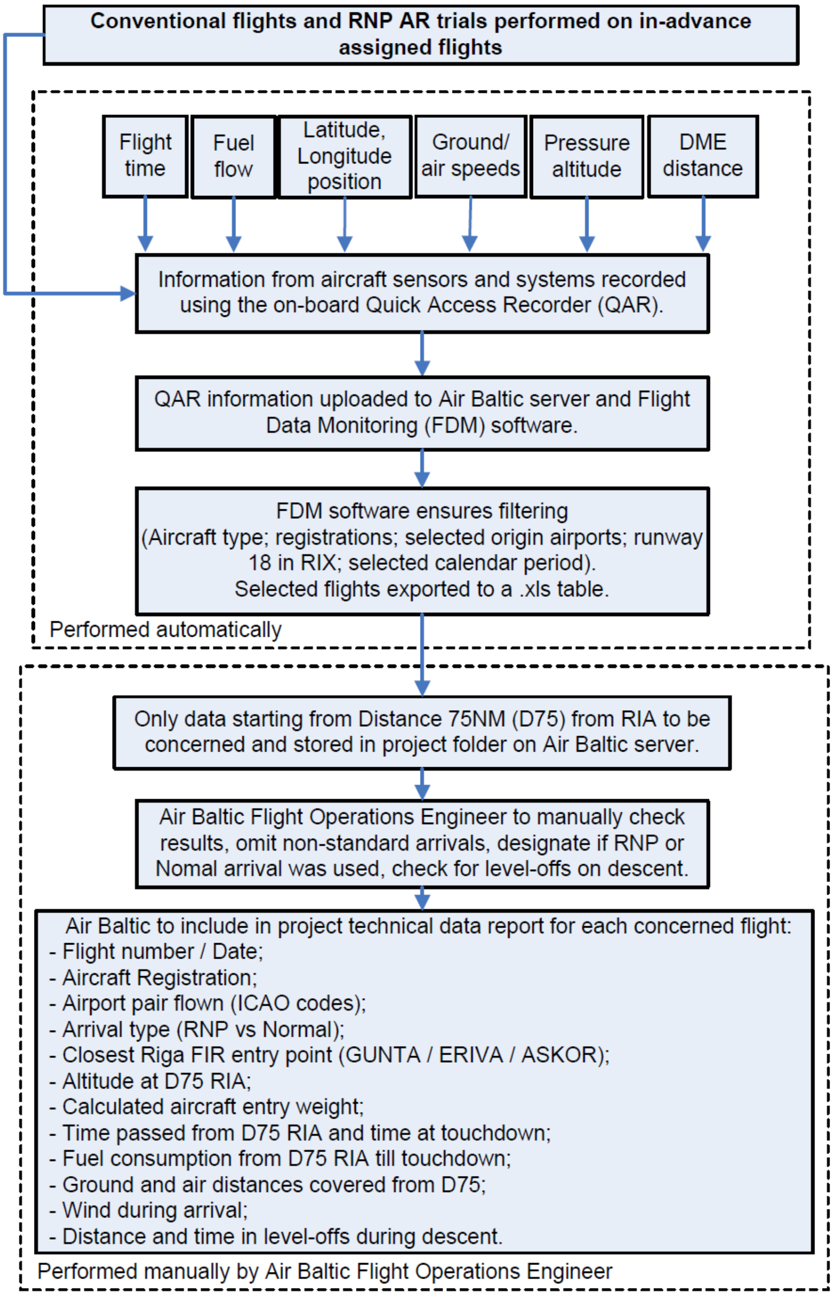


Figure 8: Project's data acquisition model

The Key indicators for this project were:

- Air distance flown
- Flight time
- Fuel consumption (CO_2 emissions derived from fuel burn)
- Level-off cumulated distance and time

The method used for indicators calculation and comparison between conventional and RNP AR approaches is to capture data when the aircraft arrived within in a 75NM radius from Riga RIX VOR DME (located on the airport), in order to ensure a realistic comparison between the conventional and RNP approach. This calculation method allows to:

- Observe the benefits of both shorter tracks and continuous descent profile

- Compare RNP AR arrivals (overflying actual waypoints) to conventional arrivals which sometimes are vectored direct to Riga, without overflying an actual entry point.

75NM distance was chosen as a compromise, where Riga RIX VOR DME frequency is already normally selected by the cockpit crew, and majority of flights are still in level cruise.

The extracted data was further filtered in order to exclude traffic congestion hours, flights with unusual holdings or go-around and arrivals in high winds.

Level-off calculations were performed by using computer-based visualisation of flight profile and manual processing – from the flight profile picture level-off sections were manually selected and checked if considered significant (above 30 seconds duration normally). The used method resulted in margin of vertical speed for level-off selection of around 300-500 fpm. The method is considered accurate enough for obtaining acceptable level-off distance and duration values. For AMBER RNP arrivals technical level-offs (introduced as described in 5.1.3.3.4) of 2.5-3.5 NM at 2500 ft altitude are not accounted in calculation, as these were introduced based on technical capabilities of specific aircraft, not on the RNP arrival procedure design itself. Such technical level-offs were performed on 50% of recorded AMBER arrivals (i.e. 61 of the 122 flights with recorded data).

5.1.3.3 Results per KPA

5.1.3.3.1 Environmental benefits:

Via ASKOR:

	flight	fuel	CO2
	count	kg	kg
ASKOR (conv)	72	209	658.2
ASKOR Z	29	187	588.7
difference		-22	-69.5

	flights	fuel	CO2
	count	kg	kg
ASKOR (conv)	72	209	658.2
ASKOR Y	7	167	526.7
difference		-42	-131.5

The average savings are quite important for these approaches, especially via ASKOR Y.

Via ERIVA:

	flight	fuel	CO2
	count	kg	kg
ERIVA (conv)	125	262	825.6
ERIVA Z	49	256	806.7
difference		-6	-18.9

	flight	fuel	CO2
	count	kg	kg
ERIVA (conv)	125	262	825.6
ERIVA Y	6	225	707.3
difference		-37	-118.3

The average savings are less important than for ASKOR, but regarding the geographical location of ERIVA, the RNP option still provide some benefits.

During the conventional approach via ERIVA, aircraft are usually radar guided to the east of the runway in order to proceed to a “left hand” final. During the conventional approach, aircraft then fly nearby the city centre, which may lead to noise disturbances. With the RNP approaches, aircraft do not fly over the city, but also save fuel. The results are further improved by ERIVA Y.

Via GUNTA:

	flight	fuel	CO2
	count	kg	kg
GUNTA (conv)	40	249	783.0
GUNTA Z	17	208	654.1
difference		-41	-128.9

	flight	fuel	CO2
	count	kg	kg
GUNTA (conv)	40	249	783.0
GUNTA Y	3	175	550.7
difference		-74	-232.4

GUNTA arrivals show the most important savings regarding fuel consumption and CO2 emissions.

Via ORVIX:

	flight	fuel	CO2
	count	kg	kg
ORVIX (conv)	23	188	590.8
ORVIX Z	10	183	577.3
difference		-5	-13.5

	flight	fuel	CO2
	count	kg	kg
ORVIX (conv)	23	188	590.8
ORVIX Y	1	156	491.9
difference		-32	-98.9

ORVIX Z and especially ORVIX Y arrivals provide important savings regarding fuel consumption and CO2 emissions. Even if only 1 flight performed the ORVIX Y approach during the flight trials, the result is reliable since the lateral trajectory and the vertical profile hardly vary between 2 approaches performed on the same RNAV (RNP) approach.

5.1.3.3.2 Track mile savings

Via ASKOR:

	flight	time	air dist
	count	min	NM
ASKOR (conv)	72	20.5	91.9
ASKOR Z	29	20.1	84.3
difference		-0.4	-7.6

	flight	time	air dist
	count	min	NM
ASKOR (conv)	72	20.5	91.9
ASKOR Y	7	18.6	77.9
difference		-1.9	-14.0

The results show an important track mile savings for both ASKOR Y and ASKOR Z.

Via ERIVA:

	flight	time	air dist
	count	min	NM
ERIVA (conv)	125	23.0	99.2
ERIVA Z	49	23.8	100.6
difference		0.8	1.4

	flight	time	air dist
	count	min	NM
ERIVA (conv)	125	23.0	99.2
ERIVA Y	6	21.4	91.8
difference		-1.6	-7.4

ERIVA Z arrivals introduce a slight increase in arrival distance (still offering a fuel saving), but ERIVA Y arrivals already provide improvement also in this KPA.

Via GUNTA:

	flight count	time min	air dist NM
GUNTA (conv)	40	22.9	101.8
GUNTA Z	17	20.9	91.5
difference		-2.0	-10.3

	flight count	time min	air dist NM
GUNTA (conv)	40	22.9	101.8
GUNTA Y	3	19.9	82.3
difference		-3.0	-19.5

GUNTA RNP approaches show the most important track mile savings compared to the conventional approaches.

Via ORVIX:

	flight count	time min	air dist NM
ORVIX (conv)	23	18.9	86.4
ORVIX Z	10	19.5	82.3
difference		0.6	-4.1

	flight count	time min	air dist NM
ORVIX (conv)	23	18.9	86.4
ORVIX Y	1	19.1	74.8
difference		0.2	-11.6

Similar to ASKOR Z, the approach via ORVIX Z shows an important track mile saving compared to the conventional approach.

5.1.3.3.3 Results impacting regulation and standardisation initiatives

Not applicable

5.1.3.3.4 Unexpected Behaviours/Results

The main issue of the project was encountered during the simulator session on DH-8 Q400 simulator in Toronto. While performing a CDA and crossing the FAP on a -3° FPA, the autopilot unexpectedly disconnected at 2500ft and remained disconnected even if the crew attempted to manually re-engage it. The problem does not happen if a slight level-off segment is performed just before reaching the FAP. 2 similar cases were reported during flight trials, when the level off segment was not included.

5.1.3.3.5 Quality of Demonstration Results

The quality of the results obtained in AMBER flight trials is very good. The QAR data are acceptably accurate and the sample of the analysed data is sufficiently large to allow for meaningful results.

During the project a parallel study was performed by EUROCONTROL specialists using the V-PAT (Vertical Profile Analysis Tool) tool. Automatically generated surveillance data was supplied for 121 AMBER flights by LGS, the profiles were analysed to determine how much level flight occurred during each descent, and therefore the degree to which the flights undertook Continuous Descent Operations (CDO). Also a fuel consumption figure was calculated.

The results obtained by V-PAT tool were very similar to the ones calculated for AMBER project with the methods described in previous sections. One flight was found as performed with intermediate level-off; noise profile of flights was calculated as averagely at or slightly better than that expected by CDO arrivals. Mean fuel burn difference was 5.3 kg, which is considered very low. Such facts are further increasing trust in reliability of performed calculations. For a full V-PAT analysis report please refer to Appendix D.

5.1.3.3.6 Significance of Demonstration Results

The significance of the results obtained in AMBER flight trials is good, highly supporting the goals set for both the project and the initiative in general. Project results have demonstrated that RNP AR approach technology offers considerable environmental benefits also for applications with the relatively less fuel consuming turboprop aircraft as well as for airports which are not currently considered amongst top highest traffic European air traffic hubs.

5.1.4 Feedback from the exercise

5.1.4.1 Feedback from the pilots

12 Captains and 9 First Officers, most with more than 2 years of flying experience on the type were selected to participate in the AMBER trial flights. After one training session in a Dash 8 Q400 simulator, they were approved.

On average, each pilot performed 12 approaches and filled in a report form after every attempt. Feedback on the experience via this form was consistently positive (in truth the ability to provide a comment easily and frequently was reportedly highly appreciated by participants). Individual interviews also confirmed that pilots generally liked this procedure.

The approach was generally described as "simple and straightforward". Pilot involvement consisted primarily of system monitoring and speed control which reportedly made the final low altitude turn unnerving in the beginning. This disappeared after a few successful trials.

Reportedly, being the first European turboprop group to perform such approaches elicited pride. Involvement also led pilots to investigate their aircraft's automation capability and trust it more. Withdrawal rate from the project and refusal to share results remained nil.

5.1.4.2 Feedback from the ANSP

During the trial period, no outstanding related operational reports were received from ATC controllers, thus the provided preparations are considered adequate. Especially highly evaluated by ATC personnel were the performed ATC simulator sessions.

After completion of the trial a detailed survey was performed for the ATC officers who participated in the process, revealing both the operational difficulties experienced and the improvements introduced in the ATC environment. The main difficulties were related to integration of both AMBER and conventional flights in periods of high traffic and non-standard situations due to nearby airspace restrictions related to military activities or dangerous weather. Also it has been noted that more frequent RNP arrivals would have been useful for more comprehensive everyday experience of merging RNP and conventional arrivals. On the other hand the very high demonstrated track keeping accuracy during all of the trials was especially highly apprised. Also the minimised airtime in terminal airspace and reduced number of radio transmissions per arrival have been evaluated as very useful improvements from ATC side.

ATC officers also highlighted further valuable considerations for perspective widening of RNP AR approach usage and its integration with conventional traffic in Riga terminal airspace, e.g. possibilities to combine vectoring and RNP AR approach and including the PBN approaches in automated arrival management system (AMAN). Related LGS AMBER project closing report has been attached to this document in Appendix B.

5.1.4.3 Feedback from the supervising Authority

During the entire course of AMBER project the CAA of Latvia actively provided the needed support and oversight, within the respective regulatory framework.

At the closing stage the project is evaluated as successfully completed and valuable, ensuring and verifying both the capability of Air Baltic flight crews and operational personnel to conduct RNP AR Approach operations as well as will and capability of LGS to provide such possibility in Riga International Airport. The acquired expertise has potential to highly facilitate a full scale approval and introduction of specific PBN specifications in everyday operations and promote necessary amendments in operator manuals. Based on analysis of project results a well-grounded economical assessment can be done, justifying the required investment into new aircraft equipment. Also the need for high effort and participation of both airline and ANSP is underlined in further introduction of PBN specifications in Latvia, to ensure highest possible efficiency of the airspace use. For a full text of opinion letters of CAA of Latvia in Latvian, please refer to Appendix C.

6 Communication Activities

In addition to regular communication and coordination between project partners (e.g. the regular project scorecard, as illustrated in chapter 7.2.6., a number of external communication activities were carried out.

Activity	When	Who responsible	Where	Expected cost	Direct Target
Press release	Demonstration Flight (Aug 2013)	Air Baltic –with input and/or participation from Airbus Prosky/LGS	n/a	n/a	-Latvian people -Northern Europe aviation community -6000+ contacts of the Airbus Prosky Group - ATM Industry - Trade Publications
Contribution to SESAR Demonstration Activity Annual report	Q4 2013		By email		SESAR and AIRE partners
Participation in the SJU yearly communications event for the Integrated Flight Trials and AIRE	Q4 2013	Air Baltic	Lisbon		Other projects in the Integrated Flight Trials and AIRE programmes
Press release & Two Promotion videos	Project Conclusion Q3 2014	Air Baltic –with input and/or participation from Airbus Prosky/LGS	n/a	n/a	-Latvian people -Northern Europe aviation community -6000+ contacts of the Airbus Prosky Group -ATM Industry -Trade Publications
Project closure event in Riga	Q3 2014	Air Baltic	Riga		Population of Riga area Aviation community
AIRBUS ProSky Website & Press release	Q3 2014	Airbus Prosky –with input and/or participation from other partners.	n/a	n/a	Aviation community

Table 7: External communication activities

During the project two digital promotion videos have been prepared. First Video (No.1) is targeted to general public, explaining project background, framework, principles and goals, using user-friendly filmed material in combination with video effects and animations.

Figure 9: Screenshot of project promotional video No.1

Figure 10: Screenshot of project promotional video No.1

The second video is targeted to aviation professionals, covering one full AMBER "Y" approach and key facts about the project.

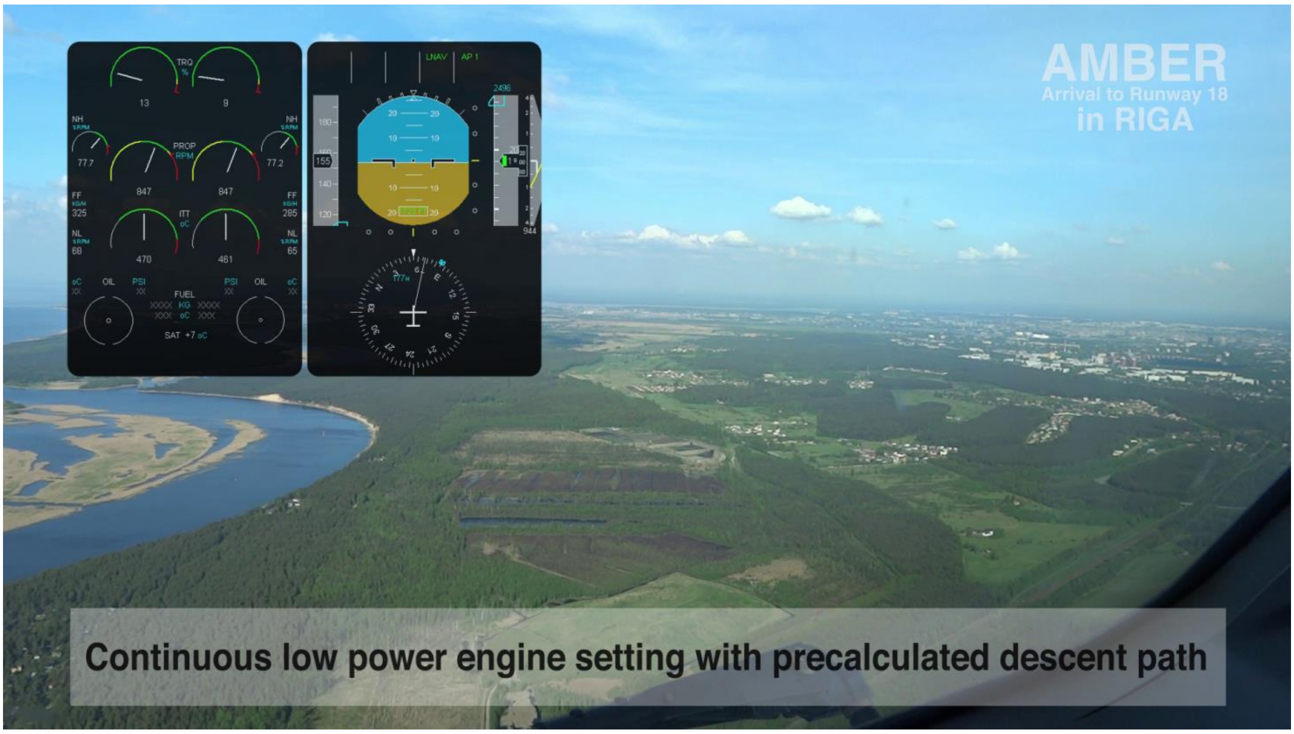


Figure 11: Screenshot of project promotional video No.2

Figure 12: Screenshot of project promotional video No.2

7 Next Steps

7.1 Conclusions

The AMBER project realised in Riga on Bombardier Q400 aircraft has successfully showed the ability for turboprop regional aircraft to benefit from the latest navigation technologies, in order to optimize their flights and reduce the environmental impact of aviation on the community. The project has resulted in successful completion of all of the set objectives.

The set objective OBJ-01.01-2 has been completed by executing and capturing valid data about 122 trial flights, as a result of appropriate design and validation of procedures, as well as training of the involved airline and ATC personnel.

Objectives OBJ-01.01-1 and OBJ-01.01-3 have been simultaneously completed, as successful implementation of laterally optimised arrival and approach paths and optimal constant descent arrivals has allowed to observe significant fuel savings, directly resulting in CO2 emissions reduction.

Following is a sum-up table of project results regarding time and distance savings, emissions reduction and CDA implementation (detailed results are described in chapter 5.1.2.4):

Entry	*Differences (from D75 RIA till touchdown)*						
	CO2 emissions		*Time*		*Air dist*		*Flights with level-off*
	kg	*%*	*min*	*%*	*NM*	*%*	*%*
ASKOR Z	-70	-10.6%	-0.4	-2.0 %	-7.6	-8.3 %	-29 %
ERIVA Z	-19	-2.3%	+0.8	+3.5 %	+1.4	+1.4 %	-41 %
GUNTA Z	-129	-16.5%	-2.0	-8.7 %	-10.3	-10.1 %	-55 %
ORVIX Z	-13	-2.3%	+0.6	+3.2 %	-4.1	-4.7 %	-26 %
Average difference AMBER Z vs conventional	**-58**	**-7.9%**	**-0.3**	**-1.0 %**	**-5.2**	**-5.4 %**	**-38 %**
ASKOR Y	-132	-20.0 %	-1.9	-9.3 %	-14.0	-15.2 %	-29 %
ERIVA Y	-118	-14.3 %	-1.6	-7.0 %	-7.3	-7.4 %	-41 %
GUNTA Y	-232	-29.7 %	-2.9	-12.7 %	-19.5	-19.2 %	-22 %
ORVIX Y	-99	-16.7 %	0.1	0.5 %	-11.6	-13.4 %	-26 %
Average difference AMBER Y vs conventional	**-145**	**-20.2 %**	**-1.6**	**-7.1 %**	**-13.1**	**-13.8 %**	**-30 %**

In the best case (GUNTA Y arrival), **up to 20 NM and 230 kg of CO_2 emissions** are saved per arrival thanks to the introduced RNP AR technology. Average savings amongst the "Y" entries used during the trials were 13 NM and 145 kg of CO_2 emissions per arrival.

The performed study by Riga International airport has illustrated that also the objective OBJ-01.01-4 has been completed. Noise sensitive area of Jūrmala has been avoided, and noise level in the overflown communities is even further reduced when comparing to the conventionally used practices.

Overall, the AMBER project has demonstrated that RNP AR technology is a positive step towards modernization of the airspace and reduction of environmental impact of commercial aviation around cities in Europe.

The results are considered reliable, as appropriate methods were used for recording and calculating the figures, and a parallel independent study performed with EUROCONTROL V-PAT tool has shown very similar results.

7.2 Lessons learnt and recommendations

The following provides some elements of lessons learnt and recommendations for possible similar projects and trials in the future, based on the experience of the AMBER project.

7.2.1 Overall

Importance of stakeholders' cooperation and involvement

The AMBER project was successfully conducted and completed thanks to a good general teamwork between all stakeholders, since the project's start until its completion. Stakeholders need to have a clear understanding of what their involvement will be throughout the project, and need to maintain communication on their progress and difficulties, to mitigate risks of blockage or delays.

In the case of AMBER project, as for possible other similar projects of PBN implementation in Europe, the following stakeholders have been involved from Day 1 through the realization of the project:

- The airline;
- The ANSP;
- The regulation authority;
- The airport;
- The procedure design company.

A kick-off meeting should present the project objectives and general framework, and should allow for everybody to agree on the general design and execution objectives. Making the kick-off meeting a publicity event could further solidify the persistent commitment towards a successful result.

<u>Note</u>: A pre-kick off meeting supported by SESAR could help to establish grounds and responsibilities for the project before the project actually starts.

Regular progress meetings or telecons need to be organized so that all stakeholders are well informed of the progress of the project, and of the difficulties that others may encounter in their own respective tasks.

7.2.2 Design of the procedures

Short lateral track

The design of the procedures should be carefully studied from the start of the project, and agreed by the project participants. In particular, for projects such as AMBER, with environmental objectives such as track miles reduction, and fuel/CO_2 savings, it should be avoided to try and design the shortest possible track, but instead design a less ambitious but more operationally comfortable track, in order to facilitate the discovery of RNP technology by the project stakeholders.

In the example of Riga, the initially targeted savings of 25 NM was only achievable by a quite challenging track (Y, which was eventually approved in a second step of the trials) but the project team opted to preferably develop and use a more standard and comfortable approach path to begin the operation, leaving the more challenging for days with good weather and calm winds. Savings were therefore less, but this less challenging approach allowed gaining confidence and experience in the technology, which was a positive step forward.

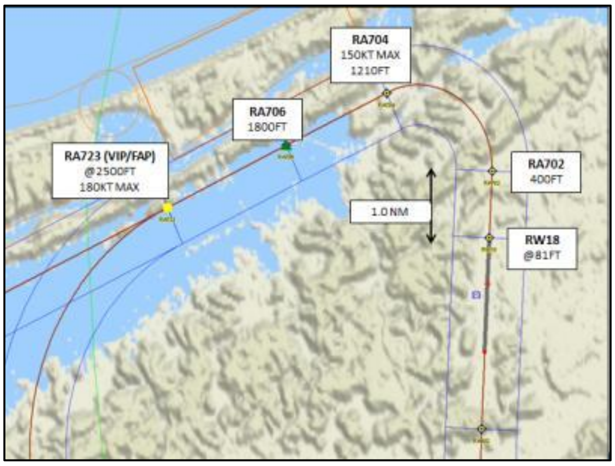


Figure 13: Short lateral “Y” track

Late design changes

Late design changes, such as the ones decided during AMBER project (a couple of weeks only before the validation), are a risk, since they need to be carefully discussed and approved by the stakeholders. Risks associated to late design changes are:

- heavy (re)design costs, and possible long delay in delivery of the procedures;
- insufficient involvement by ATC in the choices made for the changes, and risks for traffic separation issues;
- inadequacy of the changes with the aircraft’s capabilities, procedures not flyable;
- inadequacy of the procedures with environmental constraints (e.g. noise impact study).

Vertical profile and altitude constraints

One of the potential benefits of implementing PBN procedures is the capability to perform the approach in a continuous descent operations (CDO) mode. However, airspace management and ATC considerations usually dictate that altitude constraints be implemented for easier airspace organization and strategic separations of traffic. The design phase should ensure that these altitude constraints will not prevent aircraft of various performances to operate the procedure in continuous descent, in particular it should be preferred as much as possible to:

- Avoid “AT” constraints, and prefer “AT OR ABOVE” constraints;
- Avoid as much as possible “constraining” constraints, e.g. altitudes that will impose a level off or earlier descents with shallow path;
- Avoid keeping the aircraft high until late in the arrival, that will necessitate a steeper and non-optimal descent to reach the final altitude (possibly with early use of speedbrakes and landing gear);
- Avoid early and unnecessary speed reductions, which usually translates into sub-optimal descent paths (e.g. descent at 220KT is shallower and less fuel efficient than at 250kt).

7.2.3 Aircraft and Aircrew

Obviously, one of the challenges of implementing RNP AR procedures, even for flight trials, is to have aircraft and aircrew qualified for such operations.

For non-equipped or non-capable fleets, getting systems upgrade, or certification to operate RNP AR approaches may involve extra costs, and delay in the process.

Before engaging in such a project, airlines should carefully consider these aspects and their associated costs, to determine whether the project is feasible and viable for them.

At the beginning of the AMBER project, Air Baltic made a clear choice of modernization of their fleet, and took benefit from receiving brand new Q400 Next Gen aircraft to have them upgraded to RNP AR capability. This goes along with a more global fleet modernization strategy for the airline, whereby Air Baltic will replace their aging B737s by brand new CS300 series aircraft, all capable of RNP AR as well.

As RNP AR arrivals rely on automation on-board the performing aircraft, technical reliability issues have to be properly addressed for execution of trials, with minimum equipment lists accordingly updated and proper contingency procedures developed.

Also aircrew qualification is an important consideration. Associated training constraints and costs have to be considered as they will be a pre-requisite for the start of the operations, even in a trial mode.

In the case of AMBER, only a subset of aircraft and aircrew were eventually qualified to operate RNP AR in the frame of the flight trials, and therefore this induces a complexity in the dispatch considerations for the trials (the dispatch had to match qualified tail numbers with qualified crew, on adequate routes, so these would be targeted to request an AMBER approach trial).

7.2.4 Authority

An adequate and pro-active involvement of the supervising authority must be ensured from Day 1 of the project, to guarantee its success. Typically, if the demonstration is to be conducted in a country where no/little previous PBN experience exists, the authority will need to process and study regulations in order to allow the implementation of RNP technology and eventually approve the flight trials. This task may appear overwhelming, and may induce reluctance to carry on, or unexpected delays at some stage, eventually jeopardizing the planning for the trials.

In the example of AMBER project, the CAA of Latvia was on-board, and actively supporting the project and the direction taken by Air Baltic since the start. Latvia CAA had already started activities to modernize the airspace and included PBN in their roadmap, and therefore the AMBER project was seen as an additional step in this roadmap. However, it was a challenge to implement the regulations quickly, and account for all the technical considerations involved in RNP operations, in time for the trials approval.

Authorities should be supported in this effort by experts of the PBN/RNP world, and by SESAR previous experiences. As an example, PBN/RNP workshops can be organized beforehand of the project's kick-off (as was the case for AMBER) in order to review the various implications of PBN implementation and plan ahead the possible difficulties.

7.2.5 ANSP

As for the authority, the Air Navigation Service Provider (ANSP) needs to be very much involved in the project, at all stages. In particular, the following aspects seem to have been important for AMBER:

- Before starting such a project, ATC controllers should be briefed on what RNP operations are, and what kind of implications it will have on their work;
- Sufficient ATC simulator training was found very useful by LGS employees;
- Air Traffic Controllers need to be involved in the design of the procedure, since their inputs will be essential to an efficient design. Separation strategies should be implemented at the procedure level (e.g. SID versus approaches, separation between approaches, tie points…) to minimize the work of the controllers down the road;
- Air Traffic Controllers need to receive adequate theoretical and practical training on RNP operations. In particular simulation scenarios involving RNP traffic, and RNP versus non-RNP traffic should be considered to familiarize with possible situations;

- The ANSP must conduct a safety assessment, in order to anticipate on the possible implications of introducing new procedures with the existing operations of the airspace.

Generally, it is found by previous experiences (USA, Middle East) that RNP implementation does not add workload or complexity to the Air Traffic management, or to ATC controller's job, quite the contrary. However it is a significant change in the way to work separations between traffic and this point has to be carefully considered.

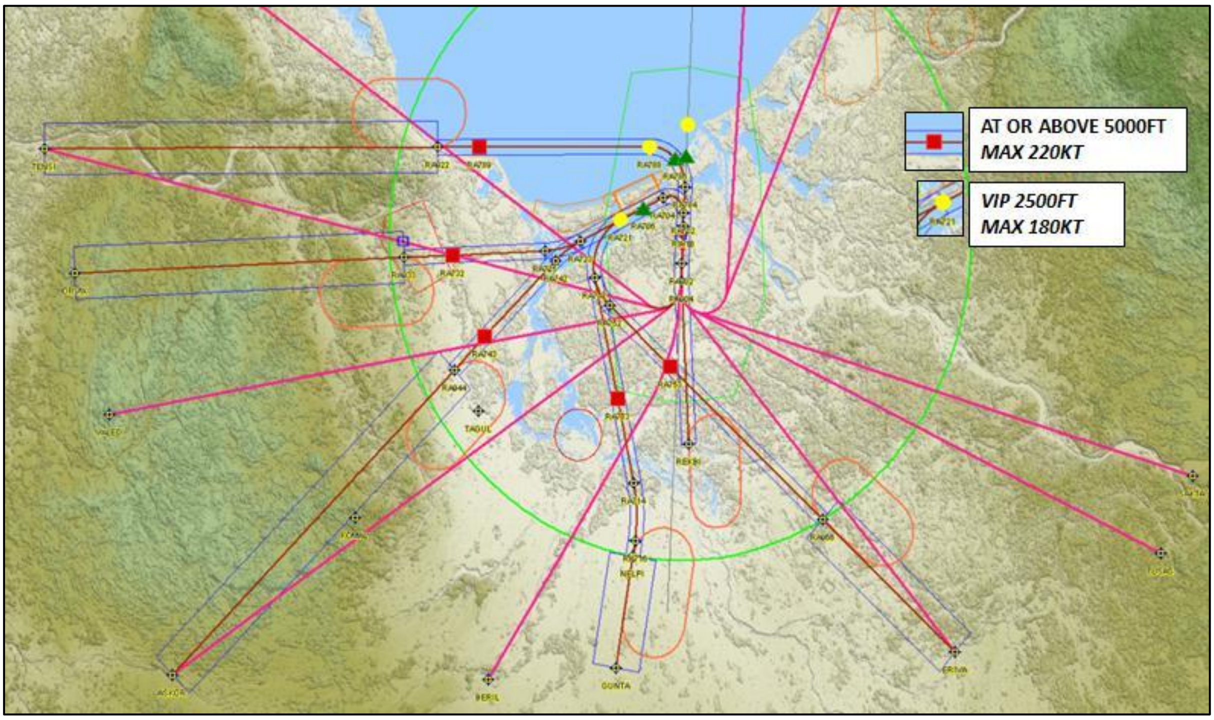


Figure 14: Example of route interaction study
RNP AR approaches versus conventional SIDs RWY 18

7.2.6 Flight trials execution

The AMBER project involved the execution of flight trials in VMC conditions, in order to use the new RNP procedures. The requirement for VMC conditions was put from the start, because it was neither planned nor possible to go through a complete RNP AR approval process (allowing IMC operations) for the project. The thresholds for VMC conditions were discussed and agreed with the regulator. Because the MSA in Riga is very low (2000ft) it was possible to put rather low VMC ceiling requirements. However, it has to be noted that, in the case of AMBER, imposing such VMC requirements was a heavy burden on the rapid execution of the trials phase in some seasons (autumn/winter), and played a big part in the fact that the flight trials lasted much longer than initially anticipated (more than 7 months, instead of 3-4 months anticipated). Thus a precise project time planning is essential, to allow performing actual trial flights in possibly favourable weather conditions.

A regulatory framework to approve the flight trials has to be discussed and considered at an early stage of the project, between the stakeholders, in order to ensure that the flights can start on schedule when all the previous milestones have been completed. In the case of AMBER, the regulator was able to ensure that:

- The aircraft were capable for RNP AR;
- The aircrews were trained and qualified;
- The approaches would be operated in VMC below the MSA 2000ft, thus alleviating the need for a complete RNP AR approval process as per EASA rules.

Feedback on the progress of the flight trials was provided continuously by Air Baltic Flight Operations through a score card indicating the number of successful/unsuccessful approaches, and reasons.

Date: 22.04.2014

AMBER PROJECT TRIALS SCORECARD

	Since previous scorecard (2 weeks)	Total results	Reason: RWY 36 in use	ATC rejected	Weather limited	Status not reported	RNP APCH problem
Total dispatched trial flights:	45	282					
Trial dispatched, AMBER approach not started:	27	168	66	17	83	2	
AMBER arrival started but discontinued:	2	8		1	5		2
AMBER arrival successfully completed:	**16**	**106**					

COMPLETED TRIAL FLIGHTS LIST

No	Flight No	Year	Month	Date	A/C registration	DEP	DEST	Arrival	Entry

Figure 15: AMBER Scorecard during flight trials campaign

7.2.7 Data measurement

Because demonstration activities need to provide factual data to show the results and benefits of the exercise, it is important to decide from an early stage on how data will be captured, and which data will be used to compare conventional approaches to RNP approaches.

The first consideration is whether to use aircraft systems automatically recorded data or manual data reports by pilots. To facilitate the decision it's required to learn what data is the aircraft able to record and if the data are available to be downloaded for post-flight analysis. Essential data such as position, speed, altitude, fuel burn should be available to allow making an analysis of the results.

Processing and re-computation of available data allowed to:

- Determine the "equivalent FIR entry" of conventional arrivals, to be compared to the FIR entry points used by the AMBER arrivals;
- Calculate the level off cumulated times and distances (time spend in level flight in excess of 30s);
- Calculate the cumulated wind effect, and air/ground distance flown during the approach.

Also analysis by separate tools, such as V-PAT, may allow to process the radar exported track, and make an independent, cross-checkable assessment of the vertical profile, in addition to aircraft downloads.

7.2.8 Communication

Communication about the project is important to promote the concept of aviation modernization, and aviation innovations for environmental benefits and sustainability.

Communication should both target the aviation community, and the general public.

In the case of AMBER, several communications activities have been carried out, included press releases, media events, Internet links, and a promotion video explaining the AMBER project for the general public. This video explains in generic terms how it was possible to implement shorter tracks for arrival to Riga, how the project was conducted, what were the main positive results, and how the public (passengers and neighbouring communities) will benefit from this technology.

7.3 Next steps

7.3.1 Steps following AMBER project in Riga/Latvia

The possible next steps for a wider implementation of the AMBER trials in Riga are:

For Air Baltic:

- To have a wider fleet of aircraft qualified for RNP AR operations (both turboprops and jets);
- To submit a request for RNP AR approval, in order to be able to operate the approaches with less restrictive weather conditions and capitalize on AMBER benefits regularly.

For LGS:

- To capitalize on the experience gained during the AMBER project, and implement RNP traffic regulation during more busy time slots, and involving more RNP traffic at the same time.

For Latvia and specifically Riga airspace and operators:

- To develop RNP approaches to RWY 36, and possibly tailored RNP departures;
- Publish the procedures in the Latvian AIP, and target a wider use of the procedures by other operators.

7.3.2 Other similar projects in Europe

Similar projects to promote new technologies and demonstrate the benefits for the environment and sustainability of the aviation industry could be considered in other countries having no or little experience. Further technological improvements could be studied where applicable and economically feasible, e.g. RNP to ILS applications.

The AMBER project has shown that even for a country not having PBN experience, it is possible to implement a successful PBN project, having clear and quantified positive outcome for the airline, for the communities and for the environment, in a rather short period of time. This experience has also helped to build experience and confidence in this new technology and will certain play a positive role in preparing other steps of PBN implementation in Latvia in the future.

Guidance and possibilities provided by experienced and resourceful supporting organisations, such as SESAR JU in the case of AMBER project, are essential for success in such cases, especially if the country in question is rather small airspace-wise. Additionally an introduction of pan-European agency has played a role to make the involved parties more open for even closer cooperation, as a clear common goal is provided.

8 References

8.1 Applicable Documents

[1] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

8.2 Reference Documents

The following documents provide input/guidance/further information/other:

[1] Demonstration Design

[2] Deployment Scenario Descriptions

[3] Communication Plan

[4] AATM Master Plan
https://www.atmmasterplan.eu

[5] AMBER project technical data report

[6] Drošuma novērtējums, projekts AMBER. RNP testa lidojumi. DL-GSV-09/1

[7] AMBER project flight noise assessment report

[8] AMBER lidojumu radītā trokšņa izvērtējuma atskaite, ar pielikumiem

[9] Report on Continuous Descent Operations at Riga Airport W16.06.03 – D7 2LGS AMBER project closing report

Appendix A AMBER Project Flight Noise Assessment Report

RIX

STARPTAUTISKĀ LIDOSTA "RĪGA"

AMBER flight noise assessment report

Prepared by:

SJSC Riga International Airport

[redacted] 06.08.2014.

Mārupe novads, 2014

Table of contents

1. Foreword

AMBER flight noise assessment report is shortened English edition of report "AMBER lidojumu radītā trokšņa izvērtējuma atskaite", which have been published in Latvian.

English version does not contain any Appendixes, neither methodological and reference sections of report. Please look in the appendix of the Latvian edition of the report, where it is referred to any Appendixes. The numbering of chapters is the same as in Latvian edition of the report to allow easier cross check.

2. Results of noise monitoring measurements of AMBER flights

2.2. Measured Noise Level

According to Test Report 14-004-P (Annex 1), the arithmetic mean noise level of Bombardier Dash Q 400 (DH8D) Approach Z flight noise events L_{ASmax} was 58.2 ±4.4 dBA (see Annex 1). The noise level was established by means of 91 flight noise level measurements.

The DH8D aircraft, using Approach Y procedures, at the noise monitoring station TMS 1 have been statistically significantly (p=0.05) less noisy than the aircraft following the standard RWY 18 procedure, which can be explained by a longer distance (see previous sub-chapter). The distance correction 3.8 dBA was applied, calculated according to the formula $11{,}8 * (\ln x_o - \ln x)$, where x_o was the average diagonal distance of traditional flights determined in the Intermediate Report as 829 m, and x was the average diagonal distance of Approach Y flights equal to 1140 m (see data in Annex 7). The correction was calculated according to the equation published in the Intermediate Report: -11.8*ln(x)+142.5, meaning that, as the distance doubles, the noise level reduces by 8.2 dBA.

The reason, why the flights according to Approach Y procedure are less noisy, is not known. Errors or the impact of some overlooked factor, such as the placement of a microphone, cannot be excluded. At the same time, the difference is so striking that it can be stated with some confidence that the AMBER flights are less noisy than the standard RWY 18 arriving flights. Such a decrease in the noise level could be explained by more efficient operating of an aircraft saving the engine power.

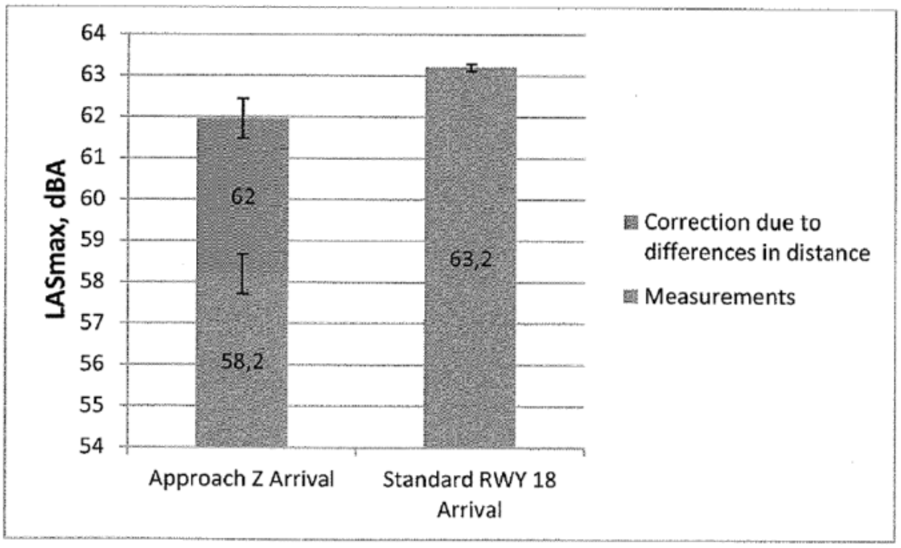


Figure 1. **Comparison of DH8D aircraft Approach Z and standard RWY 18 arrival L_{ASmax} noise levels** (based on the data of Annexes 1, 7 and Test Report 14-003 P).

The analysis of the information on the propeller rotation per minute provided by AirBaltic (RPM) showed that at RPM 1020 the noise level is 1.7 dBA higher, yet this difference is statistically insignificant (p=0,05), due to the fact that only on 10 flights L_{ASmax}

was credibly measured at RPM 1020. In order to achieve the statistical significance at the existing dispersion and difference of average level, in total 25 noise event measurements at RPM 1020 are required.

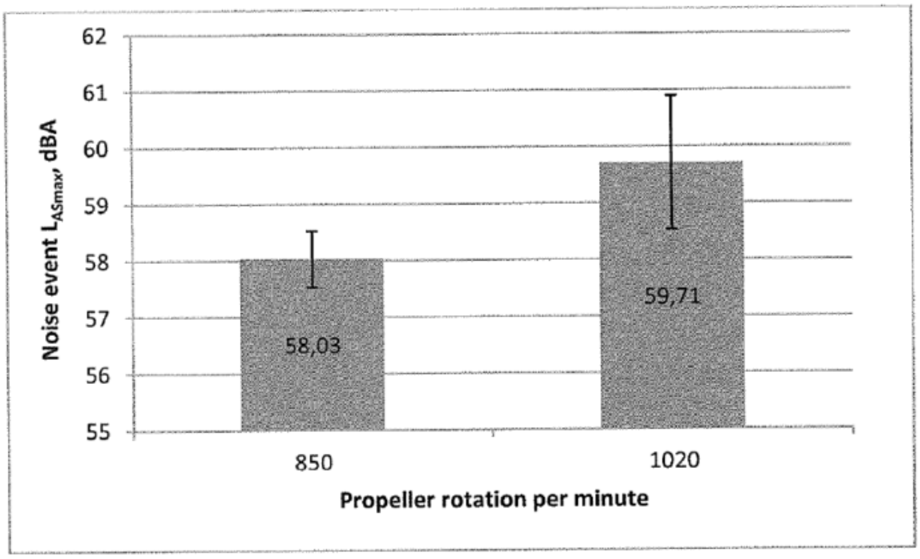


Figure 2. **Dependency of Noise Level L_{ASmax} on the propeller rotation per minute** (based on the data of Annexes 1, 7).

3. Noise contour calculation of arrival procedures

3.2. Results of Noise Contour Calculation

The graphic map of the noise contour calculation is attached in Annexes 2 – 4.
According to the noise contour calculation, Approach Y arrival affects a larger number of residents than the standard RWY 18 arrival procedure or Approach Z arrival procedure.

Chart 1. **The number of residents and dwellings affected by larger than the defined L_{Amax} noise level when executing approach manoeuvres**

L_{Amax}, dBA	RWY 18 A		Approach Z A		Approach Y A		Difference with RWY 18 A	
							Approach Z A	Approach Y A
	Dwellings	Residents	Dwellings	Residents	Dwellings	Residents	Residents	Residents
>60	382	1367	315	1157	463	1712	-210	345
>65	230	781	216	770	248	882	-11	101
>70	110	385	142	488	169	613	103	228
>75	64	238	65	235	72	242	-3	4

Approach Z arrival procedure affects a larger number of residents at maximum noise level exceeding 70 dBA, due to approaching Mežāres while making a turn. At the same time, considerably fewer residents are affected at maximum noise level exceeding 60 dBA, due to avoiding Rītabuļļi village and a longer distance from an aircraft to Liepezers village.

2. tabula. **Modified noise index values**

Procedure	Index value	Relative to RWY 18 A
RWY 18 A	473572	
AMBER Z	486031	+3%
AMBER Y	602560	+27%

The 3% rise of the index is equivalent to the increase of noise level by 0.1 dBA, which affects all of residents. 27% rise is equivalent to the increase of noise level by 0.7 dBA, which affects all of the residents. The greater impact of the Approach Y procedure can be largely explained by a closer flight over Spilve village and Mežāres village, and secondarily also over the vicinity of Priedaine in the town of Jūrmala.

6

4. Analysis of the Obtained Results

The Approach Z flights are 1.2 dBA less noisy than the standard (other) RWY 18 flights, including ILS RWY 18 flights. The statistically calculated error (p=0.05) is considerably smaller. Even in the worst-case scenario the Approach Z flights are at least 0.6 dBA less noisy. Therefore, the approach to Mežāre, aggravating the noise situation by 0.1 dBA, will be counterbalanced by the noise level decrease achieved by the procedure itself. Thus, it can be argued that the evidence is sufficient to prove that the Approach Z procedure will help decrease the impact of aircraft on residents.

The Approach Y procedure stipulates the restriction of flight speed to 150 knots at the final turn which is less than in the ILS RWY 18 procedure where the speed is set at 160 ±10 knots, and less than in the Approach Z, stipulating maximum speed restriction to 180 knots from the height of 2500 feet. The noise of aircraft is lower if their speed is slower unless it is achieved by use of speed brakes. Therefore this restriction of speed will decrease the noise levels generated by the Approach Y procedure.

Although the calculation of the noise contours shows a growing impact on the residents, there are still some aspects indicating that the negative impact assessed by using calculation methods will be smaller than the positive impact created by the procedure itself. The measurements show that the impact of the Approach Z procedure is smaller than that of the traditional arrival; moreover, the improvement is bigger than the calculated deterioration, which is equivalent to an aircraft that is noisier by 0.7 dBA. Besides, the decreased maximum speed will generate additional noise reduction under the Approach Y procedure as compared with Approach Z. Hence, there is a sufficient amount of evidence to argue that Approach Y, too, will decrease the impact of aircraft noise on the residents.

5. Summary

The noise impact calculation shows that the Approach Z procedure will generate a slightly bigger (equivalent to 0.1 dBA), and Approach Y an even bigger (equivalent to 0.7 dBA) noise impact on the residents than the existing RWY 18 procedures, if executed manually.

The measurements of Noise Monitoring Station No 1 show that Approach Z creates a statistically significant (p=0.05) decrease of the noise level. According to the calculations, the decrease is statistically significantly bigger (p=0.05) than the difference applicable to the spread in the distances of aircraft. Therefore, it can be said that the aircraft flying according to the Approach Z procedure are at least by 0.6 dBA less noisy that the aircraft observing the existing RWY 18 procedure.

The evidence is sufficient to state that on the whole the use of the Approach Z procedure will minimize the noise impact on the residents as compared with the existing arrival procedures.

The decrease of the aircraft noise achieved by using the Approach Y procedure, in combination with a maximum aircraft speed restriction, gives sufficient confidence that the Approach Y procedure, too, will decrease the impact of noise on the residents despite the fact that under this procedure the aircraft fly above a slightly more densely populated area.

Appendix B LGS AMBER Project Closing Report

VAS Latvijas gaisa satiksme

Int. airport Riga, LV1053

AMEBR report

The AMBER project has successfully passed and it is clear that it was a great challenge for Air Traffic Service (ATS) in RIGA FIR. New TRIAL arrival routes were implemented for testing and in general they differed from actual conventional STARs. From one side they were to improve efficiency, but from the other they caused some operational problems.

At the end of the project a survey among approach Air Traffic Control (ATC) Officers (ATCO) was made to find out about their experiences and discover their evaluation on current activity to improve efficiency and increase capacity. ATCOs marked that documentation, which consisted of procedures, charts and phraseology that was provided in advance and was comprehensible.

Great part of participants noted that they had a situation when there was not possible to allow TRIAL approach to RIGA at least once. Problem was caused by conflicting traffic. It was admitted that in traffic situations where TRIAL flight was out of sequence or there was no significant influence on the other traffic it was cleared for TRIAL approach without delay. There were even possibilities to use TRIAL approach when this flight was in the beginning of the sequence and sometimes when the flight was as final element for current sequence block. That was due to specific arrival routes that were much shorter than conventional STARs. The use of speed control increased number of positive outcomes. Also it was mentioned that one or two separate aircraft in the big sequence wished to make their own specific and short arrival routes, inconvenient to normal operations.

After the discussions with controlling ATCOs some obvious problems were discovered. First of all, TRIAL approaches were not always requested at low traffic situations. It is quite difficult to separate test flights from normal flights in a real life situation. There are always flights arriving or departing.

Secondly, arrival route from point ERIVA – ERIVA TRIAL APPROACH – which was crossing all departure routes (SID) for RWY18 and was admitted as being difficult and unpredictable in case of any failure. Arrival was crossing departure route exactly in front to the departing course and allowed altitude was 1000ft higher than departure at crossing point. After crossing the aircraft was allowed to descend lower so it was conflicting with any of the departing traffic. It means that the arrival route was not separated horizontally or even vertically from the departure routes. It caused additional delays for arrivals and useless vectors, sometimes ineffective altitudes for departing traffic. It produced additional stress and workload for approach ATCOs.

1

Thirdly, military activity (active military training areas, operational and military training flights) also had a significant influence on execution of TRIAL flights. The arrival routes from ASKOR and GUNTA were blocked by TSAs in VILNIUS FIR up to FL280 that is too high for normal operations of arriving traffic. In such cases, point ERIVA became exit route for conventional standard traffic. So if we check again the previous paragraph about arrival route from ERIVA, it is clear that safety comes first for ATCO and there was a need to reject test arrivals in these cases.

As a final fact, that some of the requests for TRIAL approaches were in non-standard situations. For example, requests from aircraft that were vectored to keep them safe enough from military activity zones in adjacent sectors, specifically in VILNIUS FIR. After avoiding these zones there were some requests to re-join arrival on any position of TRIAL route, but according to the procedures and charts each route started at the exact position (specific point) in the airspace and continued as it was described. Other example is about requests for TRIAL approach for opposite RWY in case of arriving and departing traffic. There were some cases of rejections due to runway operations. To specify - in winter there was frequent snow cleaning process and in other cases RWY cleaning and inspection after departing heavy cargo aircraft.

Overall, despite the facts mentioned before, there were also some positive aspects of the project. It was a useful experience for the development of future ATM systems. It is easier to create safe and efficient airspace when you know all of the potential problems concerning traffic flow.

Another thing that ATCOs mentioned was the opportunity to save time on communication. It was more obvious when it was a single flight. Moreover, ATCOs much rather preferred "Y" TRIAL approaches than "Z", because they were a bit shorter than "Z" and much shorter than normal vectoring for conventional short approach for ILS. It also reduced time being in the air that offered possible decrease of abnormal situations in the flight.

There were no cases of position deviation from exact proposed RNP routes. It was one of the most important aspects and ATCOs admitted that the use of RNP routing has a great potential and might be useful in future.

There are some tips to improve future RNP implementation process in RIGA FIR, in TMA:

- One of the most important goals is to develop universal routes for majority of operating types of aircraft. They should be published in the AIP and should be available for any interested operator.
- There should be several possibilities for each arriving direction to improve flexibility and efficiency in sequence.
- New arrival routes should be designed as an option for ATCOs to produce good sequencing.
- Arrival routes should be well designed to exclude possibilities of conflict as a standard. They should be separated horizontally or at least vertically. Fewer crossings mean less possibility for loss of separation.

- RNP routes should be connected to arrival manager (AMAN) routes or they should be the same.
- RNP routes should be mixed with vectoring for flexibility in cases when there are military operations or any other airspace restrictions. After avoiding adverse weather it should be possible to return to "standard" arrival route.
- Qualified pilots and ATCOs will improve use of effective routes when level of safety is not decreased. So additional training might be required for implementation.

29.08.2014 [redacted]

3

Appendix C Civil Aviation Authority of Latvia opinion letters about AMBER project (in Latvian)

LATVIJAS REPUBLIKAS SATIKSMES MINISTRIJA
Valsts aģentūra „CIVILĀS AVIĀCIJAS AGENTŪRA"
LIDOSTA "RĪGA" 10/1, MĀRUPES NOVADS, LV-1053, LATVIJA, TĀLRUNIS 67830936, FAKSS 67830967, latcaa@latcaa.gov.lv

MINISTRY OF TRANSPORT OF THE REPUBLIC OF LATVIA
CIVIL AVIATION AGENCY
AIRPORT "RĪGA" 10/1, MĀRUPES NOVADS, LV-1053, LATVIA, PHONE (371)67830936, FAX (371)67830967, latcaa@latcaa.gov.lv

Mārupes novadā

02.09.2014 Nr. 01-8-100/911

GAISA KUĢU EKSPLUATĀCIJAS DAĻA

AS„ AirBaltic Corporation"
SVP Lidojumu dienesta vadītājam P.Cālītim

Par AMBER projektu

Pamatojoties uz gaisa kuģu ekspluatanta AS „Air Baltic Corporation" (turpmāks – GKE) 2014. gada 14. augustā elektroniski nosūtīto vēstuli ar lūgumu sniegt izvērtējumu par AMBER projekta norises gaitu, valsts aģentūras „Civilās aviācijas aģentūra" Gaisa kuģu ekspluatācijas daļa (turpmāk - Gaisa kuģu ekspluatācijas daļa) ļoti pozitīvi novērtēja AMBER projekta sākuma daļu, kas tika sekmīgi pabeigta ar izmēģinājumu lidojumu programmu.

Gaisa kuģu ekspluatācijas daļa vienmēr ir aktīvi piedalījusies visos ar AMBER projektu saistītajos pasākumos un atbalstījusi šī projekta realizāciju noteikto prasību ietvaros ciktāl tas vien ir bijis iespējams. Šeit var pieminēt gan ar AMBER projektu saistītos izmēģinājuma lidojumus uz trenažiera, gan izmēģinājumu lidojumu programmas izvērtēšanu un akceptēšanu.

No Gaisa kuģu ekspluatācijas daļas viedokļa ieguvumi ir sekojoši:

1. GKE lidojumu apkalpes un lidojumu nodrošināšanas personāls ir guvis vērtīgu pieredzi šādu lidojumu izpildei. Šī pieredze lieti noderēs, kad GKE veiks šādas lidojumu nosēšanās pieejas (RNP APCH un/vai RNP APCH AR) gan Rīgas lidostā, gan citviet pasaulē un, nevis izmēģinājumu lidojumu programmas ietvaros, bet gan kā apstiprinātas nosēšanās pieejas procedūras;
2. GKE lidojumu izpildes menedžments ir guvis vērtīgu pieredzi procedūru izstrādei saistībā ar šo nosēšanās pieeju izpildi, kas vēlāk tiks apkopota un ieviesta kā vispārējās procedūras Darbības rokasgrāmatas A daļā, procedūras attiecībā uz katru izmantojamā gaisa kuģa tipu tās rokasgrāmatas B daļā un tās Obligāto iekārtu sarakstā (MEL), kā arī apmācība un treniņi rokasgrāmatas D daļā;
3. GKE augstākā līmeņa menedžments ir guvis pārliecību par šādu ekonomiski izdevīgāku lidojumu izpildes iespējamību un varēs tikt izvērtēta iespēja investēt līdzekļus pārējo gaisa kuģu aprīkošanai atbilstoši šo pieejas procedūru izpildē iesaistīto gaisa kuģu tehniskā aprīkojuma prasībām.

Gaisa kuģu ekspluatācijas daļa cer, ka līdz ar šo noslēguma ziņojumu GKE aktivitātes saistībā ar AMBER projektu nebeigsies un tiks turpināts darbs pie RNP APCH un/vai RNP APCH AR apstiprinājuma/u saņemšanas saskaņā ar dokumentos AMC 20-26 un AMC 20-27 minētajām prasībām.

Gaisa kuģu ekspluatācijas daļas vadītājs [redacted]

Auziņš 67507910

airBaltic
REĢ. Nr. 40003245752
IZEJOŠAIS Nr
IENĀKOŠAIS Nr 562/09/14
DATUMS 08.09.14

LATVIJAS REPUBLIKAS SATIKSMES MINISTRIJA
Valsts aģentūra „CIVILĀS AVIĀCIJAS AĢENTŪRA"
LIDOSTA "RĪGA" 10/1, MĀRUPES NOVADS, LV-1053, LATVIJA, TĀLRUNIS 67830936, FAKSS 67830967, Latcaa@latcaa.gov.lv

MINISTRY OF TRANSPORT OF THE REPUBLIC OF LATVIA
CIVIL AVIATION AGENCY
AIRPORT "RĪGA" 10/1, MĀRUPES NOVADS, LV-1053, LATVIA, PHONE (371)67830936, FAX (371)67830967, Latcaa@latcaa.gov.lv

Mārupes novadā

AERONAVIGĀCIJAS DAĻA

04.09.2014. Nr. 01-8-400/917

AS „Air Baltic Corporation"
SVP Lidojumu dienesta vadītājam P. Cālītim
Kopija: VAS „Latvijas gaisa satiksme"

Par AMBER projektu

Pamatojoties uz gaisa kuģu ekspluatanta AS „Air Baltic Corporation" (turpmāk – Air Baltic) 2014. gada 14. augustā elektroniski nosūtīto vēstuli ar lūgumu sniegt izvērtējumu par AMBER projektu un "VAS „Latvijas gaisa satiksme" (turpmāk- LGS) šā gada 28. augustā elektroniski pārsūtīto analīzi par AMBER projekta laikā veiktajiem lidojumiem, Aeronavigācijas daļa pozitīvi novērtē Air Baltic iniacitīvu veikt RNP AR 0.3 testa lidojumus un LGS vēlmi un iespējas atbalstīt šo lidojumu veiksmīgu un drošu izpildi.

Aeronavigācijas daļa aicina Air Baltic aktīvi piedalīties LGS plānotajā Latvijas gaisa telpas pārstrādē, lai izstrādājot noteiktas navigācijas specifikācijas procedūras, pēc iespējas vairāk tiktu ņemta vērā AMBER projekta laikā gūtā pieredze un LGS dispečeru sniegtās rekomendācijas lidojumu efektivitātes un lidojumu drošuma nodrošināšanai. Lai gan, RNP AR procedūras atsevišķam gaisa kuģa tipam un individuālam gaisa kuģu ekspluatantam nozīmīgi samazina gaisa telpas izmantošanas efektivitāti, jo netiek izmantotas vienotas lidojumu procedūras, turpmākai praktiskai noteiktas precizitātes procedūru ieviešanai, nepieciešams ņemt vērā optimālās lidojumu trajektorijas vairākiem gaisa kuģu tipiem, lai šīs ielidošanas un izlidošanas procedūras varētu harmoniski izmantot pēc iespējas lielāks gaisa telpas lietotāju skaits, tajā pašā laikā uzturot iepriekšējā līmenī vai pat samazinot darba noslodzi gaisa satiksmes vadības dispečeriem.

Daļas vadītājs [redacted]

Neimane 67830953

Appendix D V-PAT Analysis Report

On the following 17 pages is included the AMBER project V-PATH Report on Continuous Descent Operations at Riga Airport.

CGP

Report on Continuous Descent Operations at Riga Airport

W16.06.03 – D7-2

CGP Associates Ltd
23 Wood Farm Road
Malvern
Worcs WR14 1GQ
UK

Ref: CGP07/110/35.04
Contract: 12-221028-C
Dated: 17/07 2014
Status: Final
Version: 1 Issue: 3

AMENDMENT RECORD

PROJECT NO./TITLE SESAR Project 16.03.01: V-PAT tool update, run and training					
~~SOFTWARE~~/DOCUMENT TITLE Report on Continuous Descent Operations at Riga Airport					
CGP DOCUMENT REFERENCE CGP07/110/35.03					
DATE ISSUED	ISSUED ~~TO~~/BY	BRIEF DESCRIPTION OF AMENDMENT	UPDATED VERSION NO.	INCORPORATION DATE	INCORPORATED BY
27/03/14	I Pugh	Draft for review	Draft 1.1		
28/03/14	I Pugh	Raised to final following incorporation of review comments	1.1	28/03/14	I Pugh
14/4/14	I Pugh	Incorporating EUROCONTROL comments	1.2 d1	14/04/14	I Pugh
24/4/14	I Pugh	Raised to final following incorporation of review comments	Final 1.2	24/4/14	I Pugh
17/07/14	I Pugh	Document updated with extra flights and comparative analysis	Draft 1.3 d1	17/07/14	I Pugh
17/07/14	I Pugh	After internal review	Final 1.3	17/07/14	I Pugh

EXECUTIVE SUMMARY

This study was commissioned by EUROCONTROL Experimental Centre as part of their support to AIRE projects under SESAR work package W16.06.03. The objective was to analyse data provided as part of the AMBER project by Latvijas Gaisa Satiksme (LGS), the Air Navigation Services Provider (ANSP) for the Riga Flight Information Region (FIR). The flights were all operated by Air Baltic. The AMBER (Arrival Modernization for Better Efficiency in Riga) project aims to introduce new arrival procedures at Riga International airport (EVRA).

Surveillance data was analysed for 119 flights arriving at Riga International airport in the period from September 2013 to May 2014. EUROCONTROL's V-PAT tool was used to analyse the profiles to determine how much level flight occurred during each descent, and therefore the degree to which the flights undertook Continuous Descent Operations (CDO). Results from the "AMBER project data report – scorecard" were used to compare with V-PAT fuel burn estimates. 114 flights were reported on in the AMBER scorecard (12/05/14).

The flights in the AMBER dataset exhibited continuous descent profiles from the Top of Descent (TOD), with the following caveats:-

1) All flights landed on runway 18 approaching from the North. As all flights were arriving from airports south of Riga, they all had to execute a turn to the North of the runway to bring them onto the correct heading. Several flights had exhibited level flight during the turn.
2) Nearly half of flights in the dataset showed an initial shallow descent angle. Presumably this is simply a slowing down manoeuvre, although confirmation is needed.
3) Several flights showed visible variation in the descent angle during the descent. This could be explained by slowing down manoeuvres during descent.

Fuel burn measurements were available from the AMBER scorecard, reporting fuel used from the 75NM crossing point to touchdown. V-PAT estimates fuel consumed using fuel flow rates for cruise, climb and descent phases at different altitudes. Fuel flow rates were obtained from manufacturer's tables and used in V-PAT to estimate fuel burned during the descent.

Generally there was a good correlation between the actual fuel burn measurements, and the V-PAT estimates, the mean difference was 5.3 Kg. The shallow descent phases may also explain part of the difference depending on the engine settings during these phases.

Table of Contents

1 INTRODUCTION

This report has been commissioned by EUROCONTROL Experimental Centre as part of their support to AIRE projects under SESAR work package W16.06.03. The report contains the results of analysis of data provided as part of the AMBER project by Latvijas Gaisa Satiksme (LGS), the Air Navigation Services Provider (ANSP) for the Riga Flight Information Region (FIR). The flights were all operated by Air Baltic. The AMBER (Arrival Modernization for Better Efficiency in Riga) project aims to introduce new arrival procedures at Riga International airport (EVRA).

Surveillance data was supplied for 122 flights arriving at Riga International airport in the period from September to December 2014. EUROCONTROL's V-PAT tool was used to analyse the profiles to determine how much level flight occurred during each descent, and therefore the degree to which the flights undertook Continuous Descent Operations (CDO).

V-PAT (Vertical Profile Analysis Tool) was developed to enable users to assess the performance of large volumes of flights and provide an overview of the performance of the dataset with summary statistical results. In this case, a relatively small number of flights were supplied. Therefore the tool was used to provide a more detailed investigation of each flight.

The report contains the following sections: Section 2 provides an explanation of the V-PAT algorithms. Section 3 describes the data set that was analysed. Section 4 contains the detailed flight analyses, including the noise analysis. Section 5 contains the conclusions of the study. Annexes A to C provide detailed results for each flight.

2 EXPLANATION OF V-PAT ALGORITHMS

2.1 INTRODUCTION

The principal discriminator for identifying level flight is the rate of change of altitude. A flight is considered "level" during a descent when the rate of change of altitude between consecutive plots is less than a configured parameter (default = 200 feet per second).

Additionally, it was decided that only segments of greater than 10 seconds would be deemed as level flight. This is because the altitude measurements are only resolved to increments of 25 feet (standard ASTERIX field), and with plots occurring every 4 seconds some shallow descents are reported with adjacent plots at the same altitude.

Therefore the V-PAT analysis has been run twice once with the minimum period of level flight parameter set to 10 seconds and secondly set to zero. This second analysis allows us to identify shallow descent periods.

2.2 ARRIVALS ANALYSIS

The CDA (CDO) analysis focuses on the approach phase of flight from a top-of-descent (TOD) within a range from the destination airport (ADES) ("Radius from ADES") down to the altitude "Min Altitude Plot Cut-Off" (both of these cut off points are defined by configurable parameters). 100NM has been set for "Radius from ADES" because it is a realistic boundary for the data set being analysed. All of the flights in the sample undertake a turn to align with the runway at approximately FL25. This causes many flights to level out briefly. The actual flight level varies around FL25, so by setting the minimum threshold ("Min Altitude Plot Cut-Off") above this level at FL30 the turn is excluded.

2.3 CDO METRICS

The following metrics are calculated to measure CDO:

- Distance Flown from TOD to "Min Altitude Plot Cut-Off" altitude measured in NM;
- Distance Flown "Level" in NM within the above distance;
- Percentage of Distance Flown "Level" within the total distance;
- Repeat of the first three metrics over the route segment from TOD or a configurable "Radius from ADES" (whichever occurs first) to "Above/Below Altitude Cut-Off" (default = FL100) including plots at that level;
- Repeat of the first three metrics over the route segment from below an "Above/Below Altitude Cut-Off" to the "Min Altitude Plot Cut-Off" including plots at that level.

2.4 CDO ALGORITHM

The CDO Algorithm evaluates each flight in a V-PAT database in the following steps:

1. Check the location of the last radar plot and measure the distance to the ADES in the flight's plan. If the distance is greater than the parameter "Last Plot Max. Dist to ADES" then the algorithm stops for this flight.

2. Determine the highest flight level in the radar data – effectively the flight's cruise level. Check this cruise level against the parameter "Ignore Flights Cruise Below" and if the flight is below the parameter then the algorithm stops for this flight.

3. Work backwards along the flight's radar plots from the last plot to determine a start point for the analysis, which will be the point after the first point outside of the parameter "Radius from ADES".

4. If the start point for the analysis is at (or above) the cruise level, move forwards from that point to the last point at (or above) the cruise level before descending – this sets a new start point for the calculation.

5. From the start point defined in 3. & 4. work forwards through each pair of plots to measure distance flown and whether it is in "level" flight.

6. Record three sets of distances:
   a. those covering all plots
   b. those covering plots down to (and including) "Above/Below Altitude Cut-Off"
   c. those covering plots below "Above/Below Altitude Cut-Off".

7. The analysis stops at the first point below "Min Altitude Plot Cut-Off" or the end of the plots, whichever occurs first.

8. If parameter "Min Level Dist Above Alt" is not zero AND the total amount of "level" flight above the "Above/Below Altitude Cut-Off" parameter is less than the "Min Level Dist Above Alt" parameter, then that amount of "level" flight is set to zero in both 6a and 6b above. If the "Min Level Dist Above Alt" parameter is set to zero, then this is not performed. In this analysis, "Min Level Dist Above Alt" is set to zero so all level flight is measured and recorded.

9. If parameter "Min Level Dist Below Alt" is not zero AND there is only one segment of "level" flight below the "Above/Below Altitude Cut-Off" AND the total amount of "level" flight below the "Above/Below Altitude Cut-Off" parameter is less than the "Min Level Dist Below Alt", then that amount of "level" flight is set to zero in both 6a and 6c above. If the "Min Level Dist Below Alt" parameter is set to zero, then this is not performed. In this analysis, "Min Level Dist Below Alt" is set to zero so all level flight is measured and recorded.

10. Record the final distances and calculate a percentage value for "level" flight for each of the three trajectory segments, i.e. those covering all plots, those down to (and including) "Above/Below Altitude Cut-Off" and those below "Above/Below Altitude Cut-Off".

11. Also calculated and recorded during this processing are the fuel burnt, noise deltas, flight angles and final approach heading (for indications of runway direction). Values provided cover each of the three trajectory segments – although the noise delta and approach heading results are the same for each segment.

2.5 FUEL BURN CALCULATION

Fuel consumed during the descent is estimated using burn rates obtained from the EUROCONTROL BADA model. The aircraft type used is the DH8D. The calculation of fuel consumed is made between sequential pairs of radar plots from the Top of Descent to FL30, using the aircraft height, duration of between plots and the phase of flight. Separate calculations are made for the upper and lower segments of the descent (above and below FL100).

A look-up table of BADA fuel consumption rates (Kg/min) is provided below.

Level	0	5	10	15	20	30	40	60	80	100	120	140	160	180	200	220	240	250
Cruise						11.7	11.9	18.2	18.3	23.2	23.2	23.1	23	21.6	20.4	19.3	18.3	17.8
Climb	33.1	32.7	32.3	30.7	30.5	29.9	29.4	28.4	27.4	26.4	25.4	24.4	23.4	22.4	21.5	20.6	19.9	19.6
Descent	11.3	11.4	11.5	11.5	11.6	11.7	11.9	12.1	12.4	12.7	12.9	13.2	13.4	13.7	14	14.2	14.5	14.6

A look-up table of fuel consumption rates (Kg/min) derived from the Manufacturer's Fuel Tables is provided below.

Level	**0**	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**250**
Cruise	18.6	18.1	17.5	17.0	16.5	17.9	17.7	17.7	17.6	16.8	15.9	15.1	14.5	14.3
Descent	7.7	7.7	6.4	6.9	6.2	5.7	6.9	6.2	5.7	7.7	9.7	9.4	9.7	6.3

Note that no Climb figures were provided in the manufacturer's tables. Therefore in V-PAT the Cruise values were used as Climb values.

If the aircraft descends between plots, the Descent Phase values are used. During periods of "level" flight, the Cruise phase values are used.

2.6 CARBON DIOXIDE (CO_2) CALCULATION

An additional calculation made of Carbon Dioxide (CO_2) in Kg produced by multiplication of the fuel in Kg by 3.15 – so for example, 1000 Kg of fuel burnt equates to 3150 Kg of CO_2.

2.7 NOISE ESTIMATION ALGORITHM

V-PAT makes a simple estimate of the difference in noise level on the ground below the aircraft. At selected points along the descent, V-PAT calculates the height of the aircraft following an optimum descent profile, and the actual measured height of the aircraft. This difference in height will result in a difference in the amount of noise reaching the ground. V-PAT uses a simple formula for calculating the difference in noise on the ground between two different flight altitudes. The formula is as follows:

$$dB_{delta} = -20\left(\log_{10}\left(\frac{Y_2}{Y_1}\right)\right)$$

Where:

dB_{delta} = difference in decibels on ground between two altitudes;

Y_1 = Altitude 1; Y_2 = Altitude 2.

This simple formula produces the following differences in noise for a set of altitudes:

Noise Delta in decibels		***Y_1 ft***									
		200	**400**	**630**	**1,000**	**2,000**	**4,000**	**6,300**	**10,000**	**16,000**	**25,000**
Y_2 ft	**200**	0.0	6.0	10.0	14.0	20.0	26.0	30.0	34.0	38.1	41.9
	400	-6.0	0.0	3.9	8.0	14.0	20.0	23.9	28.0	32.0	35.9
	630	-10.0	-3.9	0.0	4.0	10.0	16.1	20.0	24.0	28.1	32.0
	1,000	-14.0	-8.0	-4.0	0.0	6.0	12.0	16.0	20.0	24.1	28.0
	2,000	-20.0	-14.0	-10.0	-6.0	0.0	[A] **6.0**	10.0	14.0	18.1	21.9
	4,000	-26.0	-20.0	-16.1	-12.0	[B] **-6.0**	0.0	3.9	8.0	12.0	15.9
	6,300	-30.0	-23.9	-20.0	-16.0	-10.0	-3.9	0.0	4.0	8.1	12.0
	10,000	-34.0	-28.0	-24.0	-20.0	-14.0	-8.0	-4.0	0.0	4.1	8.0
	16,000	-38.1	-32.0	-28.1	-24.1	-18.1	-12.0	-8.1	-4.1	0.0	3.9
	25,000	-41.9	-35.9	-32.0	-28.0	-21.9	-15.9	-12.0	-8.0	-3.9	0.0

A negative Noise Delta indicates less noise. A positive Noise Delta indicates more noise.

Two points are selected during the approach to make the calculation. These are defined by the configurable parameters “Noise Delta Altitude #1” and “Noise Delta Altitude #2” (defaults FL100 and FL40 respectively).

For each flight the algorithm for a descent has the following steps:

1. Calculate the distances back from the last radar plot used in the CDA (CDO) analysis to altitudes matching “Noise Delta Altitude #1” and “Noise Delta Altitude #2” for a flight using the configurable “Optimum Descent Angle” (default is -3 degrees).

2. Working back up the radar plots for each of the calculated distances in step 1, determine the altitude actually flown (Y_{actual}) and then calculate the Noise Delta in decibels using the simple formula.

3 OVERVIEW OF FLIGHT DATA

3.1 INTRODUCTION

The flight data was supplied by Latvijas Gaisa Satiksme (LGS), the Air Navigation Services Provider (ANSP) for the Riga Flight Information Region (FIR). The flights were all operated by Air Baltic. Data files were supplied for 122 flights that were arrivals at Riga airport (EVRA) during the period 15th September 2013 to 25th May 2014. The flights were all Bombardier (Dash 8) DHC−8−402 Q400 NextGen aircraft.

3.2 DATA FORMAT

The data was supplied in a set of files, one per flight. Each file contained a series of surveillance plots, one per row. The fields were separated by spaces. The field contents were date and time stamps plus selected ASTERIX CAT062 data fields.

Field Label		Example
Date		2013-09-15
Time		08:27:55
TrackNumber	(I062/070)	72
TrackMode3A	(I062/060)	A6130
Sensor	(SAC/SIC)	71/101
MeasuredFlightLevel	(I062/136)	15800
CalculatedRate of C/D	(I062/220)	-512.50
Speed Vx Vy	(I062/185)	332.40 -78.73
Longitude	(I062/105)	24.52375
Latitude	(I062/105)	56.440833
Callsign	(I062/390)	BTI3G2
ADEP	(I062/390)	EYVI
ADES	(I062/390)	EVRA

The data was converted to a format that made it suitable for import into V-PAT tool. Each flight was allocated a unique identifier. This was deemed necessary because as the data was from multiple days there was replication of callsigns in the original data.

3.3 DESCRIPTION OF FLIGHTS

One hundred and twenty two files of flight data were supplied in the data set. Two flights were removed from the data set as they could not be analysed: AMBER015 had a period of missing data during the descent, AMBER008 had no height data. One flight AMBER025 was supplied in error and was removed from the data set. AMB075 did not decode.

All flights were arrivals into Riga airport (EVRA) on Runway 018.

The table below lists the flights in the data set:

V-PAT Identifier	Callsign	Date	ADEP	V-PAT Identifier	Callsign	Date	ADEP
AMB001	BTI03X	17/09/2013	EYPA	AMB062	BTI34G	23/02/2014	EYVI
AMB002	BTI03X	09/10/2013	EYPA	AMB063	BTI34G	05/03/2014	EYVI
AMB003	BTI212	05/12/2013	EDDT	AMB064	BTI34G	23/03/2014	EYVI
AMB004	BTI212	10/12/2013	EDDT	AMB065	BTI34L	01/04/2014	EYVI
AMB005	BTI222	14/12/2013	EDDM	AMB066	BTI34L	10/04/2014	EYVI
AMB006	BTI34G	09/10/2013	EYVI	AMB067	BTI34L	13/04/2014	EYVI
AMB007	BTI34G	22/10/2013	EYVI	AMB068	BTI34L	17/04/2014	EYVI
AMBER08	BTI34G	01/11/2013	EYVI	AMB069	BTI3G2	31/12/2013	EYVI
AMB009	BTI34L	15/09/2013	EYVI	AMB070	BTI401	17/01/2014	UKBB
AMB010	BTI34L	05/10/2013	EYVI	AMB071	BTI401	21/01/2014	UKBB
AMB011	BTI34L	12/10/2013	EYVI	AMB072	BTI401	30/01/2014	UKBB
AMB012	BTI3G2	15/09/2013	EYVI	AMB073	BTI401	31/01/2014	UKBB
AMB013	BTI3G2	22/09/2013	EYVI	AMB074	BTI401	25/02/2014	UKBB
AMB014	BTI3G2	28/09/2013	EYVI	AMB075	BTI401	03/03/2014	UKBB
AMB015	BTI3G2	30/09/2013	EYVI	AMB076	BTI401	05/03/2014	UKBB
AMB016	BTI3G2	03/10/2013	EYVI	AMB077	BTI401	08/03/2014	UKBB
AMB017	BTI3G2	09/10/2013	EYVI	AMB078	BTI401	18/03/2014	UKBB
AMB018	BTI3G2	22/10/2013	EYVI	AMB079	BTI401	21/03/2014	UKBB
AMB019	BTI3G2	01/11/2013	EYVI	AMB080	BTI401	27/03/2014	UKBB
AMB020	BTI3G2	24/11/2013	EYVI	AMB081	BTI401	05/04/2014	UKBB
AMB021	BTI407	28/11/2013	UKBB	AMB082	BTI401	10/04/2014	UKBB
AMB022	BTI413	03/10/2013	UMMS	AMB083	BTI401	12/04/2014	UKBB
AMB023	BTI413	31/10/2013	UMMS	AMB084	BTI401	19/04/2014	UKBB
AMB024	BTI413	05/12/2013	UMMS	AMB085	BTI401	20/04/2014	UKBB
AMB025	BTI419	28/11/2013		AMB086	BTI413	23/01/2014	UMMS
AMB026	BTI421	12/10/2013	LUKK	AMB087	BTI413	10/04/2014	UMMS
AMB027	BTI482	15/09/2013	LKPR	AMB088	BTI482	06/04/2014	LKPR
AMB028	BTI482	19/09/2013	LKPR	AMB089	BTI482	11/04/2014	LKPR
AMB029	BTI482	22/09/2013	LKPR	AMB090	BTI492	08/02/2014	LHBP
AMB030	BTI482	29/09/2013	LKPR	AMB091	BTI492	06/04/2014	LHBP
AMB031	BTI482	30/09/2013	LKPR	AMB092	BTI492	13/04/2014	LHBP
AMB032	BTI482	13/10/2013	LKPR	AMB093	BTI492	18/04/2014	LHBP
AMB033	BTI482	14/10/2013	LKPR	AMB094	BTI7EQ	21/03/2014	EDDF
AMB034	BTI482	21/10/2013	LKPR	AMB095	BTI97T	06/04/2014	EDDT
AMB035	BTI8KT	17/09/2013	EPWA	AMB096	BTI97T	10/04/2014	EDDT

V-PAT Identifier	Callsign	Date	ADEP	V-PAT Identifier	Callsign	Date	ADEP
AMB036	BTI8KT	19/09/2013	EPWA	AMB097	BTI9HP	09/01/2014	LOWW
AMB037	BTI8KT	08/10/2013	EYVI	AMB098	BTI9HP	01/02/2014	LOWW
AMB038	BTI8KT	22/10/2013	EPWA	AMB099	BTI9HP	07/02/2014	LOWW
AMB039	BTI8KT	25/10/2013	EPWA	AMB100	BTI9HP	24/02/2014	LOWW
AMB040	BTI9HP	14/12/2013	LOWW	AMB101	BTI9HP	20/03/2014	LOWW
AMB041	BTI212	02/02/2014	EDDT	AMB102	BTI9HP	22/03/2014	LOWW
AMB042	BTI212	25/02/2014	EDDT	AMB103	BTI9HP	29/03/2014	LOWW
AMB043	BTI212	04/03/2014	EDDT	AMB104	BTI9HP	01/04/2014	LOWW
AMB044	BTI212	12/03/2014	EDDT	AMB105	BTI03X	03/05/2014	EYPA
AMB045	BTI212	18/03/2014	EDDT	AMB106	BTI218	26/04/2014	EDDT
AMB046	BTI212	20/03/2014	EDDT	AMB107	BTI218	13/05/2014	EDDT
AMB047	BTI212	27/03/2014	EDDT	AMB108	BTI222	23/05/2014	EDDM
AMB048	BTI218	12/04/2014	EDDT	AMB109	BTI34L	23/05/2014	EYVI
AMB049	BTI222	06/01/2014	EDDM	AMB110	BTI3G2	18/05/2014	EYVI
AMB050	BTI222	24/02/2014	EDDM	AMB111	BTI401	26/04/2014	UKBB
AMB051	BTI222	26/03/2014	EDDM	AMB112	BTI401	07/05/2014	UKBB
AMB052	BTI222	01/04/2014	EDDM	AMB113	BTI413	01/05/2014	UMMS
AMB053	BTI222	05/04/2014	EDDM	AMB114	BTI413	22/05/2014	UMMS
AMB054	BTI222	11/04/2014	EDDM	AMB115	BTI421	24/05/2014	LUKK
AMB055	BTI222	12/04/2014	EDDM	AMB116	BTI482	18/05/2014	LKPR
AMB056	BTI222	18/04/2014	EDDM	AMB117	BTI482	23/05/2014	LKPR
AMB057	BTI34G	09/01/2014	EYVI	AMB118	BTI492	01/05/2014	LHBP
AMB058	BTI34G	21/01/2014	EYVI	AMB119	BTI492	23/05/2014	LHBP
AMB059	BTI34G	30/01/2014	EYVI	AMB120	BTI97T	24/04/2014	EDDT
AMB060	BTI34G	31/01/2014	EYVI	AMB121	BTI97T	01/05/2014	EDDT
AMB061	BTI34G	02/02/2014	EYVI	AMB122	BTI97T	25/05/2014	EDDT

The flights that have been excluded from the further analysis are shown below where possible.

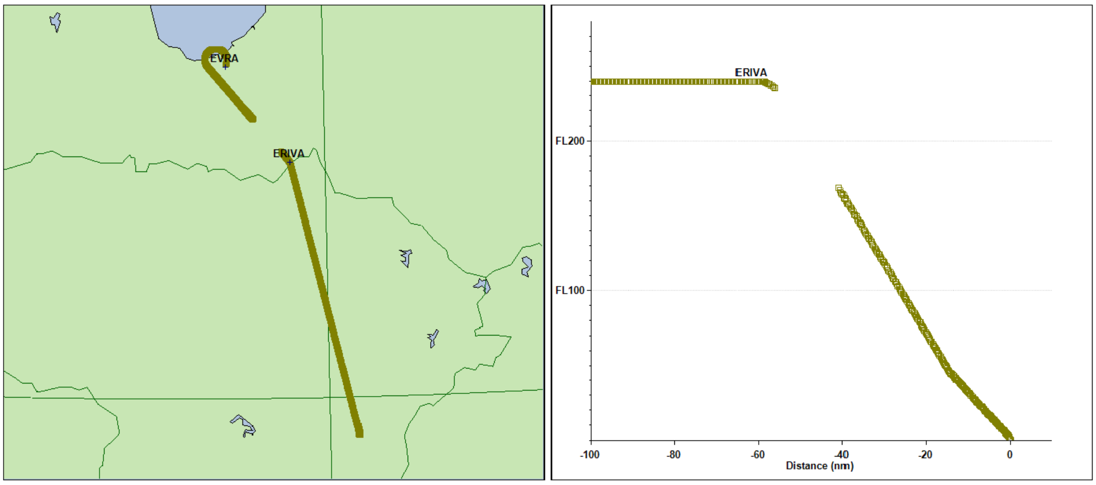


Figure 1 – Flight AMB015 showing period of missing data

4 CONTINUOUS DESCENT ANALYSIS

4.1 V-PAT ANALYSIS

Having removed the flights identified above, one hundred and nineteen flights are considered in the analysis. The CDO analysis is conducted from the Top Of Descent (TOD) within a radius of ADES of 100NM down to a lower level of FL30. Annex A provides charts in plan and profile view for each flight.

Four STAR Entry Points have been used: ORVIX, ASKOR, GUNTA and ERIVA.

Number of Flights	STAR Entry Point				Total
	ASKOR	ERIVA	GUNTA	ORVIX	
Total	36	54	18	11	119
With Level Flight Detected (TOD to FL30)	1	0	0	0	1
With No Level Flight from TOD to FL30	35	54	18	11	118

Only one flight AMB122 had level flight, and this was above FL100.

Table below summarises flights containing level flight segments of less than 10 seconds. Visual inspection of the descents indicates that a significant number of flights exhibit a period of initial shallow descent. This accounts for the bulk of the level flight reported in the table. It is not actually level flight but rather an artefact of the altitude quantisation error (see section 2.1).

Values	STAR Entry Point				Total
	ASKOR	ERIVA	GUNTA	ORVIX	
Number of Flights	17	29	9	6	61
Average of Distance Flown (NM)	67.8	54.7	59.0	64.7	60.0
Average of Distance Level	1.5	1.7	1.4	1.0	1.5
Maximum Distance Flown	67.8	54.7	59.0	64.7	60.0

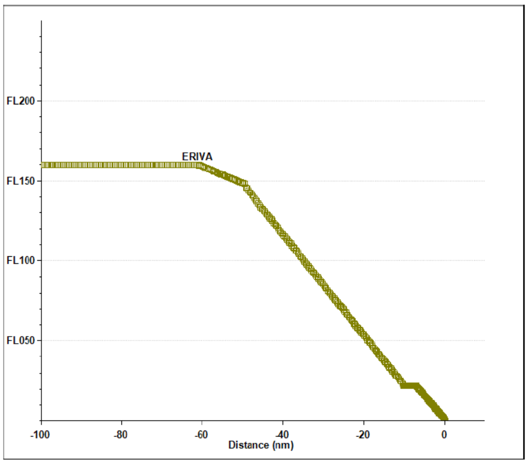
Table below summarises the flights with no level flight.

Values	STAR Entry Point				Total
	ASKOR	ERIVA	GUNTA	ORVIX	
Number of Flights	36	54	18	11	119
Average of Distance Flown (NM)	65.2	52.5	58.4	67.7	58.6
Mean Descent Angle (degrees)	3.1	3.2	3.2	3.0	3.2
Maximum Descent Angle (degrees)	3.8	4.2	3.9	3.4	4.2
Minimum Descent Angle (degrees)	2.2	3.2	2.7	2.7	2.0

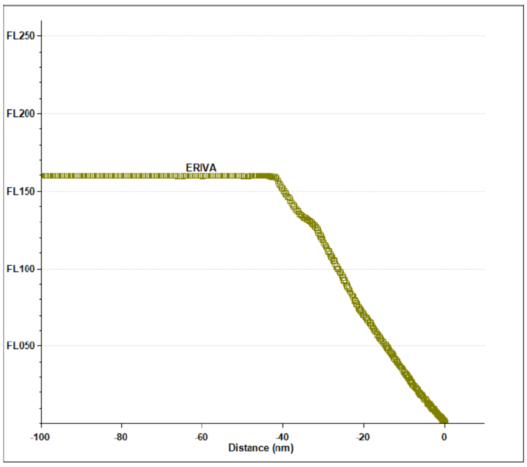
The table indicates considerable variation in the overall descent angle. The typical optimum descent angle for CDO flights is 3 degrees. However, this can vary with aircraft type and other operational considerations. Further analysis would be required to determine whether these descent angles are within an acceptable envelope for CDO flight for these specific flights.

4.2 VISUAL INSPECTION

All flight trajectories were plotted using the V-PAT charting tool. This provides both plan and profile views of the flight. Each flight was visually inspected. Three features of the descent were observed: 1) shallow descent angles during the descent phase, 2) variation in the descent angle during the descent, and 3) level flight during the turn onto the final approach. Examples are shown below.



Example of Initial Shallow Descent and Level Flight during Final Turn



Example of Variable Descent Angle

Values	ASKOR	ERIVA	GUNTA	ORVIX	Total
Number of Flights	36	54	18	11	119
Average of Distance from TOD	65.2	52.5	58.4	67.7	58.6
No of Perfect Descents	7	10	2		19
Number of Initial Shallow Descents	17	28	5	7	57
No of Level Offs during Final Turn	21	24	7	6	58

4.3 COMPARATIVE FUEL BURN ANALYSIS

The AMBER Project provided measurements on the flights investigated by the V-PAT analysis. These were manually matched using date, arrival time and route. A comparison was made between the fuel burned, and the estimated fuel burn from V-PAT. The measurement supplied was from where the flight crossed the 75NM radius from the airport, and the touchdown point. V-PAT estimates fuel burned from the TOD of descent. Therefore the V-PAT result was adjusted by calculating the time flown from the 75NM point to the top of descent and adding additional fuel burned during this cruise phase.

V-PAT estimates were initially made using fuel burn rates from the BADA database. However, these were found to be very high compared to the actual measurements. Manufacturer's fuel burn estimates were obtained from Air Baltic and these were used to replace the BADA values. Using these values the V-PAT fuel estimates proved to be more closely matched to the actual measurements.

The mean difference between the measured fuel consumption values and the V-PAT estimates using the manufacturer's fuel burn rates was 5.3Kg with a standard deviation of 33.2Kg. Using the BADA rates, VPAT significantly overestimates the fuel consumed with a mean difference of 86.8Kg and a standard deviation of 43.4Kg.

Annex B contains more details of the fuel burn analysis.

4.4 NOISE ANALYSIS

Annex C lists the flights and the calculated theoretical noise difference between the optimum and actual descent paths at the points where on the optimum flight path the aircraft would be at FL100 and FL40.

The table below shows mean values for the noise difference. Negative values show that the noise is lower than calculated for the optimum descent path, indicating that the flight is higher.

Values	STAR Entry Point				Grand Total
	ASKOR	ERIVA	GUNTA	ORVIX	
Noise Difference at FL40 (dB)	-0.2	-0.3	-0.2	-0.2	-0.2
Noise Difference at FL100 (dB)	-0.5	-0.7	-0.6	-0.4	-0.6

99 out of the 119 flights analysed show negative values at the FL100 point, six flights are zero, and 14 are positive. The values are 0.4 dBs or less. The flights generally demonstrating a good noise profile.

At the FL40 point, the differences are even smaller with the maximum difference being 0.5.dBs.

5 CONCLUSIONS

The analysis has resulted in the following conclusions:

1. The flights in the AMBER dataset show good compliance to continuous descents. Only one flight showed significant level flight (AMB122) and this was above FL100.

2. Substantial numbers of flights in this dataset showed an initial period of shallow descent angle (57 out of the 119).

3. Several flights showed visible variation in the descent angle during the descent. This could be explained by slowing down manoeuvres during descent.

4. All flights had to make a turn at approximately FL25 in order to bring them on to the correct approach heading. Substantial numbers of flights showed periods of level flight during the turn. This could be explained as slowing down manoeuvres during descent.

5. V-PAT fuel estimates were compared with actual measurements made during the trial. Two sets of fuel burn rates were used by V-PAT: 1) manufacturer's supplied values, and 2) BADA model values. Using the manufacturer's values, V-PAT made good estimates with a mean error of 5.3Kg and a standard deviation of 33.2Kg. The descent was analysed from the point where the flight crossed a radial distance 75NM from the airport to touchdown. Using the BADA values, V-PAT overestimates the fuel burn by an average of 86.8Kg with a standard deviation of 43.4 Kg.

6. A comparison of noise on an optimum descent profile versus noise on the actual profiles shows that the variation in noise on the ground below aircraft at the measurement points is always less than 0.5 dB above the optimum.

-END OF DOCUMENT-