# ODP - B1 Final Project Report (Demonstration Report)

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***Abstract***

This document describes the Demonstration Exercises, of the "Optimised Descent Profiles" (ODP) project (DFS Ref. SESAR/ODP/001) in response to invitation Ref. SJU/LC/0102-CFP, Lot no 1, submitted by DFS Deutsche Flugsicherung GmbH as Consortium Leader and partners: Austrocontrol, DSNA, EUROCONTROL Maastricht UAC and Skyguide as ANSPs; Air France, Lufthansa, and Swiss Airlines, as Airspace Users and EUROCONTROL as Network Manager.

A total of 33 Demonstration Exercises were executed in the frame of the ODP project with objective to demonstrate feasibility and support implementation of cross-border Optimised Descent Profiles capabilities.

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In accordance with §18.1.2 (a) of the underlying Co-Financing Agreement this deliverable consists of SJU Foreground.

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# Executive summary

The "Optimised Descent Profiles" (ODP) project, co-financed by the SESAR Joint Undertaking as part of the SESAR Large Scale Demonstrations, has been successfully carried out in 2015-2016.
A total of 33 Demonstration Exercises provided evidence that cross-border Optimised Descent Profiles capabilities extending across over multiple ANSP AORs with complex to very complex airspace structures, comprising several major hubs and an extremely high traffic density, can be realised. Moreover, these capabilities have a positive impact on the KPAs Efficiency and Environmental Sustainability, without adversely affecting safety and capacity, under specific conditions that require tailored solutions on a case by case basis.

A total of fifteen recommendations for the way forward are detailed in this Demonstration Reports chapter Conclusions and Recommendations.

Major conclusions are:

- Optimised profiles can be implemented but in most cases there needs to be a comprehensive approach addressing all performance areas to avoid negative impacts. In densely used airspaces optimum profiles are certainly not always achievable. Profile optimisation should, nevertheless, be part of every initiative affecting procedure design or airspace reorganisation regardless of traffic volume. Areas with low traffic volumes or hours of low traffic load are predestined for trialling optimised profiles starting at cruising FL and allowing the pilots to "descend when ready", continuously.
- Current VFE is not always at optimum level in the planning phase, but tactical interventions and clearances are already of benefit for the airline operators. As the actual benefit of a tactical intervention largely depends on the working habits and the level of practical experience of acting ATM-staff and flight crew, the formal development of optimised and/or CDO profiles will help to bridge existing gaps. However, compared to HFE gains, achieving VFE gains requires bigger efforts for preparation, design and implementation. Developed solutions may then serve as template and can be applied flexibly whenever deemed suitable, although all ODP experts agree on the fact that solutions should be tailored to local needs and constraints (e.g. based on time of day, sectorisation, actual traffic).
- In anticipation of Europe's ATM-system evolving in accordance with the concept of trajectory management, these efforts for preparation, design and implementation are an excellent opportunity to shape the mind-set of concerned staff, thus contributing to increased consciousness regarding optimum trajectories. To calculate such routing benefits, tools have to be further developed and need to consider a commonly agreed framework including airlines requirements.
- It is also desirable to develop a more unified standard for the assessment of the VFE. Lacking such a standard, a wide range of methods, technics and tools have been used by consortium airlines, ANSPs and NMD for qualitative and quantitative performance assessments of the demonstration exercises.
- For an extensive implementation of optimised profiles, new concepts including airspace re-design and support tools are needed in order to minimise workload (e.g. separation etc.) and impact on working environments. Whenever modifications are

considered in future procedure design (like free routing, curved approaches, X-MAN etc.), ODP should be used as part of a holistic structure.

The 33 Demonstration Exercises involved nine aerodromes (Bale-Mulhouse, Berlin-Tegel, Frankfurt, Geneva, Munich, Strasbourg, Stuttgart, Vienna and Zurich) and were conducted by a consortium of eight partners. As a quick win, some profile optimisation exercises have already led to permanent publications and implementation in operations. Two profile optimisations exercises will be implemented after the closure of the project because of the lead in time required for publications, one exercise has been suspended as considered not feasible based on operational investigations and one exercise was decided to be a part of the FABEC VFE initiative.

In total 12.183 flight trials were measured. For 4.551 Demonstration flights a fuel saving of 7.135kg and a reduction of $CO_2$ emissions by ~11,85 tons was achieved. This measurement was calculated for flights of AFR, HOP!, Swiss and DLH. Besides measurements, BADA calculation based on trajectory data was applied for DEM-002-01 EDDF ARR via EMPAX.

# 1 Introduction

## 1.1 Purpose of the document

This document provides the Demonstration report for LSD.01.03 Optimised Descent Profiles Demonstration activities (Ref. SJU/LC/0102-CFP, Lot no 1). It describes the results of demonstration exercises defined in ODP Demonstration Plan (A2), 2nd review edition 00.01.01, 26/11/2015, and how they have been conducted.

## 1.2 Intended readership

This document is addressed to operational and technical experts dealing with the development and implementation of Optimised Descent Profiles (ODP) and/or Continuous Descent Operations (CDO) in the Air Traffic industry. The addressees includes Pilots, Manufacturers and Safety experts.

## 1.3 Structure of the document

The document comprises of:

- a general overview of the project's objectives and scope, its relation to the SESAR working programme and an evaluation of stakeholders' interests,
- details on project management regulations and management information,
- an Aircraft Profile study,
- a description of the operational concept,
- a Technical tools report (AMAN) including their contribution to descent profiles,
- detailed and updated descriptions of the demonstration exercises,
- performance analysis results and operational findings on the realised demonstration exercises,
- an overview of the safety cases (covering document)
- an outlook on follow-up activities, and
- a Communication Plan summarising the internal and external communication activities undertaken by the project partners.

## 1.4 Glossary of terms

n/a

## 1.5 Acronyms and Terminology

Throughout this document only clear names or the ICAO abbreviation is used to refer to an aerodrome. For the convenience of the reader a reference table with the relevant aerodrome, i.e. those used within this document, is provided below.

| ICAO | IATA | Aerodrome Name |
|---|---|---|
| **LFSB** | BSL | Bale-Mulhouse |

| ICAO | IATA | Aerodrome Name |
|---|---|---|
| **EDDT** | TXL | Berlin-Tegel |
| **LFST** | SXB | Strasbourg |
| **EDDS** | STR | Stuttgart |
| **EDDF** | FRA | Frankfurt |
| **LSGG** | GVA | Geneva |
| **LOWW** | VIE | Vienna |
| **LSZH** | ZRH | Zurich |
| **LFPG** | CDG | Paris Charles de Gaulle |
| **EDDM** | MUC | Munich |

**Table 1: Aerodrome reference, ICAO and IATA designators**

| Term | Definition |
|---|---|
| **A/B** | Air Brake |
| **A/C** | Aircraft |
| **A/I** | Anti Ice |
| **ACC** | Area Control Center |
| **ACG** | Austro Control Österreichische Gesellschaft für Zivilluftfahrt mbH (Austrian ANSP) |
| **ADAS** | Aircraft Data Acquisition System |
| **AF or AFR** | Air France |
| **AFS** | Advanced Function Simulator |
| **AIP** | Aeronautical Information Publication |
| **AIRAC** | Aeronautical Information Regulation and Control |
| **AirTOp** | Air Traffic Optimiser |
| **AMAN** | Arrival Manager |
| **ANSP** | Air Navigation Service Provider |
| **AO** | Airline Operator |
| **AOC** | Aircraft Operations Center |

| Term | Definition |
|---|---|
| **AOM** | Airspace Organisation and Management |
| **AoR** | Area of Responsibility |
| **AP** | Autopilot |
| **ASM** | Airspace Management |
| **ATC** | Air Traffic Control |
| **ATCO** | Air Traffic Controller |
| **ATFCM** | Air Traffic Flow and Capacity Management |
| **ATFM** | Air Traffic Flow Management |
| **ATM** | Air Traffic Management |
| **ATS** | Air Traffic Service |
| **ATSU** | Air Traffic Services Unit |
| **BADA** | Base of Aircraft Data |
| **BRE** | Bremen ACC |
| **CAA** | Civil Aviation Administration / Civil Aviation Authority |
| **CAPAN** | Capacity Analyser |
| **CAS** | Calibrated Airspeed |
| **CCO** | Continuous Climb Operations |
| **CDA** | Continuous Descent Approach |
| **CDO** | Continuous Descent Operations |
| **CDM** | Collaborative Decision Making |
| **CFL** | Cruising Flight Level |
| **CFMU** | Central Flow Management Unit |
| **CI** | Cost Index |
| **CNS** | Communication Navigation Surveillance |
| **Conf** | Configuration |
| **CONOPS** | Concept of Operations |
| **CRZ FL** | Cruising Flight Level |

| Term | Definition |
|---|---|
| **CWP** | Controller Working Position |
| **DCT** | Direct: In ATM a clearance to proceed to a designated waypoint on the shortest way possible |
| **DDR** | Demand Data Repository |
| **DFS** | Deutsche Flugsicherung GmbH (German ANSP) |
| **DFS-PMH or PMH** | Deutsche Flugsicherung GmbH – Project Management Handbook |
| **DLH** | Deutsche Lufthansa AG |
| **DOD** | Detailed Operational Description |
| **DSNA** | Direction des Services de la Navigation Aérienne (French ANSP) |
| **E-ATMS** | European Air Traffic Management System |
| **ECTL** | EUROCONTROL – The European Organisation for the Safety of Navigation |
| **EMS** | Event Measurement System |
| **E-OCVM** | European Operational Concept Validation Methodology |
| **FAB** | Functional Airspace Block |
| **FABCE** | Functional Airspace Block Central Europe |
| **FABEC** | Functional Airspace Block Europe Central |
| **FCOM** | Flight Crew Operating Manual |
| **FDM** | Flight Data Monitoring |
| **FDPS** | Flight Data Processing System |
| **FE** | Flight Efficiency |
| **FIR** | Flight Information Region |
| **FL** | Flight Level |
| **FMC** | Flight Management Computer |
| **FMGS** | Flight Management and Guidance System |
| **FMS** | Flight Management System |
| **FPA** | Flight Path Angle |
| **FPL** | Flightplan |
| **FRA** | Free Route Airspace |

| Term | Definition |
|---|---|
| **FRAMaK** | Free Route Airspace Maastricht and Karlsruhe |
| **FT** | Flight Trial |
| **FTE** | Full-time Equivalent |
| **FTS** | Fast Time Simulation |
| **HDG** | Heading |
| **HFE** | Horizontal Flight Efficiency |
| **HOP!** | HOP! Air France subsidiary regional Airlines |
| **IAS** | Indicated Airspeed |
| **ICAO** | International Civil Aviation Organisation |
| **ISA** | International Standard Atmosphere |
| **ISO 9001** | International Organisation for Standardisation, Standard, No. 9001, Quality management |
| **KPA** | Key Performance Area |
| **KUAC** | Karlsruhe Upper Area Control Centre |
| **LoA** | Letter of Agreement |
| **LT** | Local Time (standard time) |
| **MLAW** | Maximum Landing Weight |
| **MUAC** | Maastricht Upper Area Control Centre |
| **NAM** | Nautical Air Miles (distance in still air) |
| **NM** | Nautical Miles (distance only) |
| **NMD** | Network Management Directorate |
| **ODP** | Optimised Descent Profiles |
| **OFA** | Operational Focus Area |
| **OI** | Operational Improvement |
| **PSB** | Project Steering Board |
| **R&D** | Research & Development |
| **RAD** | Route Availability Document |
| **ROD** | Rate of Descent |

| Term | Definition |
|---|---|
| **RT** | Radio telephony |
| **RTS** | Real Time Simulation |
| **SAAM** | System for Analyses and Assignment at a Macroscopic level |
| **SES** | Single European Sky |
| **SESAR** | Single European Sky ATM Research |
| **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. |
| **Skyguide** | Skyguide Schweizerische Aktiengesellschaft für zivile und militärische Flugsicherung (Swiss ANSP) |
| **STAR** | Standard Arrival Route |
| **SWISS** | Swiss International Air Lines |
| **TMA** | Terminal Control Area |
| **TOD** | Top of Descent |
| **UAC** | Upper Area Control Centre |
| **UIR** | Upper Flight Information Region |
| **UTC** | Coordinated Universal Time |
| **VFE** | Vertical Flight Efficiency |
| **VNAV** | Vertical Navigation |
| **V/S** | Vertical Speed |
| **WEF** | With Effect From |
| **WP** | Work Package |
| **XMAN** | Extended Arrival Management / Cross Border Arrival Management |

**Table 2: List of Abbreviations**

# 2 Context of the Demonstrations

As the next step following activities aiming for improved Horizontal Flight Efficiency related to Free Route Operations, the project partners formed this consortium for the Optimised Descent Profiles (ODP1) project in order to foster Continuous Descent Operations from the highest Flight Level possible (ideally this would be the Cruising Level) down to the destination airport allowing for a seamless and continuous descent across ACC/UAC boundaries and thereby improving Vertical Flight Efficiency.

In ICAO Document 9931, "Continuous Descent Operations Manual", CDO is defined as

> *"an aircraft operating technique aided by appropriate airspace and procedure design and appropriate ATC clearances enabling the execution of a flight profile optimized to the operating capability of the aircraft, with low engine thrust settings and, where possible, a low drag configuration, thereby reducing fuel burn and emissions during descent. The optimum vertical profile takes the form of a continuously descending path, with a minimum of level flight segments only as needed to decelerate and configure the aircraft or to establish on a landing guidance system (e.g. ILS)."*

Doc 9931 also says:

> *"Note: The Generic term "CD Operations" (CDO), has been adopted to embrace the different techniques being applied to maximize operational efficiency while still addressing local airspace requirements and constraints. These operations have been variously known as, Continuous Descent Arrivals, Optimised Profile Descents, Tailored Arrivals, 3D Path Arrival Management and Continuous Descent Approaches".*

In addition to the ICAO definitions, operations discussed and demonstrated in the framework of the ODP project may also include descents solely provided on a tactical basis or via unpublished procedures.

Another aim of the project was to improve the predictability for AOs (publications of CDOs, publication of trajectory closer to current actual trajectories) and to create the awareness and extend the usage of optimised descents at the ANSP side. With the ODP video this part of awareness and educational aspects will be addressed effectively.

## 2.1 Scope of the demonstration and complementarity with the SESAR Programme

### 2.1.1 Background

The current definition of the Key Performance Area (KPA) "Efficiency" is limited to the consideration of horizontal flight efficiency (usually expressed in terms of route length). From projects like Free Route Airspace Maastricht and Karlsruhe (FRAMaK) and from discussions with airspace users we have learnt that shortcomings regarding horizontal flight efficiency have to be eliminated as far as possible by means of enhanced routing options, e.g. by means of FPL-plannable DCTs.

However, in addition to horizontal inefficiencies there are situations in which flights are:

- being requested to start the descent from CFL to lower Flight Levels ahead of the FMS-calculated Top of Descent (TOD), the so-called "Early Descent".
- Kept under the cruising flight level calculated by the FMS

[1] ODP is not to be confused with the NextGen project "Optimal Profile Descent" (OPD).

The consequence for the airspace user is that the aircraft cannot descend in the most fuel-efficient way, which would be idle or optimum range descent and fly on a non-optimal flight level. Those non-optimal descents or cruising FL results in higher fuel burn and – in turn – higher emissions. Thus, vertical optimisation can bring some benefits to the AO and therefore should be studied.
From an ANSP point of view, , "early descent" clearances by ATC can be – inter alia – the provision of separation between inbound and outbound flows or between overflights and climbing/descending traffic, which reduces communication time between sectors. In addition, of the safety aspects, both objectives shall ensure a maximum sector capacity. The aforementioned clearly means that there are situations where we can find a conflict of aims between fuel efficient flight operations on the one side and sector capacity on the other.
With Free Route initiatives like FRAMaK further improvements in Flight Efficiency could be achieved even in high-density areas. Despite some initial activities which addressed the vertical profiles, the focus of FRA projects usually lies in the en-route flight phase. ODP project was dedicated to address the vertical efficiency study needs, bringing together ANSP and Airliners.

### 2.1.2 Scope

In the framework of ODP, partners are aiming to:

- Develop Cross-Border routings for Continuous Descent Operations,
- Avoiding Early Descents,
- Balance Environmental Sustainability on one side and Capacity on the other,
- Demonstrate related performance gains,
- Evaluate, as a preparatory activity, assessment methods / tools for Vertical Flight Efficiency,
- Investigate the applicability of AMAN/XMAN in the context of CDO,
- Close the "efficiency gap" between Direct/Free Route Airspace and the TMA.

The ODP demonstration has been realised for arrival flows of the following aerodromes:

- Berlin-Tegel (EDDT)
- Basel-Mulhouse-Freiburg (LFSB)
- Frankfurt/Main (EDDF)
- Geneva (LSGG)
- Munich (EDDM)
- Strasbourg (LFST)
- Stuttgart (EDDS)
- Vienna (LOWW)
- Zurich (LSZH)

In order to find solutions for Cross-Border Descent Operations starting from (ideally) Cruising Level, ODP involves ACCs acting in the Upper Airspace and in the Lower Airspace, which serve arrival flows to aforementioned aerodromes:

- Bremen ACC (DFS)
- Geneva ACC (skyguide)
- Karlsruhe UAC (DFS)
- Langen ACC (DFS)
- Maastricht UAC (EUROCONTROL)
- Munich ACC (DFS)
- Reims ACC (DSNA)
- Vienna ACC (ACG)
- Zurich ACC (skyguide)

To amplify the demonstrations of Cross-Border Descent Operations with in-depth analyses of airborne data the following Airline Operators will provide comparative data analysis for flights under CDO and non-CDO for the abovementioned airports.

- Air France:
  serving Basel, Berlin-Tegel, Frankfurt, Geneva, Munich, Strasbourg, Stuttgart, Zurich and Vienna (some destinations are operated by HOP!, also 3rd party partner in the ODP project)
- Lufthansa:
  serving Basel, Berlin-Tegel, Frankfurt, Geneva, Munich, Stuttgart, Vienna and Zurich (some destinations are operated by GWI, also partner in the ODP project)
- SWISS:
  serving Berlin-Tegel, Frankfurt, Geneva, Munich, Stuttgart, Vienna and Zurich

The execution of CDOs or ODPs demonstration activities or implementations will be accomplished in WP 5 "Demonstration". These above mentioned procedures will be designed in a way allowing for one or more of in total three types of demonstrations (validation techniques):

- "Public Live Trials" allowing all Airspace Users to make use of ODP solutions based on AIP-published procedures. It has to be noted that the publication of modified arrival procedures in the AIP takes a duration of approximately one year. Therefore, the number of procedures published in the AIP during project duration may be limited.
- "Operational Flight Trials" will be accomplished based on un-published operational procedures which will be available for scheduled flights of AOs participating in the ODP project, i.e. AFR/HOP!, DLH (GWI/Eurowings) and SWR.
- "Tactical Live Trials" will be performed on ANSP initiative based on un-published operational procedures: For specific traffic flows ATC will tactically offer optimised descents to all airspace users whenever the traffic situations permits.

### 2.1.3 Links with the SESAR Programme

On the basis of preceding Free Route activities in Upper Airspace (e.g. FRAK, FRAM, FRAMaK, FABEC FRA, FABCE) on the one side and local, to a greater extent TMA-related initiatives fostering Continuous Descent Operations (CDO, e.g. CDO trials Munich, CDO Strasbourg) on the other, the ODP project is referring to both concept elements and is aiming for improvements in overall flight efficiency by means of optimised and seamless connections between Upper Airspace (En-Route) and TMAs. In this framework the ODP project is primarily linked to WP 5 of the SESAR Programme dealing with the optimisation of vertical profiles. Covering aspects of both horizontal and vertical efficiency it is in particular linked with OFA 02.01.01 “Optimised 2D/3D Routes” (e.g. Solution #10). Due to aspects related to Upper Airspace (En-Route), especially Free Route, ODP has common fields of work with OFA 03.01.03 “Free Routing”. Here a close connection is given to SESAR WPs 4 and 7.

The existing cross-border AMAN application (Munich ACC / Vienna ACC for Munich airport) will be taken into account in order to study the applicability of this system in Continuous Descent Operations, derive respective requirements and enhance the system-supported coordination between UACs, ACCs and TMA control. This topic is also linked to WP 5 and OFA 04.01.02 of the SESAR Programme.

Anticipating coming-up regulations and requirements as formulated in the Pilot Common Project (PCP ATM functionalities 1 and 3) the ODP partners are aiming for accelerating the implementation of CDO in order to close existing efficiency gaps between Upper Airspace and TMAs. Doing so, the ODP project is clearly linked to the goals of the European ATM Master Plan and is addressing the OI Step AOM-0702: Advanced Continuous Descent Operations.
The project “Optimised Descent Profiles” will take into account results of SESAR and will complement ongoing SESAR activities.

- WP 05.06.02 “QM2 – Improving Vertical Profile”:

  ODP complements the project’s validation exercises by enlarging the scope towards Cross-Border aspects of Continuous Descent Operations;

- WP 05.06.07 “QM-7 – Integrated Sequence Building/Optimisation of Queues”:

  ODP complements the project’s validation exercises by focussing on the use of AMAN / enhanced AMAN functionalities for facilitating Continuous Descent Operations across ACCs’ AoR boundaries;

- WP 07.05.02 “Advanced Flexible Use of Airspace” (comprising Free Route),
- OFA 02.01.01 “Optimised 2D/3D Routes”,
- OFA 03.01.03 “Free Routing”, and
- OFA 04.01.02 “AMAN and Extended AMAN horizon”.

Since in each case at least one of the ANSPs participating in ODP is contributing to or is leading one of the aforementioned activities of the SESAR Working Programme a good coordination is ensured.

### 2.1.4 Objectives

The ODP project aims for closing the "efficiency gap" between Direct/Free Route Airspace (foreseen to be implemented from FL 310 and above at minimum, see IR 716/2014), the airspace below (in which operations could still be based on the ATS route network) and the TMA, i.e. efficiency degradations during the descent phase.
In detail the project partners are aiming for benefits in the Key Performance Areas of Efficiency and – being strongly linked to that – Environmental Sustainability. Effects on Capacity shall be carefully studied. It must be ensured that Safety is not jeopardised by the project's activities.

The operational objectives of the ODP Large Scale Demonstration are

- to demonstrate the potential to reduce the frequency of Early Descents in high-density airspace by offering new routing options for Cross-Border Descent Arrivals which shall provide an improved balance between Efficiency and Environmental Sustainability on one side and Capacity on the other, and
- to assess the performance gains achieved by these implementations.

The identification of new descent / arrival routings options between CFL and e.g. the Initial Approach Fix shall be achieved by

- identifying break-even points, i.e. the trade-off between horizontal and vertical flight efficiency,
- de-skewing complex traffic flows in order to allow for more flexible handling of traffic between ATC sectors and units, and
- reassessing, and if applicable vertical reordering of crossing points of arrival and departure streams taking into account recent studies which favour CDO, instead of CCO.

As a preparatory action with regard to the assessment of benefits in vertical flight efficiency the project will evaluate different model-based approaches for the calculation of vertical efficiency metric. If required model parameters will be improved based on amplified data provided by Airline Operators. Key Performance Indicators and related metrics are to be identified which allow for performance assessments in-line with SES / SESAR regulations and recommendations.

In order to support Air Traffic Controllers in situation assessment while evaluating the potentials for offering Continuous Descent Approaches the project will investigate in which way existing AMAN tools can facilitate this assistance. As far as possible within the limited project duration the partners will implement requirements in existing operational systems.
The demonstration in this ODP framework shall result in CDO implementations based on a commonly-agreed concept accompanied by a performance assessment in line with SESAR and FAB (FABEC, FABCE) recommendations.

These CDOs shall be available to be filed. The agreed CDAs shall be established as an easy procedure (as few constraints as possible, as many as needed) with consistent and unambiguous phraseology (in line with ICAO Doc 4444) and shall not hamper tactical directs.

Proposals that will be developed and implemented within the frame of ODP Project shall be integrated into the European Route Network Improvement Plan and experiences shared at network level.
For details regarding exercise objectives common to all demonstration activities please refer to section 2.1.6. Details on the operational context, the expected results per KPA, related SESAR projects and the OFA addressed can be found in the exercise description in section 5.1.

### 2.1.5 Perimeter of the demonstration

The demonstration should bring evidence that cross-border CDO / ODP capabilities extending over multiple ANSP AoRs can be realised and that these capabilities lead to significant benefits for the Airspace Users, measurable in the Key Performance Areas of Efficiency and Environmental Sustainability.

The geographical scope of the project entailed the arrival flows for the above mentioned aerodromes and ACCs/UACs. The demonstration comprised a very complex airspace structure and a traffic density, which is one of the highest of Europe, serving major traffic streams and major European hubs. In the course of this demonstration, solutions for AO Flight Plan filing, airspace regulation publications, ANSP procedures, etc. were to be developed.

### 2.1.6 Demonstration Objectives

The following table describes the objectives and hypotheses of the demonstration programme and informs about KPAs which were addressed. Details on applied metrics (KPIs and other) for operational implementation of these KPAs are described in section 5.2.

| Objective ID | Description | Success Criterion |
|---|---|---|
| OBJ-0103-001 | Flight Efficiency of Cross-Border CDO<br>It is to be demonstrated that wherever possible published CDO provide higher overall efficiency than existing procedures.<br>The improved efficiency positively affects fuel burn and $CO_2$ emission. | To demonstrate benefits for better flight efficiency (fuel burn saving and less $CO_2$ emission), the ODP Team used the following solutions:<br>• optimising cruising levels<br>• reducing level-offs<br>• speed constraints to improve energy mgmt.<br>• changing transfer conditions (e.g. later ToD, higher hand over level)<br>• usage of “DESCEND WHEN READY (continuous descent)<br>• published descend profile procedures / CDOs |
| OBJ-0103-002 | Capacity related to Cross-Border CDO<br>It is to be demonstrated that the airspace Capacity is not negatively affected by Cross-Border CDO. | To demonstrate no decrease of capacity in Cross-Border CDO operations. |

| | | |
|---|---|---|
| OBJ-0103-003 | Operational Feasibility of Cross-Border CDO<br><br>It is to be demonstrated that Cross-Border CDO provide a sufficient feasibility for operational usage. | To demonstrate that there is no adverse operator feedback regarding Cross-Border CDO operations. |
| OBJ-0103-004 | Operator Workload related to Cross-Border CDO<br><br>It is to be demonstrated that the execution of Cross-Border CDO will not negatively affect operator workload and situational awareness of both ATCOs and flight crews. | To demonstrate, that the designed Cross-Border CDO does not negatively affect workload and situational awareness of both ATCOs and flight crews, and can be applied most time of the day up to and ideally 24/7. |

**Table 3: Demonstration Objective layout – example**

The investigation of AMAN/XMAN in the context of CDO demonstrations (EXE-0103-004) aims for better understanding the applicability of AMAN/XMAN related information for these kind of operations. At this stage, there is no objective directly linked to the AMAN/XMAN aspect.

### 2.1.7 Indicators and Metrics

| KPA | KPI / Metric | Data Type | Scale level |
|---|---|---|---|
| Efficiency | Vertical Flight Efficiency:<br><br>Descent profile (planned vertical profile, actual vertical profile flown) | quantitative | ratio |
| Efficiency | Horizontal Flight Efficiency:<br><br>Route length (planned trajectory, actual trajectory flown, great circle) | quantitative | ratio |
| Environmental Sustainability | Fuel Burn:<br><br>Amount of fuel burn in the decent phase | quantitative | ratio |
| Environmental Sustainability | $CO_2$ Emission:<br><br>Amount of $CO_2$ emission in the decent phase | quantitative | ratio |
| Capacity | En-Route Throughput:<br><br>Total number of movements per volume of en-route airspace per hour | quantitative | ratio |
| Other | Operational Feasibility:<br><br>Questionnaire | qualitative/ quantitative | -/<br>nominal or ordinal |
| Other | Operator Workload: | qualitative/ quantitative | -/<br>related to technique |

| KPA | KPI / Metric | Data Type | Scale level |
|---|---|---|---|
| | Questionnaire or workload rating (esp. in the context of RTS, e.g. ISA, NASA TLX) | | |

## 2.2 Demonstration Scenarios

Each aerodrome in the scope of the ODP project forms a specific Demonstration Scenario. These aerodrome-related scenarios will comprise different arrival flows under study in the ODP project.

| Scenario ID | Description |
|---|---|
| SCN-01##-001 | Cross-Border CDO Basel |
| SCN-01##-002 | Cross-Border CDO Frankfurt |
| SCN-01##-003 | Cross-Border CDO Geneva |
| SCN-01##-004 | Cross-Border CDO Munich |
| SCN-01##-005 | Cross-Border CDO Strasbourg |
| SCN-01##-006 | Cross-Border CDO Stuttgart |
| SCN-01##-007 | Cross-Border CDO Vienna |
| SCN-01##-008 | Cross-Border CDO Zurich |
| SCN-01##-009 | CDO Berlin-Tegel |

**Table 4: Demonstration Scenario layout**

## 2.3 Stakeholder identification, needs and involvement

Initiatives for testing or even implementing Continuous Descent Operations started individually at DFS and DSNA in the framework of local projects on ACC-level, both having published several CDO routing options for aerodromes within their AoRs. Clearly in local projects the vertical limits of ACCs' Areas of Responsibility form a major constraint of operational capabilities provided to the airspace user.

Thus, the project partners formed this consortium for the ODP project in order to define CDAs from the highest Flight Level possible (ideally this would be the Cruising Level) down to the destination airport allowing for a seamless and continuous descent across ACC/UAC boundaries.

The consortium fosters this common project for cross-border applications which addresses major aerodromes in the ANSPs' AoRs and which allows for better efficiency in the development of a common, i.e. consistent, concept and which will allow for benefits especially with regard to KPA Efficiency.

The ODP Large Scale Demonstration can facilitate exposure and act as catalyst for further CDO initiatives beyond or completing the targeted areas, and helps the consortium members to speed up planned implementations.

In the ODP project five ANSPs and three Airline Operators form a consortium in order to cooperate in finding optimised solutions from both Efficiency and Capacity perspectives:

- ANSPs:
  - Austro Control Österreichische Gesellschaft für Zivilluftfahrt mbH,
  - DFS Deutsche Flugsicherung GmbH,
  - Direction des Services de la Navigation Aérienne,
  - EUROCONTROL, and
  - Skyguide Schweizerische Aktiengesellschaft für zivile und militärische Flugsicherung;
- Airline Operators:
  - Air France (incl. HOP!),
  - Deutsche Lufthansa AG, and
  - Swiss International Air Lines.

DFS will act as the consortium leader. From DFS, Bremen ACC, Langen ACC, Karlsruhe UAC and Munich ACC will be operational ANSP target entities for the envisaged demonstrations. DFS Situation and Information Centre will support data collection and analyses. DFS Simulation Centre will support – if needed – the execution of Fast Time and Real Time Simulation with regard to prototyping of CDO solutions and/or performance assessment.

Air France is a consortium member. AFR will participate in preparation tasks, especially profile design, the Flight Trial execution and the performance assessment in terms of post-hoc analyses.

Austro Control will act as a consortium member. From ACG, side Vienna ACC will be the operational ANSP target entity for the envisaged demonstrations.

DSNA will act as a consortium member. Reims ACC as well as Basel and Strasbourg airport are the DSNA entities involved in the different activities of the project, especially in the preparation work and the flight trials.

EUROCONTROL is a consortium member. They will participate with Maastricht UAC as one of the operational ANSP target entities for the envisaged demonstration. NMD will contribute particularly to the evaluation of network impact in the pre demonstration phases and in the post operational analysis phase by utilisation of various network assessment tools as required. Furthermore, NMD will provide project partners with FPL data and track data for data analyses.

Deutsche Lufthansa AG is a consortium member. They will provide customer expectations with regard to route design. DLH will conduct flights in the framework of the envisaged demonstration. DLH will provide analyses of airborne flight data from an Airline Operations point of view.

Skyguide will act as a consortium member. Geneva ACC and Zurich ACC are operational ANSP target entities for the envisaged demonstrations.

Swiss International Air Lines Ltd. is a consortium member. As the home carrier in LSZH they will provide inputs for vertical profile optimisation based on performance calculations, conduct flight trials and analyse post flight analysis based on aircraft data.

# 3 Programme management

## 3.1 Organisation

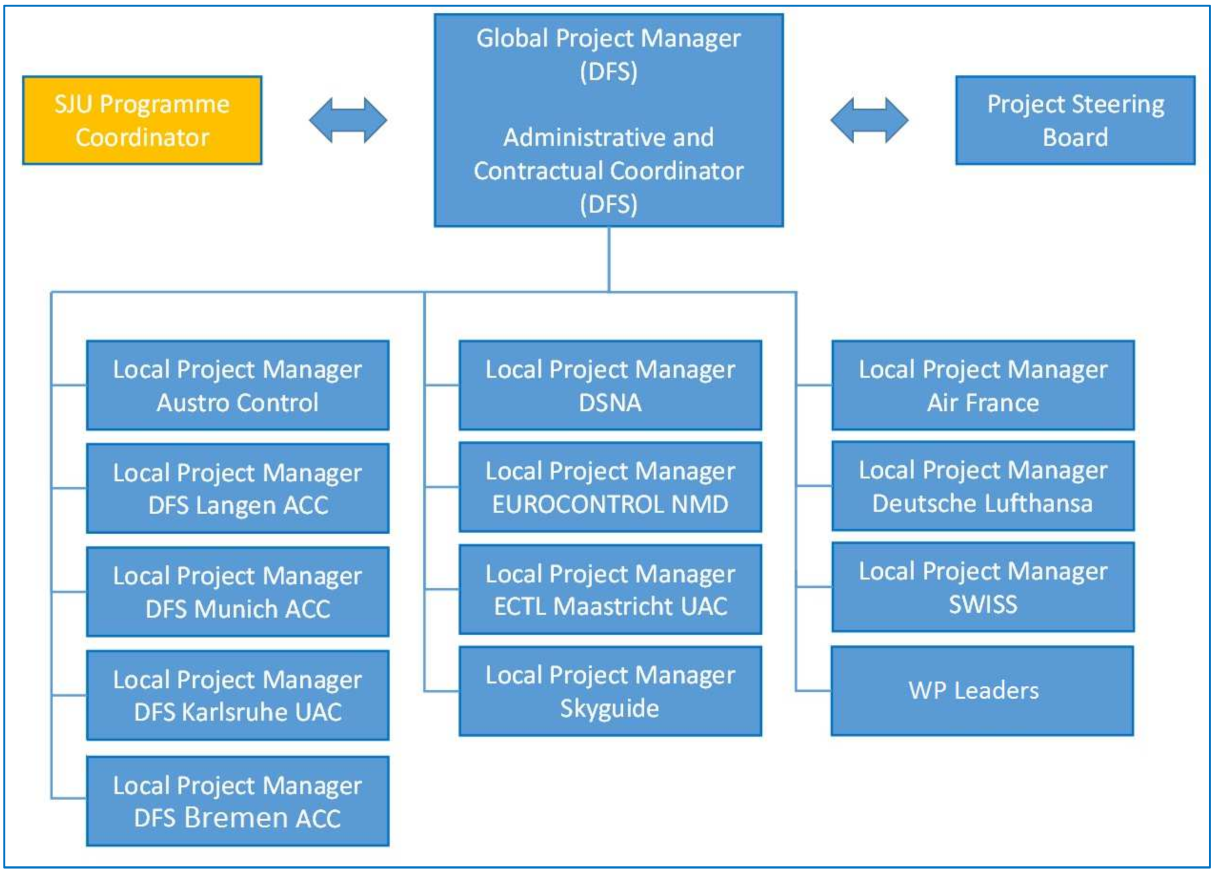



*Figure 1: ODP project organisation*

DFS as the consortium leader will provide an overall project coordinator (Global Project Manager), whose task is to ensure – together with the project leaders of the individual organisations – the planning, execution, reporting and communication of the project. The coordinator acts as the direct interface to / the point of contact for SJU. The coordinator will be supported by an administrative and contractual coordinator and a quality manager.

Each of the consortium members (in case of participation of multiple local units each unit) will be represented by a local project manager with responsibility for the contribution of his/her organisation/unit and the internal organisation, coordination, communication and reporting of the project.

A Project Steering Board (PSB) will be installed to advise and supervise the project from the perspective of the participating organisations. The steering board will be staffed with executive managers.

The work done by the project itself will mainly be performed by experts committed by the line organisations from project partners. These will involve dispatcher, flight-planners, flight crews from Airline Operators, airspace design experts and project experts from the ANSPs. The SESAR Contribution Management rsp. Coordination Offices of the partners will be involved.

The following table informs about the designated assignments of persons to roles.

| Role | Designated Person | Company |
|---|---|---|
| Global Project Manager | Ilhan AKIN | DFS |
| Administrative and Contractual Coordinator | Frank CÖSTER | DFS |
| **Local Project Managers** | | |
| Air France<br>HOP! | Sandra LALOUX<br>Russel OLIVER | AFR<br>HOP! |
| Austro Control | Kristian WOLLNER | ACG |
| DFS Bremen ACC | Enrico STUMPF-SIERING | DFS |
| DFS Langen ACC | Reinhard SPORS | DFS |
| DFS Karlsruhe UAC | Michael JUNG | DFS |
| DFS Munich ACC | Hansjörg TROST | DFS |
| DLH | Valentin REINHARDT | DLH |
| DSNA | Hervé ROBERT and<br>Jérôme DUFOSSEZ | DSNA |
| EUROCONTROL Maastricht UAC | Julie FAIRBAIRN | EUROCONTROL |
| EUROCONTROL NMD | Borce DVOJAKOVSKI | EUROCONTROL |
| Skyguide | Philipp SEILER | skyguide |
| Swiss | Thomas HIRT | SWISS |
| **Project Steering Board Members** | | |
| Laurent RENOU, ATM project department manager | | Air France |
| Andreas SCHALLGRUBER, Director of OPS | | Austro Control |
| Andreas PÖTZSCH, Head of Business Unit Control Centre | | DFS |
| Frank NAGEL, Programme Manager SESAR Demonstrations | | DLH |
| Frédéric GUIGNIER, Deputy Director of Operations | | DSNA |
| Dimitris APSOURIS, Head of Strategy Unit (Network Manager Directorate) | | EUROCONTROL |
| Pascal LATRON, Head of OPS Capabilities Development | | skyguide |
| Eric NANTIER, Head of Operations Research & ATM | | SWISS |

**Table 5: Roles and Members**

## 3.2 Work Breakdown Structure

The project comprises the following work packages and respective tasks:

| WP | Name | Tasks |
|---|---|---|
| **0** | **Project Management** | • Project organisation and steering,<br>• Controlling,<br>• Reporting |
| **1** | **A/C Profile Studies**<br>Lead: DLH | In WP 1 Airline Operators (AOs) performed company-related studies on feasible descent profiles from Cruising Level down to the TMA based on company's speed schedules and taking into account relevant aircraft types of AOs.<br>The companies' results will be consolidated into an "average profile" which is generally applicable for CDO development (WP2).<br>This work package has been delivered successfully and on time, details can be found in 4.2.1. |
| 1.1 | AFR | Identification of feasible descent profiles for AFR flights. |
| 1.2 | DLH | Identification of feasible descent profiles for DLH flights. |
| 1.3 | SWISS | Identification of feasible descent profiles for SWR flights. |
| **2** | **CDO Development**<br>Lead: DFS | In general, WP 2 comprises the development of ODP proposals with the following steps:<br>• ANSPs and AOs elaborated optimised descent profiles for different configurations of runway-in-use<br>The ODP proposals were based on the optimum A/C descent profile (WP1). Relevant constraints (e.g. due to sector sequence, demand/capacity) as well as shortcuts by provision of tactical DCTs were taken into account. Operational availability in terms of times and altitudes have been maximised.<br>Simulation-based prototyping by means of Fast Time Simulations were accomplished.<br>• NMD contributed to the analysis of the ODP proposals particularly when interfaces between different ACCs, ANSPs, FABs were addressed. Trade off/solutions that were agreed at the interfaces were evaluated at network level.<br>• AOs accomplished simulation-based evaluations of ODP proposals.<br>• AOs analysed the trade-off between Horizontal Flight Efficiency and Vertical Flight Efficiency for certain flows (e.g. LFPG-EDDF)<br>This work package has been delivered successfully and on time, meaning all designs have been finished. This work package was the basis for the trials execution and later on the performance analysis. |

| WP | Name | Tasks |
|---|---|---|
| 2.1 | Basel (LFSB)<br>Lead: DSNA - Reims ACC | Development of Cross-Border CDO solutions for Basel-Mulhouse airport. The Initial proposal refers to an arrival flow involving – apart from Reims ACC. For details please refer to 6.1. |
| 2.2 | Frankfurt (EDDF)<br>Lead: DFS - Langen ACC | Development of Cross-Border ODP solutions for Frankfurt/Main airport. Initial proposals comprise of arrival flows involving – apart from Langen ACC – Karlsruhe UAC, Maastricht UAC, and Munich ACC. For details please refer to 6.2. |
| 2.3 | Geneva (LSGG)<br>Lead: skyguide – Geneva ACC | Development of Cross-Border CDO solutions for Geneva airport. The Initial proposals are referring to arrival flows involving – apart from Geneva ACC – Reims ACC, Karlsruhe UAC and Zurich ACC. For details please refer to 6.3. |
| 2.4 | Munich (EDDM)<br>Lead: DFS - Munich ACC | Development of Cross-Border CDO solutions for Munich airport. Initial proposals comprise of arrival flows involving – apart from Munich ACC – Geneva ACC, Karlsruhe UAC, Langen ACC, Reims ACC, and Zurich ACC. For details please refer to 6.4.<br>The CDO development will be coordinated with WP 3.2 “AMAN support CDO Munich”. |
| 2.5 | Strasbourg (LFST)<br>Lead: DSNA - Reims ACC | Development of Cross-Border CDO solutions for Strasbourg airport. Initial proposals comprise of arrival flows involving – apart from Reims ACC – Karlsruhe UAC, Langen ACC. For details please refer to 6.5. |
| 2.6 | Stuttgart (EDDS)<br>Lead: DFS - Langen ACC | Development of Cross-Border CDO solutions for Stuttgart airport. Initial proposals comprise of arrival flows involving – apart from Langen ACC – Geneva UAC, and Zurich ACC. For details please refer to 6.6. |
| 2.7 | Vienna (LOWW)<br>Lead: ACG - Vienna ACC | Development of Cross-Border CDO solutions for Vienna airport. Initial proposals comprise of arrival flows involving – apart from Vienna ACC – Karlsruhe UAC, and Munich ACC. For details please refer to 6.7. |
| 2.8 | Zurich (LSZH)<br>Lead: skyguide – Zurich ACC | Development of Cross-Border CDO solutions for Zurich airport. Initial proposals comprise of arrival flows involving – apart from Zurich ACC – Geneva ACC, Langen ACC, Karlsruhe UAC, and Reims ACC. For details please refer to 6.8. |
| 2.9 | Berlin-Tegel (EDDT)<br>Lead: DFS - Bremen ACC | Development of CDO solutions for Berlin-Tegel airport. For details please refer to 6.9.<br>After experience is gained the extension to upper airspace will be investigated. |
| **3** | **AMAN support for CDO**<br>Lead: DFS | In WP 3 the applicability of existing AMAN / XMAN functionalities for Continuous Descent Operations were analysed.<br>Requirements for future system developments will be derived from ODP demonstrations (WP5). |

| WP | Name | Tasks |
|---|---|---|
| 3.1 | AMAN/XMAN support CDO Frankfurt | After postponed in the XMAN Project the AMAN/XMAN support CDO Frankfurt will not be demonstrated within ODP timeframe. This is a deviation from the A1 Demonstration Plan and proposal and already communicated in A2 Demonstration Plan 2nd review edition. |
| 3.2 | AMAN support CDO Munich | AMAN functionalities for Karlsruhe UAC, Vienna ACC regarding EDDM arrival flows<br>(Munich ACC / Vienna ACC) |
| **4** | **Performance Assessment Framework**<br>Lead: DFS | The aim of WP 4 was to determine the framework and assessment techniques for the performance assessment of ODP demonstration activities and to elaborate and maintain the Demonstration Plan. |
| 4.1 | Evaluation of vertical flight efficiency calculations | Since there is no “golden standard” for the assessment of Vertical Flight Efficiency on ANSP side a feasible model was evaluated in a comparative study referring to other models (e.g. BADA, LIDO). |
| 4.2 | Evaluation of SAAM / NEST VFE model and adaptation | The first aim was to perform a thorough analysis of the vertical (efficiency) model of SAAM / NEST versus the requirements of the project and potentially upgrade SAAM / NEST model.<br>The second aim was also to analyse any inputs (e.g. Radar data recorded information) required to perform the later post-ops assessment and adapt to these inputs. |
| 4.3 | Demonstration Plan Maintenance | Elaboration and maintenance of the Demonstration Plan:<br>• Planning of Demonstration Exercises.<br>• Identification of metrics in accordance with performance assessment guidelines provided by SESAR / FABCE / FABEC.<br>• Elaboration of the statistical approach.<br>• Preparation of questionnaires for flight crews and ATCOs<br>• Preparation of data collection and data pre-processing. |
| 4.4 | CDO Impact Analyses | The aim was to determine general design principles for CDO procedures. The study identified effects of both optimised descent profiles and optimal descent profiles with regard to sector load and capacity. Furthermore, the study identified situations in which a check-back to previous standard descent procedures may be necessary again. Where necessary due to local characteristics detailed analyses, e.g. capacity analysis by means of CAPAN and AirTOp was accomplished. |
| **5** | **Demonstrations**<br>Lead: DFS | In WP 5 the ODP demonstration activities were operationally prepared and executed. |

| WP | Name | Tasks |
|---|---|---|
| 5.1 | Operational Preparation of Demonstrations | Preparatory activities comprised of:<br>• Provision of CDO procedure descriptions<br>• Coordination with EUROCONTROL NMOC<br>• Subject to the limited project duration: Publication of CDO procedures in AIP<br>• ATCO training by means of briefings, CBTs or if needed Simulations<br>• Flight Crew training by means of briefings<br>• Tailoring of FMS Databases of ODP-AOs' aircraft participating in Flight Trials |
| 5.2 | SAAM/NEST Network Assessment – Potentials | Analysis of the potential benefits of ODP solutions and assessment of effects on Network level. |
| 5.3 | Real Time Simulations | There was no need for a Real Time Simulation. Therefore this WP 5.3 is not applicable any more but left in in order to keep the original numbering and the fact that the consortium members analysed the design requirements in detail. |
| 5.4 | Operational Flight Trials | Execution of Flight Trials of ODP-AOs using un-published CDO procedures. For definition see section 4.2.2. |
| 5.5 | Tactical Live Trials | Execution of flights making use of un-published CDO procedures based on tactical ATC clearances. For definition see section 4.2.2. |
| 5.6 | Public Live Trials | Execution of Public Live Trials based on AIP-published procedures. For definition see section 4.2.2. |
| 5.7 | Overall Performance Assessment | Statistical analyses of Demonstration Activities based on WP 5.4 – WP 5.6. |
| **6** | **Safety**<br>Lead: DFS | WP 6 comprised the accomplishment of safety analyses based on existing regulations under responsibility of the affected parties (ANSPs / ACCs, AOs) and bringing them into an overall ODP Safety Letter. |
| **7** | **Communication**<br>Lead: DFS | WP 7 comprised of both external and internal communication and dissemination activities:<br>• Dissemination of project's outcomes towards the public, Airspace Users and adjacent ANSPs / ACCs.<br>• Internal Communication (e.g. Joint ATCO – Flight Crew Workshops) |

**Table 6: Work Breakdown Structure**

## 3.3 Deliverables

| Deliverable name | Date | Delivery and Status |
| --- | --- | --- |
| Demonstration Plan (A1) | 31/01/2015 | On time and no reservations |
| Demonstration Plan (A2), 2nd Review | 30/11/2015 | On time and no reservations |
| Demonstration Report (B1) | Draft to SJU: 25/08/2016<br>Final version (incl. FCS): 17/11/2016 | On time |

**Table 7: Work Breakdown Structure**

## 3.4 Risk Management

For details regarding risk management processes and mechanisms applied in the framework of the ODP project please refer to the project's documentation associated with the ODP Project Handbook [11]. All risks and issues and their assessment can be found in the reference document "Risk Register" [17].

# 4 Execution of Demonstration Exercises

## 4.1 Exercises Preparation

It is clear that in today´s densely used airspaces the optimum profiles are in most cases not achievable. The most common reasons that lead to constraints for arriving aircraft are:

- **Airspace design:**
  - Crossing traffic flows of significant proportions.
  - ATC control sectors that need to be avoided in order to prevent excessive workload situations.
  - Military airspaces, such as exercise areas (e.g. TRAs).

By taking these considerations taken on-board, the following design principles have been observed during the search for solutions:

- **Keep the procedure as simple as possible** – The easier it is, the higher the acceptability for both pilots and air traffic controllers, which in turn leads to more application.
- **As few restrictions as possible, as many as necessary –** When aiming at the "best" solution, by adopting restrictions that cover every theoretical issue, it is quite easy to overstrain even the most sophisticated FMC, the pilot and/or the air traffic controllers; the result of which is a negative impact on the success of the procedure.
- **If the optimum cannot be achieved all the time, find the times when it works –** Airspace design usually takes into account a workable solution for traffic peaks but may hamper optimised profiles during times of lower traffic figures. When these times are determinable, or conditions that allow better profiles can be specified, solutions for these times can and should be found. This means that optimised descent profiles can be available:
  - During specified times , e.g. only in the early morning or later afternoon hours
  - On specified days , e.g. only on weekends and/or public holidays
  - During special seasons, e.g. during winter months only
  - Under specified conditions, e.g. when a military exercise area is de-activated.
- **The procedure shall leave room for the flexibility required –** Depending on the local requirements it may be helpful to include certain fixed restrictions, e.g. speed restrictions in order to harmonise arriving traffic, while in other cases it might be better to leave it to the air traffic controllers to apply certain restrictions when needed. In the latter case training of the controllers should make clear, that an optimum descent profile, under specified restrictions is only possible when the restrictions are known to the pilot as early as possible, i.e. before the top of descent. It needs to be locally determined if it is more helpful to publish restrictions which may be altered or removed as required or not to publish restrictions, but to issue them individually when necessary.
- **If possible, use the benefits of landing-runway dependent restrictions –** The remaining flight distance depends on the runway-in-use, therefore, in order to optimise the descent profile, it would be very fruitful to apply restrictions that meet the requirements for the intended landing runway by ensuring a better fuel efficiency

and predictability at airline operators' site. To make use of flexible transfer levels between adjacent sectors the support of technical solutions for the flight data processing system might be helpful or necessary.

In the end it may be and it is even probable that the optimum profile for all aircraft types, as defined in ICAO DOC 9931 for CDOs, under every condition will not be available. Still, it may be possible to optimise the profile and this should be done. As a wise procedure designer has put it:

### "Achieved realisation with mind changing approaches"

These principles and prerequisites brought a wide variety of solutions to be tested within the ODP project, which can be put into different categories (or combinations of these):

- **Optimised cruising levels –** Although strictly speaking this is not about an optimised descent, however the descent does start at cruising level, therefore an optimisation of the cruising level automatically optimises the descent profile. For that reason, it was analysed if, and under which conditions, existing level constraints can be altered or removed, such in LoAs. On short city pairs, there are level capping restrictions, keeping flights on different CRZ FL than their optimised cruising FL. ODP took the opportunity to ease those constraints when possible (LoA or RAD update).
- **Changed transfer conditions –**
  1) Many restrictions for aircraft are not published to the pilots but form part of letters of agreements between different ATC units or part of operational orders for different sectors of the same ATC unit to optimise capacity during peak hours. An alteration of these directly influences the profiles flown. This way of working impacts directly the execution of the descent and its optimisation (restrictions are not known by the FMC or the pilots). Some of those restrictions will have a negative impact on FE and so ODP worked to ease those constraints.
  2) In order to increase predictability for pilots it would be helpful to make handover conditions, and therefore the flight level to be expected at a certain waypoint, known to the flight crew.
- **Usage of "DESCEND WHEN READY" –** Of course safety comes first, so whenever needed to ensure separation, flight level changes have to be performed in due time. However, when possible, it is a real benefit to let the pilot descend when it is the optimum TOD from an aircraft point of view. Therefore, ODP promoted to ATCO the use of pilots´ discretion descents by using the phrase "DESCEND WHEN READY (TO CROSS … AT FL …)". In a trial environment, briefing of air traffic controllers in this regard can lead to improved optimised profiles.
- **Published descent profile procedures –** For some aerodromes, the project published standard arrival routes (STAR) including expected levels or level restrictions (to be "at or above", "at or below" or both "at or above… and at or below…"). They tried to take into account input from AO in terms of charting, FMS constraints and optimisation. A published procedure, if followed by both stakeholders, leads to predictability both for pilots and air traffic controllers.

- **Speed constraints to improve energy management –** Published speed constraints not only improve predictability for air traffic controllers by harmonising traffic but may be used to improve energy management for pilots. This may be beneficial if aircraft often arrive at a position at which a lower level below FL100 cannot be assigned immediately (e.g. frequent crossing traffic or unavailable airspace below). Pilots, knowing in advance the possible speed restrictions, will manage properly its speed profile and thus the aircraft energy to meet with the traffic constraints. By publishing a speed limit, the pilot is encouraged to reduce speed while waiting for further descent clearance. This prevents a thrust increase during the undesired level-off and anticipates speed reductions (e.g. 250kt below FL100). This is particularly beneficial if the use of air brakes would then be required to destroy the energy added for keeping normal descent speed during a level-off phase. Those speed constraints have been discussed, and should be discussed, with local airlines (best knowledge of the area, flight execution in this environment) and ATCO (best knowledge of the traffic constraints). It is also to be remembered that speed constraints should be kept to a minimum and that speed limits below 220kt should be avoided as much as possible (or kept the closest to the airport) in order to avoid anticipated use of drags (which would result in additional airframe noise and fuel burn).
- **Path stretching –** Longer tracks that are published with a speed limitation in order to delay an aircraft by a certain exact time, e.g. in one minute steps, might be used to optimise the descent profile. This requires in-depth study with local airlines and ANSP to make sure that the additional mileage doesn't kill the savings of a potentially better optimised descent. To build up this solution, simulations are necessary as a reorganisation of the airspace and ATM procedures is to be done. A trial based on this method was not possible within the limited timeframe of the ODP project; therefore this solution was not used in this project.

### 4.1.1 Demonstration Approach

The envisaged demonstrations brought evidence that Cross-Border Continuous Descent Operations extending over multiple ACC/UAC and/or ANSP AoRs can be realised and that these capabilities will lead to significant benefits for the Airspace Users, measurable in the Key Performance Areas Efficiency, and Environmental Sustainability.
The geographical scope of the project entails designated arrival flows starting at a certain Flight Level (ideally Cruising Level), ending at a certain Flight Level within or at the boundary of the TMAs of aerodromes Bale, Berlin-Tegel, Frankfurt/Main, Munich, Geneva, Strasbourg, Stuttgart, Vienna and Zurich.
With regard to Munich aerodrome the functionalities of existing AMAN/XMAN support tools were studied with respect to Cross-Border Continuous Descent Operations.
In the course of the ODP demonstration, solutions for AO Flight Plan filing, airspace regulation publications, ANSP procedures, and connections with sub- and adjacent fixed route systems have been developed where necessary. These items will be available for future operational usage also in terms of a common and generic application which is ready for expansion over other areas and applicable for all types of GAT flights.

The definition of optimised descent procedures took into account relevant constraints (e.g. due to sector sequence, demand/capacity) as well as the potential provision of shortcuts by

means of tactical DCTs. It was ensured that those kind of ad-hoc optimisations are not hampered. Operational availability in terms of times and altitudes were maximised. Simulation-based prototyping by means of Fast Time Simulations (EDDF via RIMET) or testing by means of trial flights was accomplished.
In WP2, ANSP work together with AO on solutions that would optimised efficiency without affecting capacity. Moreover, Airline Operators analysed the trade-off between Horizontal Flight Efficiency and Vertical Flight Efficiency in WP2 together with the Local Managers from the appropriate ANSPs.
In WP 3 arrival flows supported by AMAN Munich were trialed and results for supporting tools have been analysed. The project investigated the operational capabilities arising from existing AMAN/XMAN functionalities for CDO. During the demonstrations additional requirements resulting from CDO were collected for future system releases.

The Performance Assessment Framework for ODP demonstrations was elaborated in WP4. The ODP project was aimed to close existing gaps regarding the model-based assessment of Vertical Flight Efficiency. Therefore the work comprised of the comparative evaluation of a vertical flight efficiency Model and on the refinement of existing assessment approaches integrated in SAAM/NEST. Furthermore, the work comprised the preparation of data collection and pre-processing as well as the elaboration of questionnaires for ATCOs and flight crews. In addition, WP4 elaborated a CDO Impact Analyses in the context of the RIMET FTS for EDDF arrivals (ref. [13]).
The aim was to determine general design principles for CDO procedures. The study identified effects of optimised descent profiles vs. optimal descent profiles with regard to sector load and capacity. Furthermore, the study identified situations in which a fall-back to conventional non CDO procedures may be necessary again. Where necessary due to local characteristics detailed analyses, e.g. capacity analysis by means of CAPAN / AirTOp was accomplished.

The execution of demonstration activities (WP 5) were properly prepared by provision of training and briefings for flight crews and ATC personnel if necessary. Furthermore, for non-published CDO procedures, FMS databases of aircraft participating in demonstrations were refined in order to ensure availability of arrival procedures in the FMS. For all demonstrations of either published or un-published CDO procedures, the performance assessment (statistical analysis) was accomplished based on extensive flight plan and radar track data of real-life scheduled flights making use of ODP solutions. Respective data was available from the EUROCONTROL DDR database as well as at respective ANSPs units. Furthermore, ECTL NMD analysed the potential gains of CDO solutions based on the FPL data repository. Airline Operators participating in the ODP project also analysed flight performance by means of flight planning tools as well as through aircraft performance data collected in-flight. If the results of prototyping activities in WP2 brought evidence that the publication of specific CDO procedures, or the accomplishment of live trials, is not feasible at this stage due to unacceptable capacity degradations or for safety reasons, the performance assessment was limited to simulations of specific flows at specific aerodromes.
Concomitant to the preparation and execution of demonstration activities in WP 6, the ODP project partners independently completed safety / risk assessments in accordance with existing regulations. The summary of the individual companies' safety work is provided in the Reference [19].

## 4.2 Exercises Execution

### 4.2.1 A/C Profile Studies (WP 1)

The determination of feasible descent profiles were based on AOs' studies to be performed in WP 1 "Aircraft descent profile studies" carried out by the Airline Operators participating in the ODP project. From the different descent profiles resulting from different aircraft types, aircraft weights, speed schedules, etc. a common average [2]descent profile was be derived for CDO development.

#### 4.2.1.1 Abstract A/C Profile Studies (WP 1)

This chapter 4.2.1 is the analysis of the Airspace User's input on SESAR'S ODP Project and the optimisation of ANSP descent procedure Design.

It collects performance data from various aircrafts in different configurations in use by airlines nowadays. It has to be seen as a recommendation for optimising ANSPs descent procedures, applicable mainly in high density airspaces/sectors where a descent at pilot's discretion is not possible. It is intended to be read by procedure designers and other personnel within the ANSPs to get an impression of aircraft performance and handling qualities and the operational possibilities and limitations.

In the first part of the result section it is shown that the ideal descent from Cruise Flight Level (FL 390) starts around 110 – 135 NAM before the intermediate approach fix for long range aircraft and around 90 – 105 NAM for short range aircraft. Considering an ODP perspective alone, London City airport (EGLC), where an altitude constraint as low as FL220 is published at 100NM from the IAF, may serve as negative example.

In the second part of the report, recommendations are given for CDO design. Airspace users in general request as few restrictions as possible and the first constraint to be as close as possible to the airport.

Air France, Swiss, Lufthansa and their respective affiliated companies have positively and constructively collaborated in this report and collected data from a broad range of aircraft. It is therefore envisaged to be valid for most of the European scheduled air traffic.

#### 4.2.1.2 Introduction to A/C Profile Studies (WP 1)

Within the high density airspace of Europe, which is divided into many control sectors, requiring exact handover agreements between adjacent ATC sectors LoAs, and leaving little room for adjustments, optimum descents are often difficult to establish. This is compounded by the huge range of different aircraft types, requiring optimum descents to comprise of a range of various descent flight path angles. Additionally, oftentimes the profiles of departing (climbing) traffic are in conflict with realising CDO in today's ATC environment (see section 4.2.1.6).

[2] The delivery was several average descent profiles or minimum and maximum optimum descent angles altogether defining level bands or "tunnels".

The following example of an A330's descent from FL390 to FL 50 illustrates how challenging it is to design an optimum descent route comprising all conditions:

**Example of an A330 descent**

- 50kt of Tailwind and almost complete payload require a descent distance of 168.5NM resulting in a flight path angle of 1,9°.
- 50kt of Headwind and almost no payload require a descent distance of 97,2NM resulting in a flight path angle of 3,3°.

However, in this report parameters were restricted to the most usual conditions to calculate profiles which will be the most economic for most aircraft, while not requiring large altitude windows in order to take into account controller operational constraints in dense airspace.

This WP1 report will therefore give an overview of the descent ranges and descent flight path angles required by different aircraft in use nowadays in the European airspace. As a conclusion of these values, altitude windows are proposed to help establish CDO procedures and optimise existing descent profiles on STARs.

In a subsequent section, recommendations for the construction of CDO procedures and descent constraints are given. These are in line with the DEL 05.06.02-D03-00.01 SESAR Study.

#### 4.2.1.2.1 Aircraft Performance Considerations

The optimum descent of an aircraft is a descent with IDLE Thrust[3].

The FMGS is the central navigation and steering computer of an aircraft. It comprises the Flight Management part (in this report referred to as FMS), which provides the flight crew with assistance for aircraft navigation and the Flight Guidance part, which manages aircraft guidance in lateral, vertical and speed modes.

In the FMS, the current route is stored and can be modified. The FMS calculates in addition to the entered lateral routing a vertical routing based on known altitude constraints, uploaded wind data, temperature and aircraft parameters. This vertical profile is continuously amended according to changing input variables. During Cruise Flight an optimum descent trajectory and the approach is calculated, considering cost index, known ATC restrictions on the STAR and approach and the previously mentioned aircraft and environment related variables. Without any exterior restrictions the descent is planned with IDLE thrust and a speed, depending on Cost index used from cruising Flight Level down to the initial approach altitude.

The cost index represents the ideal balance between performance of the aircraft and trip fuel consumption. It is defined as $\frac{time\ relevant\ costs\ (connecting\ flights,\ crew,\ etc\ldots)}{fuel\ costs}$ and is fixed by the airline individually for each flight.

Therefore any tactical intervention might bring the A/C out of its optimal FMS trajectory, with potential impact on noise and fuel consumption[4].

[3] Joachim Schneiderer; Angewandte Flugleistung; Springer Verlag Berlin, page 315f.

[4] SESAR DEL 05.06.02-D03-00.01, page 19

Two kinds of guidance are available to the pilot. Managed guidance provides long term guidance by following the aircraft's flight plan, stored and calculated by the FMS part. Selected guidance is for short term usage enabling the pilot to assign the aircraft a specific HDG, Speed or V/S. This is used for example to execute a tactical intervention by the controller.

After commencing descent the aircraft's Flight Management System is enables the autopilot to follow this pre-calculated profile. This is named depending on the aircraft manufacturer, e.g. managed descent (Airbus) or VNAV (Boeing, Embraer). With the FMS controlling the autopilot, the aircraft will try to follow the profile regardless of actual environmental conditions encountered. This might lead to a variance in speed (for further information see section 4.2.1.3.2.2).

## 4.2.1.3 Calculations

### 4.2.1.3.1 Fundamentals

Calculations were made with models and software of the respective aircraft manufacturers. These might slightly differ from the aircraft's built-in FMS, which is the basis for the autopilot and crew decision in finding the optimum descent profile. Differences are small throughout most of the descent but blatant in the deceleration phase prior FL100. Here most of the manufacturer's models, used for the calculations in this report, plan for a deceleration in level flight whereas the aircraft's FMS commands a subtle deceleration between ≈ FL120 (depending on speed) and FL100 by reducing the aircraft's flightpath angle and thereby its rate of descent. In this level band the results of the calculations below might lead to errors and should be used with caution.

In this report distances are given in Nautical Air Miles (NAM) to illustrate the dependence on the wind. Nevertheless all basic calculations were made without wind influence. Therefore in the final result table NAM equals NM.

### 4.2.1.3.2 Parameters and Methods

To enable a meaningful comparison the airlines agreed on fixed parameters for the calculations. These were:

#### 4.2.1.3.2.1 Weight

90% MLAW was chosen. Without looking into details of the utilised capacity of each airline this was regarded as realistic and within one standard deviation of the real mean utilised capacity of each aircraft. Furthermore the influence of weight is small compared to other influences (±100 Passengers result in ≈± 0,6NAM per descent for an A380, ≈± 3NAM for an A330, ≈± 4,5NAM for an A321). Finally the SESAR Study 5.6.2_D03 "Recommendations for CDO procedure design" uses this weight as reference.

#### 4.2.1.3.2.2 Speed

The aircraft is flown "in managed" with a fix CI resulting in variable speeds depending on the aircraft type. In this study CI10 (≈270kt / Mach.78) for short haul and CI50 (≈290kt / Mach.82) for long haul flight calculations are applied, which are roughly used by airlines these days. Whereas a change in cost index has quite a big influence on descent distances for short haul aircraft, it does not much affect the descent of long haul aircraft at CI's <50[5] . Speed below FL100 is 250kt.

##### 4.2.1.3.2.3 Altitude

A descent from FL410 down to 5.000ft was calculated, as procedures will end at transition FL.

##### 4.2.1.3.2.4 Engine Parameters: Thrust Idle, A/I off

Thrust Idle is according to theory the most economic aircraft performance engine rating for descent and will be used by the Flight Management System during descent and therefore in calculations in this report. However, a slight increase in thrust and thus a descent distance extension can be discovered in the real airplane, if FMS descent calculations differ from actual encountered conditions during the descent (e.g. wind not as predicted). In this case the aircraft, guided by the FMS, will try to follow the precalculated vertical profile. If this profile is too shallow, with regard to actual encountered conditions, the aircraft has to increase thrust to stay on the profile. Contrariwise, if the profile is too steep, the aircraft will increase its speed and demand more drag from the pilot if applicable (see section 4.2.1.5.1).

Embraer descent procedures might even require a thrust setting higher than IDLE thrust. However, regarding the calculation results for Embraer, showing this aircraft has the steepest descent angle, the influence on the proposed altitude windows is negligible. The engine Anti-Ice will only be used in clouds and therefore not for the entire descent. Additionally its influence is highly dependent on the type of engine used and therefore not considered.

##### 4.2.1.3.2.5 Wind

For a comparative calculation of the wind influence a wind profile has been used and checked with Air France's A320 performance tool. This tool offers the possibility of a calculation using different wind speeds at different altitudes. As the aircraft's rate of descent varies with height and therefore does not spend the same amount of time in each flight level band, an average wind calculation is not straightforward. Furthermore wind influence changes the CI related speed in the cruising phase. For an Airbus A320 these changes are considerably small (±3kt for a wind at 40kt) and affect the descent time only during the first ≈5000 feet until the Mach -> Speed transition. However, there are standard operating procedures for certain fleets (i.e. B737 at DLH) to manually change the descent speeds by as much as 20kt during descent when strong wind situations are encountered.

Below is the table for an average year wind speed profile at N45° latitude[6]

[5] Airbus_Getting to grips with the Cost Index, page 53

[6] Data is from the European Centre for Medium-Range Weather Forecasts

| Altitude | Windspeed [kt] |
|---|---|
| FL380 = 200hPA | 42 |
| FL300 = 300hPA | 37 |
| FL235 = 400hPA | 30 |
| FL180 = 500hPA | 24 |
| FL135 = 600hPa | 19 |
| FL100 = 700hPA | 15 |
| FL065 = 800hPA | 11 |

**Table 8: average year wind speed profile at N45° latitude**

### 4.2.1.4 Calculation Results

#### 4.2.1.4.1 All Profiles

In figure 1 profiles for certain aircraft types are plotted. Thereafter the same data are plotted for the limiting aircraft in the short range and long range fleets.

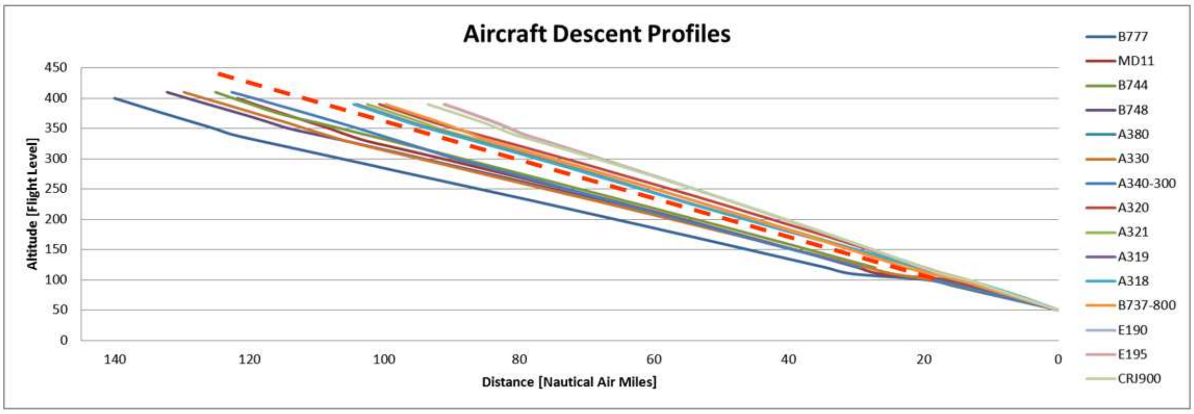



*Figure 2: Descent profiles of various aircraft from cruising flight level to 5.000ft. The red dashed line illustrates the separation between the different descent characteristics of long-range (below the line) and short-range aircraft (above the line).*

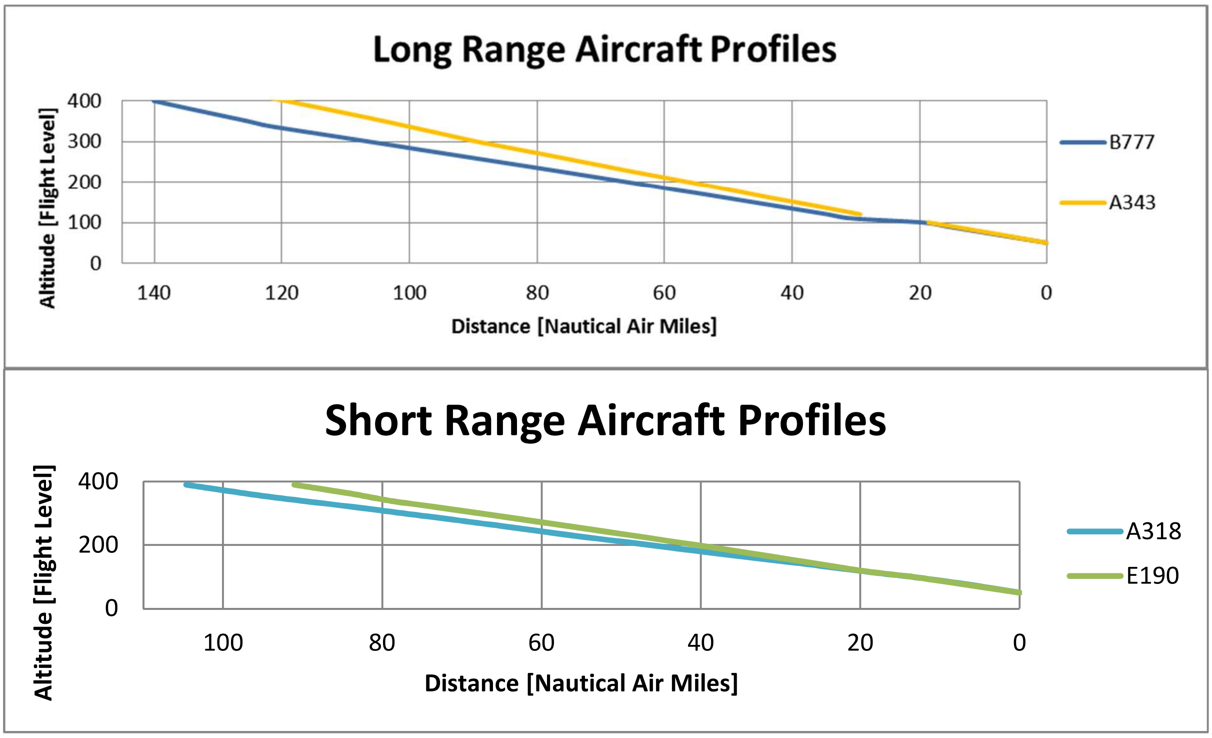



*Figure 3: Data from figure 1 for limiting aircraft in the long and short range fleets (these aircraft have the maximum and minimum FPAs).*

Established average descent angles range from 3,54° for the Embraer 190 to 2,47° for the B777-F. However, these angles are not constant throughout the approach. The aircraft start descending with a higher glide angle (4,00° for the Embraer 190 to 3,23° for the B777-F), as long as they descend with speed control at constant Mach. At transition altitude (the aircraft changes its speed control from constant Mach to constant CAS) the flight path angle is reduced by ≈0,5° to 3,46°(E190) or 2,37° (B777-F) respectively.

In Figure 5 the size of the altitude window that these two aircraft are able to follow can be observed.

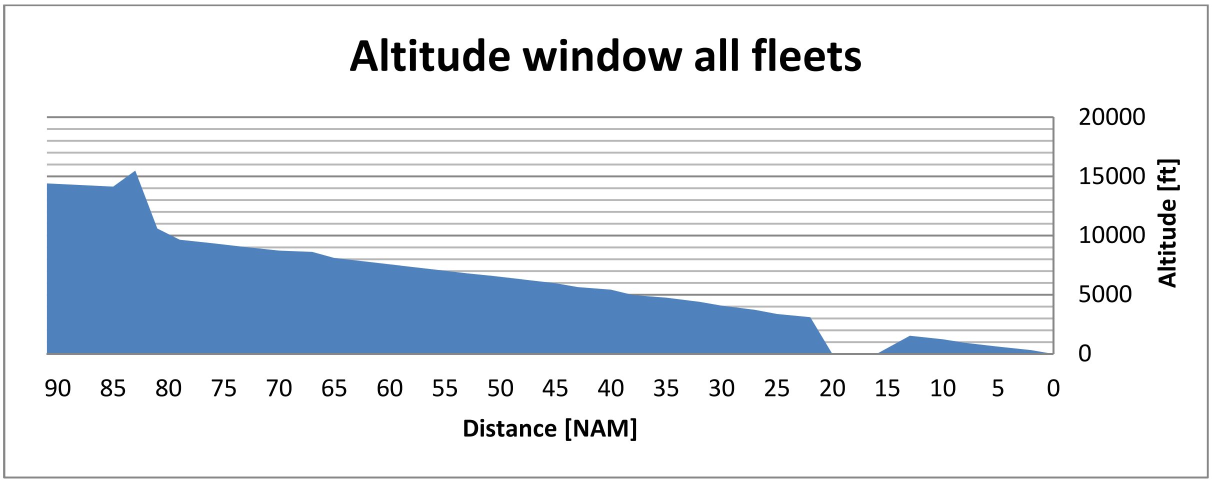



*Figure 4: This figure shows the altitude window range for B777-F and E190. For example, around 80NAM from the 5000 feet point the B777-F is around 10000 feet lower than the Embraer, resulting in a 10000 feet altitude window in an ideal CDO procedure.*

#### 4.2.1.4.2 Short vs long haul

In Figure 2 the different descent characteristics of long-range and short-range aircraft can be seen whereby long range aircraft generally have a better glide performance. The red dashed line on Figure 2 divides the areas between these aircraft. Just looking at the short range fleet the calculations yield angles between 3,54° (E190) and 3,08° (A318) resulting in a window as shown in Figure 5.

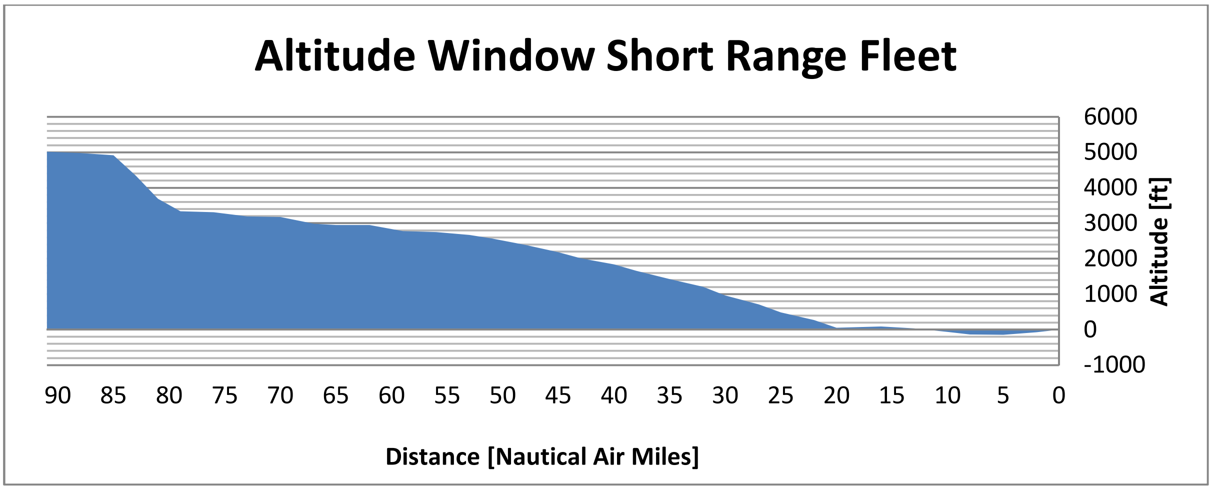



*Figure 5: Altitude window spanned by the short range fleet. The negative value implicates that below 10000ft at a speed of 250kt the E190 has actually a better gliding performance than the A318.*

Looking at the long range aircraft one can find angles between 2,87° (A340-300) and 2,47° (B777-F). The resulting altitude window is shown in Figure 6.

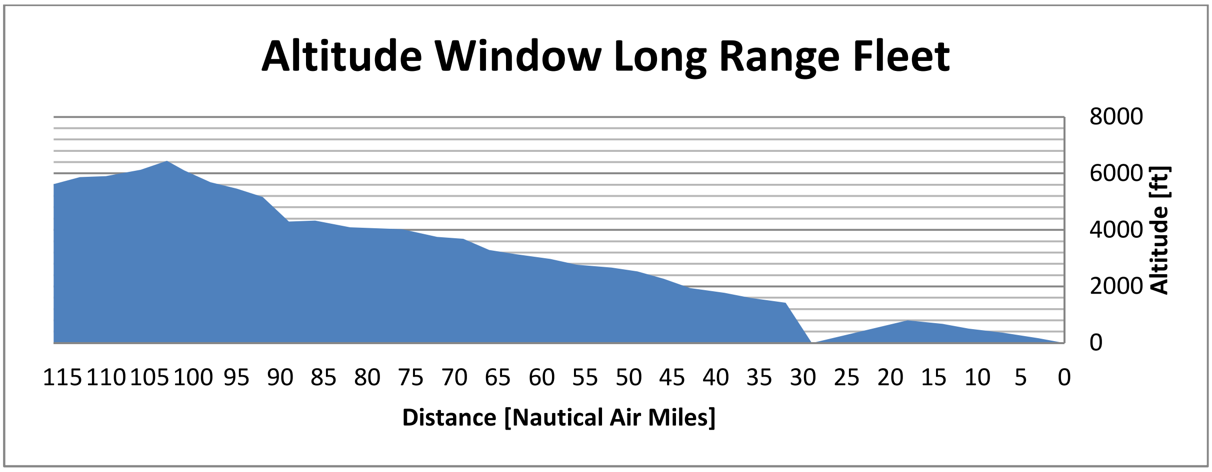



*Figure 6: Altitude window spanned by the long range fleet (comparison between B777-F and A340-300.*

While the implementation of altitude windows, for example in a CDO-tube procedure, comprising the optimum descent angles of all fleets, requires quite a big altitude window at the beginning of the descent, this span can be reduced where tubes are built for certain fleets only.

The following table shows the recommended limiting window altitudes in flight level (FL) as a result of the calculated flight path angles.

| Distance in NAM from 5000ft Speed 250kt | Minimum FL long range 2,37°/3,2° above FL350 | Maximum FL long range 2,87° | Minimum FL short range 3,08° | Maximum FL short range 3,54° |
|---|---|---|---|---|
| 0 | At 5000ft / FL50 | | | |
| 5 | 63 | 65 | 66 | 69 |
| 10 | 75 | 80 | 83 | 88 |
| 15 | 88 | 96 | 99 | 106 |
| 20 | 100 | 111 | 115 | 125 |
| 25 | 113 | 126 | 132 | 144 |
| 30 | 125 | 141 | 148 | 163 |
| 35 | 138 | 157 | 164 | 182 |
| 40 | 150 | 172 | 181 | 200 |
| 45 | 163 | 187 | 197 | 219 |
| 50 | 176 | 202 | 213 | 238 |
| 55 | 188 | 218 | 230 | 257 |
| 60 | 201 | 233 | 246 | 276 |
| 65 | 213 | 248 | 263 | 294 |
| 70 | 226 | 263 | 279 | 313 |
| 75 | 238 | 278 | 295 | 332 |
| 80 | 251 | 294 | 312 | 351 |
| 85 | 264 | 309 | 328 | 370 |
| 90 | 276 | 324 | 344 | 388 |
| 95 | 289 | 339 | 361 | |
| 100 | 301 | 355 | 377 | |
| 105 | 314 | 370 | 393 | |
| 110 | 326 | 385 | | |
| 115 | 339 | 400 | | |
| 120 | 351 | | | |
| 125 | 368 | | | |
| 130 | 385 | | | |
| 135 | 402 | | | |

**Table 9: recommended limiting window altitudes in flight level**

#### 4.2.1.4.3 Wind influence

The influence of wind was calculated with the A320 performance tool and resulted in an average wind component of ≈±35kt. In case of tailwind the average flight path angles are decreased by 0,3° for the limiting aircraft (E190, A318, A340-300 and B777-F). In case of headwind the average flight path angles are increased by 0,3° (E190, A318, A340-300) and 0,2° (B777-F).

#### 4.2.1.4.4 Rule of thumb

A lot of times CDO procedures will not be fixed by a charted procedure and/ or the AIP. Instead they will be cleared tactically by the controllers whenever possible.

Considering the fact that the ATCO's radar screen is flat (2D) and that the 3D-images are only available in each ATCO's mind, the subsequent rule of thumb will help the ATCOs to understand our specific requirements and possible day to day deviations from a "standard" descent. A possible way to do this is the development of a "rule of thumb"-table showing the controller what factor (environment or aircraft) has which impact on the optimised descent profile.

**Weight:** ≈± 1,5NAM /10.000ft each ±10t weight (respective 100 Passengers) for short range aircraft

**Altitude:** ≈± 3NAM /1 000ft for short range, ≈± 4NAM / 1 000ft for long range

**Temperature:** ≈± 1,3NAM /10 000ft each ± 10° ΔISA

**Wind:** ≈± 1NM /10 000ft each 10kt head-/ or tailwind

## 4.2.1.5 Other considerations & recommendations

### 4.2.1.5.1 Constraint design

#### 4.2.1.5.1.1 Aircraft speed profile

Aircraft are normally flown using speeds calculated by the FMS based on entered CI and current environmental factors (like wind). The flight crew does not usually modify the CI during a flight. However, the aircraft`s managed speed function allows for slight speed deviations to follow the pre-calculated optimised descent profile in the FMS, as energy trading by speed is the most efficient way for the aircraft to return to its optimum trajectory:

Airbus aircraft generally allow a deviation of ±20kt around the pre-calculated speed, modern Boeing aircraft, depending on the type, usually 10kt and the Embraer does not limit the speed to match the profile within the flight envelope.

In case of a published speed constraint on a waypoint, this range gets limited by the FMS to hold the given constraint (i.e. +5, -20kt).

If the controller needs further regulation and the pilot has to use selected speed mode, which removes the FMS speed range, the aircraft is unable to match the pre-calculated profile solely by adjusting speed. Therefore other fuel consuming measures like air brakes or thrust have to been applied by the pilot in order to return to the profile and pass given ATC altitude constraints with negative impact on CDO.

#### 4.2.1.5.1.2 Aircraft deceleration

At FL100 the deceleration rate in level flight is about 10kt/1NAM (±0.2NAM in case of 50kt head or tailwind).This value is considered in the descent calculations.

However, the aircraft's flight guidance does not:

- Fly an idle path down to FL100,

- perform a level-off at FL100 exactly,
- reduce speed in level flight before continuing the descent.

The aircraft's flight guidance does:

- Fly an idle path down to any cleared altitude below FL100,
- reduce the ROD early enough to allow for speed reduction in order to reach 250kt when descending through FL100.

During this deceleration phase the flight path angle in Airbus aircraft is reduced by about 1,5°, as can be seen in figures 7 & 8. The deceleration rate of a descending aircraft is lower than the one of an aircraft in level flight and wind variations have a big impact on the flight's ability to comply with an altitude constraint while simultaneously reducing speed.

This reduced descent rate should be taken into account when applying any speed reduction. This can either be:

- standard speed reduction to 250kt/<FL100
- standard speed reduction on a STAR/CDO procedure (i.e. max 230kt at DX123)
- tactical speed reduction by the air traffic controller

Note that speed reductions close to minimum clean speeds (see next section) require a very low rate of descent (down to ≈500 ft/min, depending on aircraft type)

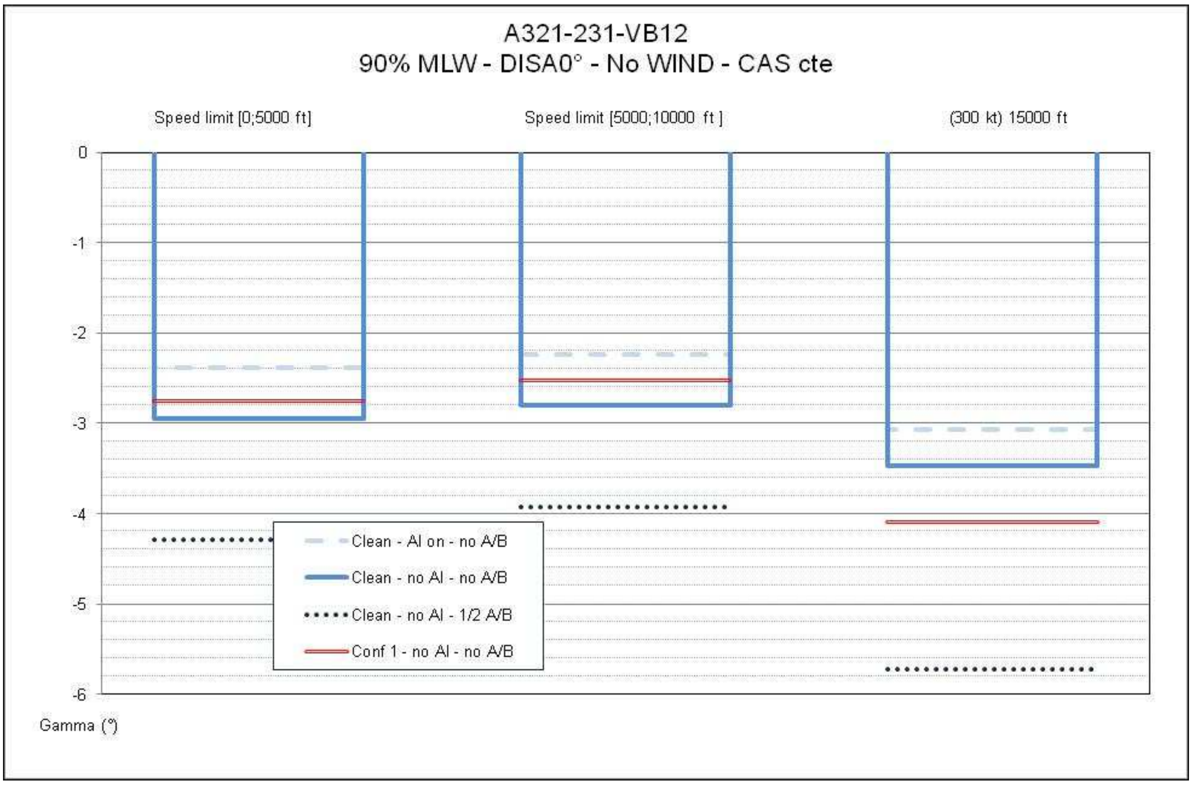


*Figure 7: Flight path angles at different speeds and configurations in un-accelerated descent for an A321. A/B = Airbrake or Speedbrake. Conf 1 is the first Slat/Flap Setting. Speed Limit is 250kt.*

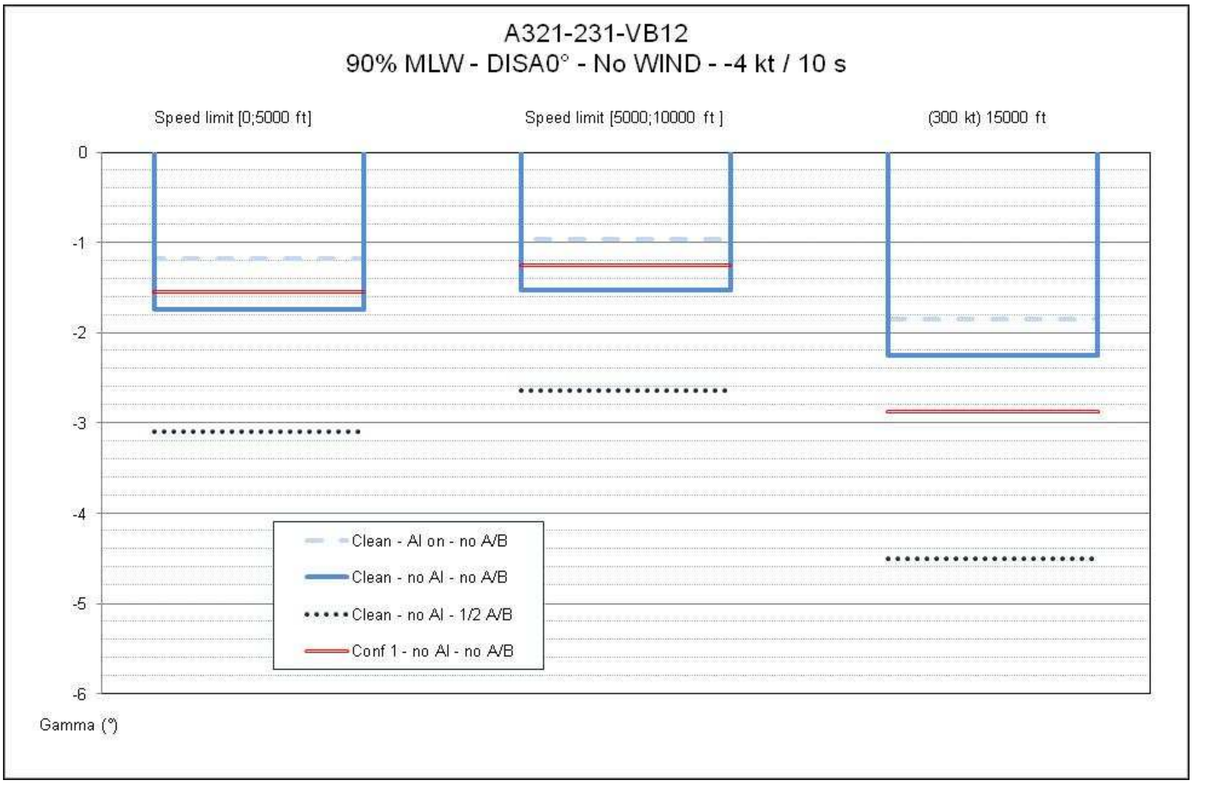



*Figure 8: Various descent angles for a decelerated descent of an A321. A/B = Airbrake or Speedbrake. Conf 1 is the first Slat/Flap Setting. Speed Limit is 250kt.*

#### 4.2.1.5.1.3 Minimum Speeds

Generally from an aircraft operator's point of view a minimum number of speed restrictions should be defined. Reasons are the above mentioned CI, taking into account airlines time related costs, the ability of the aircraft to regain the profile by speed trading, as well as passenger comfort and aircraft handling qualities. Therefore a single deceleration segment is preferable.

As can be seen in the table below, a speed below 230kt should not be coded prior 3-4 NAM of the Glide Slope intercept in a CDO procedure. This would require the aircraft to extend its flaps and increase the fuel consumption as well as noise emissions considerably.

| AIRCRAFT | Minimum Speed (KCAS) @5000ft |
|---|---|
| A318 | 205 |
| A319 | 210 |
| A320-100 | 212 |
| A320-200 | 217 |
| A321-100 | 223 |

| | |
|---|---|
| A321-200 | 227 |
| A330 | 219 |
| A340-300 | 230 |
| A340-600 | 224 |
| A380 | 202 |

*Table 10: minimum clean speeds (minimum speed without flap or slat extension) of different aircraft at maximum landing weight[7].*

#### 4.2.1.5.1.4 FMS Handling of different constraint type

There are four different types of constraints currently used for the implementation of CDO procedures.

1. AT requires the aircraft to have a certain altitude over a waypoint
2. AT or ABOVE defines a minimum altitude the aircraft is expected to maintain when crossing a waypoint.
3. AT or BELOW defines a maximum altitude the aircraft is expected to maintain when crossing a waypoint.
4. A window restriction defines the minimum and the maximum altitudes between which an aircraft is expected to cross a waypoint.
5. Speed constraints, details please see 4.2.1.3.2.2.

Without any altitude restriction the FMS creates an IDLE descent profile from cruise flight level down to the ILS glide path and advises its flight guidance part to follow it.

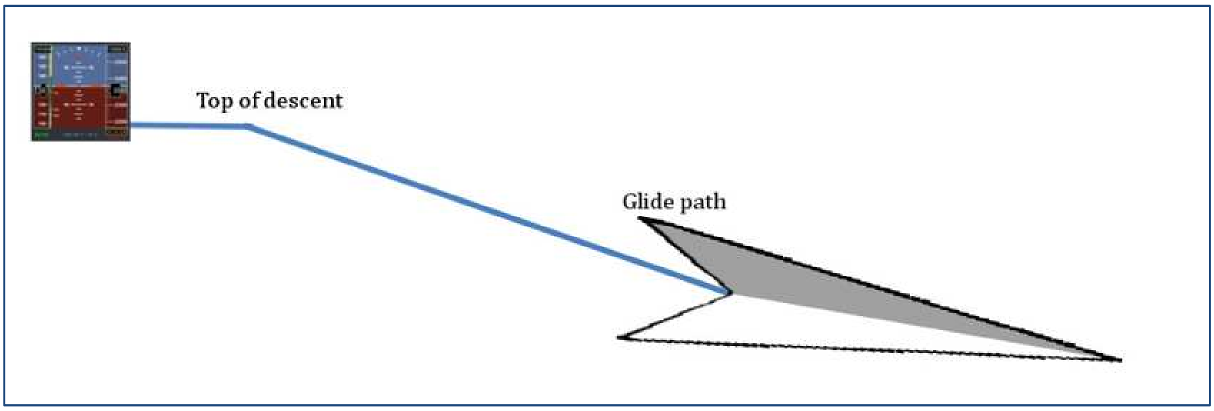



*Figure 9: Idle descent of an aircraft*

With constraints the FMS behaves differently, depending on the type of the aircraft.

For Airbus aircraft it will command a geometric profile after the first constraint not within a continuous IDLE path from cruise flight level, leading to a constant descent but requiring thrust in case the geometric FPA is below the IDLE FPA (see Figure 10 between constraint B and C).

[7] Data are from SESAR Study DEL 05.06.02-D03.01, page 35

Other aircraft will level off at the constraint altitude and apply a new IDLE profile after reaching the next calculated descent point.

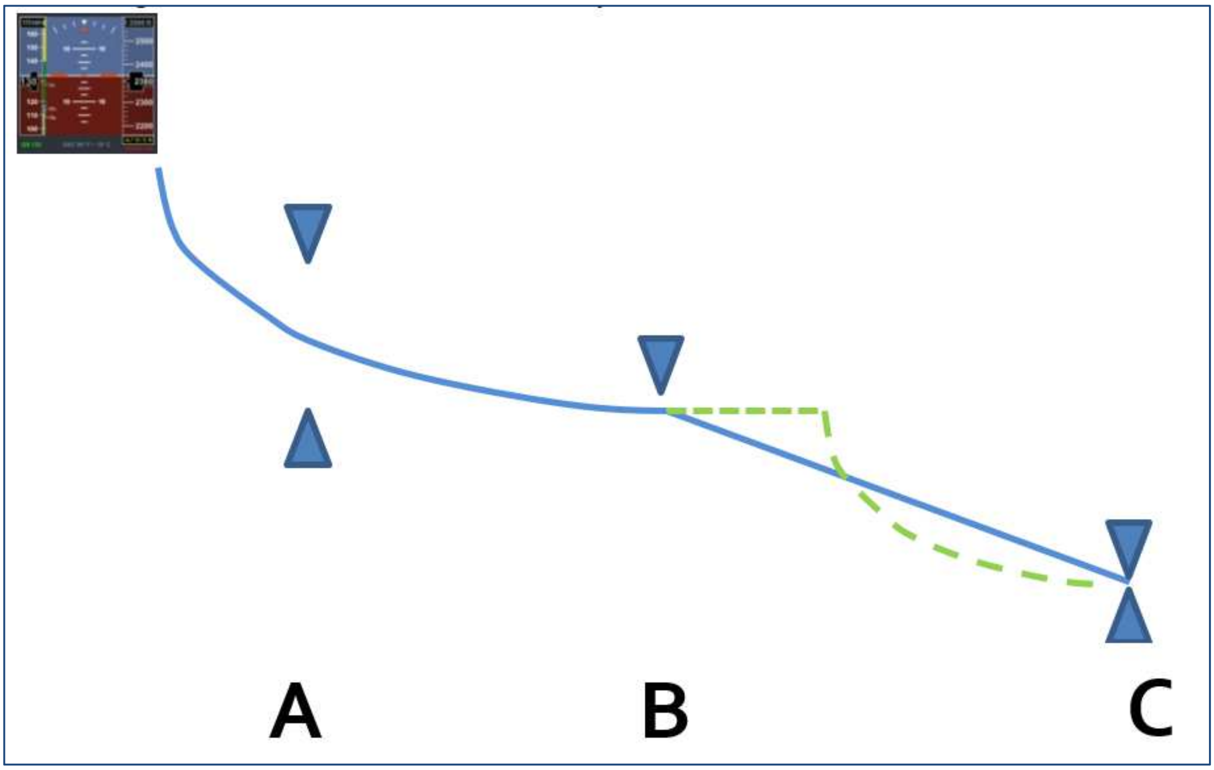



*Figure 10: Descent of an aircraft crossing several constraints. Constraint A is a "WINDOW" constraint, big enough to accommodate the first IDLE segment. As constraint B ("AT or BELOW") is too low to accommodate an IDLE descent from CFL to constraint C ("AT"), a geometric path (blue) or a level off (green) is inserted by the FMS.*

Note: A constraint that is higher than the preceding one, requiring an ascending segment, will not be considered by the FMS.

##### 4.2.1.5.1.5 Recommendation for ODP-Design

Considering the FMS behaviour, the use of AT or ABOVE, AT or BELOW and WINDOW constraints is preferable. The windows should be big enough to accommodate IDLE descent profiles for most aircraft types, as calculated in the section results.

Therefore the first constraint should be as low as possible (compare table in section 3.2 Work Breakdown Structure).

Note that speed constraints at waypoints severely change the required Flight Path angle, if a deceleration phase is required prior to the constraint as discussed above. The resulting windows should be big enough for the deceleration to be accomplished.

#### 4.2.1.6 CDO vs. CCO

Performance data of various airplanes shows that the difference in NAM per ton of fuel between two altitudes depends on the weight of the aircraft. This difference is smaller if the aircraft is heavy, like at the beginning of the flight, see Figure 12. The conclusion is that in the theoretical case of a conflict between two identical aircraft, one climbing and one descending, the descending one should fly above the climbing one. This recommendation is contradictory to today's handling procedures and also to the implementation of major air traffic flows. The recommendation for the controllers within ODP would be to keep the descending aircraft high and the climbing aircraft low. Certainly it has to be assured, that the relation of the overall fuel burn of the respective climbing aircraft is not remarkably higher than that of the descending one (e.g. to avoid prioritizing an E190s descent over a climbing A380).This should be applied outside the terminal area. Close to the airport other negative effects are to be expected if changing current procedures (due to terrain, enlargement of transitions etc.).

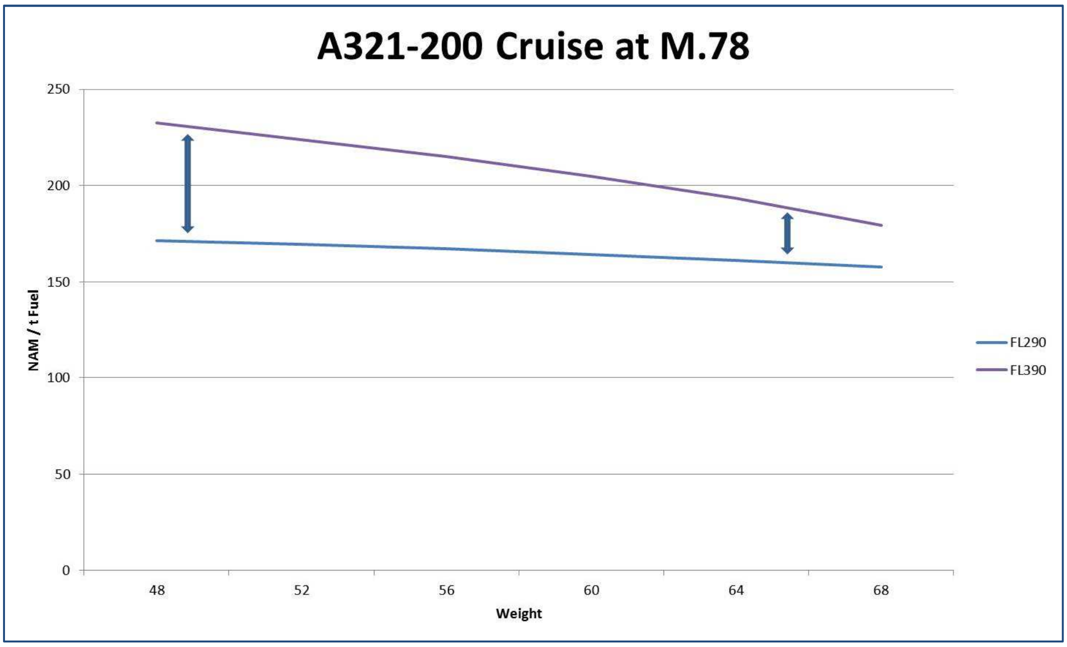



*Figure 11: Nautical air miles per ton of fuel at various weights. The result is given for two altitudes (FL390 and 290). The decreasing difference of the two lines with increasing weight means that for a heavy aircraft the altitude difference is not as important as for a light aircraft.*

### 4.2.1.7 Altitude Selection on short haul flights

Long haul flights usually fly at their cruise optimum FL in Europe. However, short haul flights are usually penalised from a flight efficiency point of view. As an example we can use the A320 cruise FL table from Airbus' FCOM:

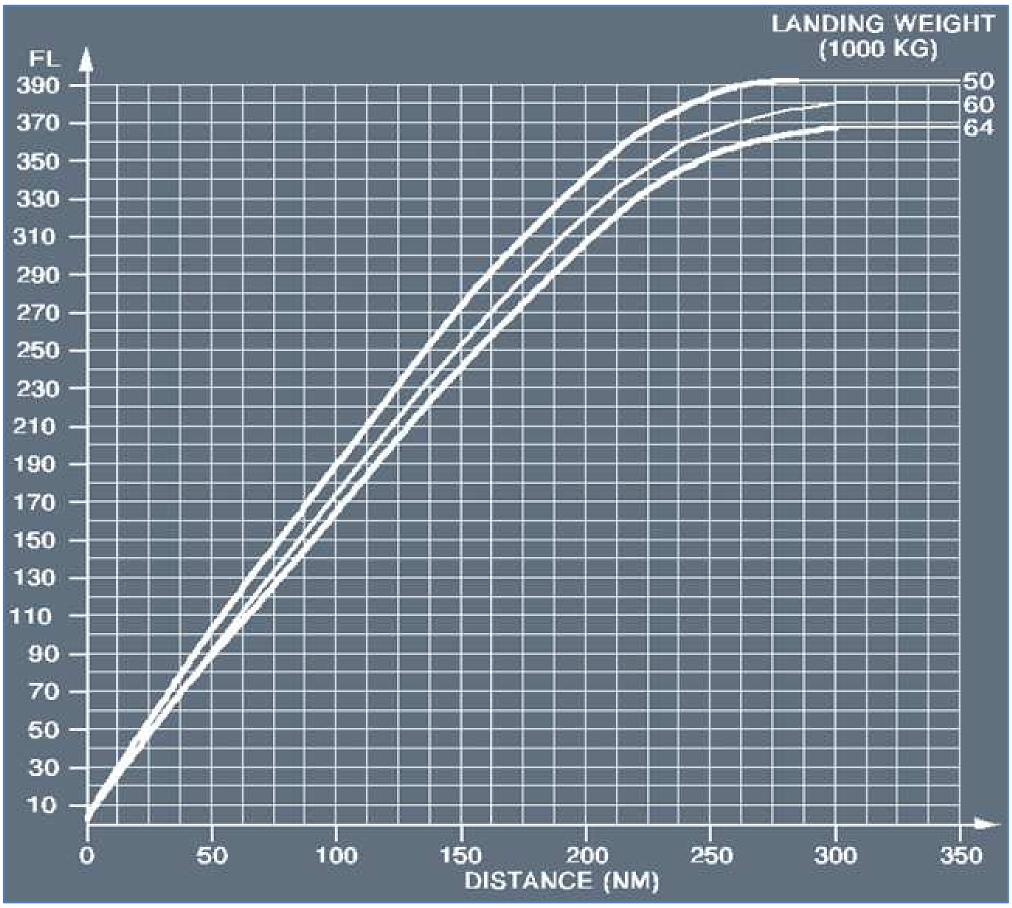



*Figure 12: Optimum CFL of an Airbus A320. Using this table, we can tell that for all distances above 250 NM, the optimum FL of the A320 is between FL350 and FL390.*

The fuel loss of a "level-capped" flight cannot be generalised and can only be calculated for each individual flight. However, this cruise altitude restriction on short flights, which typically have a flight time of less than one hour, can nonetheless induce a surplus of 100 kg fuel, equalizing roughly 15NAM of horizontal flight.

### 4.2.1.8 Vertical optimisation versus horizontal optimisation

As usual for the fuel efficiency topics, the answer will depend on local environment and the flight conditions on the day of operation (weather conditions, accelerated flight, heavy flight…) but generally spoken vertical efficiency is as important as horizontal optimisation. The following pictures, taken form an Air France study, supporting conclusions of a SAS Sabre study summarises theoretical considerations regarding the optimised descent stated above and shows the trade-off between potential savings that should be kept in mind while designing new CDO.

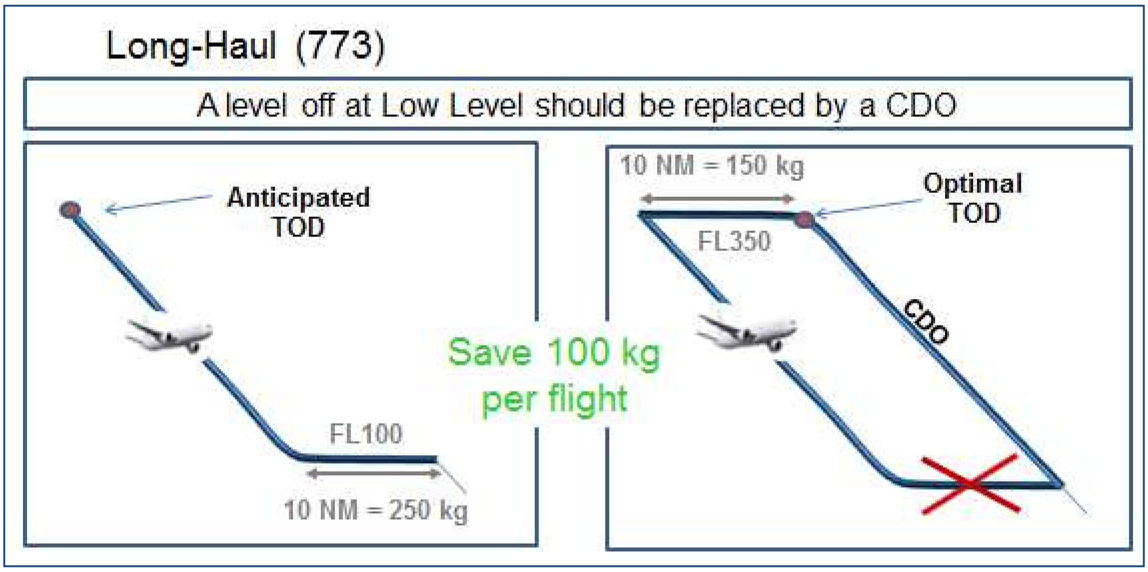



*Figure 13: Long-haul example for optimal ToD*

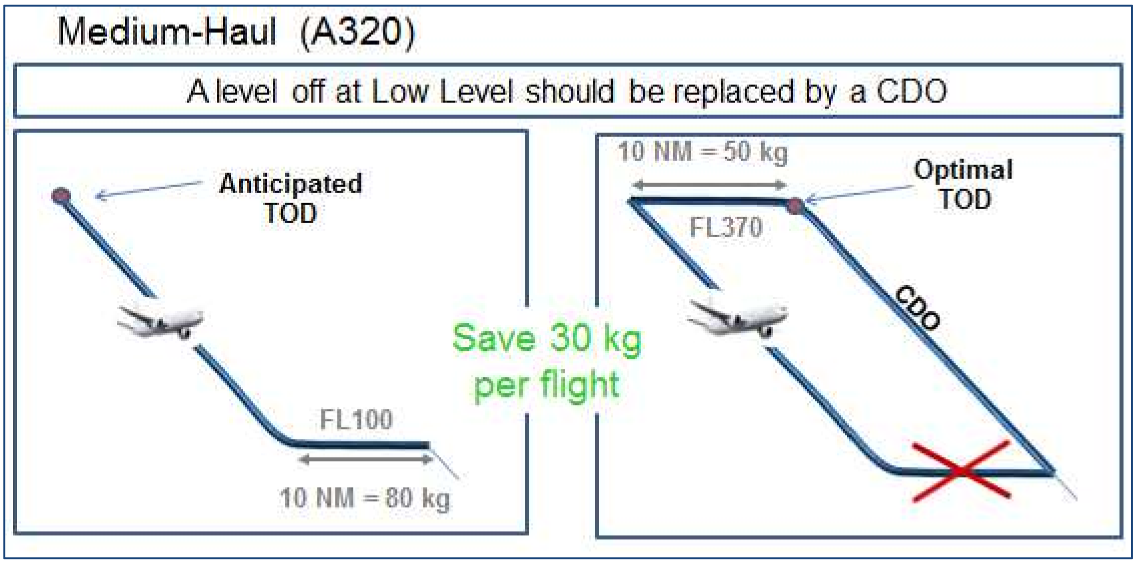



*Figure 14: Medium-haul example for optimal ToD*

Note: These are average figures that give rounded numbers. Moreover, those figures are specific to this example and should not be extrapolated. A trade-off should always be looked at locally, comprising capacity considerations.

For the A320, an **additional extension of 6 NAM (45 seconds)** before descent would **cancel out all benefits from CDO implementation.**

For the 777, an **additional extension of 7 NAM (50 seconds**) before descent would **cancel out all benefits from CDO implementation.**

## 4.2.2 CDO Development (WP 2)

The elaboration of CDOs was accomplished in WP 2. These optimised descent procedures were designed in a way allowing for one or more of in total three types of demonstrations (validation techniques):

- “Public Live Trials” allowing all Airspace Users to make use of ODP solutions based on AIP-published procedures. It has to be noted that the publication of modified arrival procedures in the AIP takes a duration of up to one year. Therefore, the number of procedures published in the AIP during project duration were limited.
- “Operational Flight Trials” were accomplished based on un-published operational procedures which were available for scheduled flights of AOs participating in the ODP project, i.e. AFR/HOP!, DLH (incl. GWI) and SWR.
- “Tactical Live Trials” were performed on ANSP initiative based on un-published operational procedures: For specific traffic flows ATC tactically offered optimised descents to all airspace users whenever the traffic situations permits.

The following table summarises the type of trials:

| Trial | Participants, Publication | Published in AIP | FMS adaptation | Routing in FPL |
|---|---|---|---|---|
| Public Live Trial | all AOs, published CDO | Y | Y | Y (N for EMPAX trial) |
| Operational Flight Trials | Project-AOs, un-published CDO | N | Y | Y/N dep. on local cases |
| Tactical Live Trials | all AOs, tactical clearances | N | N | N |

**Table 11: Type of Trials**

As far as possible within the project duration these operational procedures were published in the AIP in order to allow for Public Live Trials. However, since the publication of AIP modifications usually takes up to one year, Operational Flight Trials and Tactical Live Trials formed the primary source for data collection (see Table 12: Overview of complete ODP Demonstration activities). Processes required by EASA and/or affected National Safety Authorities were carefully attended to.

| Scenario ID | Exercise Title / Airport | Exercise ID | Demonstration ID | Routing | Relevant ATC Units | Fast Time Simulation | Tactical Live Trials | Operational Flight Trials | | Public Live Trial | todays situation | ODP trial description | Time of trial | Participant | Remarks | Deviation from DP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCN-0103-001 | Bale-Mulhouse (LFSB/BSL) | EXE-0103-001 | DEM-001-01 | Flights from Paris (CDG and Orly) | Reims ACC, Bale APP | | X (later ToD) | | | X (CDO from ARPUS) | flights have to descend below UH-sector, therefor to cross OKIPO at FL225 or below | Handover to UH-sector at FL310, Late top of descend, Published CDO-procedure starting at ARPUS | starting 10DEC2015 (CDO from ARPUS), 16.01.-31MAR2016 (later ToD) | all flights | | |
| SCN-0103-009 | Berlin-Tegel (EDDT/TXL) | EXE-0103-009 | DEM-009-01 | RWY08 NORTH: via GIRIT, VIBIS, GOLBO, RENKI | Bremen ACC | | | | | X | Inbounds are currently cleared via STARs and/or the usage of transitions to final IFPs as an overlay to radar vectoring, combined with individual radar vectoring by advising headings. Vertical guidance is by individual instructions only providing very little predictability to the pilot. | A set of transition to final IFPs with vertical guidance starting at nine transfer point from the existing ATS route system to all four final approach fixes (FAFs) will be published. | starting 23JUN2016 (not during times of medium to very high traffic | all flights | An extension especially for flights via BATEL – GIRIT with a handover from Maastricht descending FL250, crossing BATEL FL280 (for RWY08) resp. FL300 (possibly 310 or 330) (for RWY26) is to be discussed in 2017 after experience is gained. This date had to be delayed due to the delay for the publication of the procedures. | |
| | | | DEM-009-02 | RWY08 SOUTH: via LELMA, MILGU, AKUDI, BUKIG, NUKRO | Bremen ACC | | | | | | | | | | | |
| | | | DEM-009-03 | RWY26 NORTH: via GIRIT, VIBIS, GOLBO, RENKI | Bremen ACC | | | | | | | | | | | |
| | | | DEM-009-04 | RWY26 SOUTH: via LELMA, MILGU, AKUDI, BUKIG, NUKRO | Bremen ACC | | | | | | | | | | | |
| SCN-0103-002 | Frankfurt (EDDF/FRA) | EXE-0103-002 | DEM-002-01 | EMPAX | Karlsruhe UAC, Langen ACC | | | X | 2 demo trials based on individual agreements with AO, no publication of procedure | | Handover Rhein to Langen at KOVAN at FL240 ,Handover to Approach at PSA at FL110 (FL100 on tactical basis) | Demo flights to validate possible publication of a CDO within ODP time frame | Demotrials: 1. Trial: 05MAR15-01APR15 2. Trial: 24AUG15-06SEP15 | Demo trials: individual flights of DLH and CFG (Condor not part of ODP) | | |

| Scenario ID | Exercise Title / Airport | Exercise ID | Demonstration ID | Routing | Relevant ATC Units | Fast Time Simulation | Tactical Live Trials | Operational Flight Trials | Public Live Trial | todays situation | ODP trial description | Time of trial | Participant | Remarks | Deviation from DP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | but coded in FMS. | | | | | | | |
| | | | DEM-002-02 | EMPAX | Karlsruhe UAC, Langen ACC | | | 1 publication of CDO from 13OCT 2016. | X (Hand over from Zürich to Karlsruhe and CDO publication 13OCT16) | Handover Rhein to Langen at KOVAN at FL240 ,Handover to Approach at PSA at FL110 | CDO Publication by introduction of a STAR starting at EMPAX including level restrictions in order to increase the predictability of the flight profile thus reducing the need for advised rates of descend and/or vectoring. | CDO publication 13OCT16 | all airlines | publication for all flights in preparation but performance analysis is outside of ODP timeframe. | party for performance analysis |
| | | | DEM-002-03 | EMPAX | Zürich ACC, Karlsruhe UAC | | | Between Zurich ACC and Karlsruhe UAC, improved handover conditions during winter period. | X | Handover Zürich to Rhein MAX FL340 at SONOM | During winter period handover from Zürich to Rhein MAX FL360 | LoA: 15OCT15-31MAR16 | all airlines | | |
| | | | DEM-002-04 | GIMAX | Karlsruhe UAC München ACC | | | | X | Handover from Rhein to Munich at ERNAS FL320 resp. at MAH FL320, | FL320 10 NM between REDNI and ERNAS (i.e. 9 NM later for flights from the southeast, resp. 44 NM later for traffic via MAH) at GOLMO. Implementation is foreseen after ODP assessment timeframe. | Implementa-tion 18AUG2016 | all flights | effective of LoA from 18AUG 2016, but outside of ODP performance analysis timeframe. | X |
| | | | DEM-002-05 | | Langen ACC Munich ACC | | | | X | Handover from Munich to Langen 5 NM | Early descends out of FL240 are to be avoided to the | 8DEC16 or 5JAN17 | all flights | outside of ODP time frame | |

| Scenario ID | Exercise Title / Airport | Exercise ID | Demonstration ID | Routing | Relevant ATC Units | Fast Time Simulation | Tactical Live Trials | Operational Flight Trials | Public Live Trial | todays situation | ODP trial description | Time of trial | Participant | Remarks | Deviation from DP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | after GIMAX at FL240, | greatest extend possible (ASPAT STAR) | | | | |
| | | | DEM-002-06 | | Karlsruhe UAC München ACC Langen ACC | | X | | | Handover to Approach PSA at FL110 | During early hours single flights are kept at CFL until descend at pilots´ discretion to reach PSA at FL110 | Some individual flights by one single ATCO of Langen ACC | individual flights (early morning only) | permanent use of procedure not feasible due to high coordination workload requirement. | |
| | | | DEM-002-07 | LIMGO | Paris ACC Brussels ACC Maastricht UAC Langen ACC | | X | | | flights are subject to level capping at FL230 | on weekends flight are accepted to climb to FL290 as cruising level whenever traffic allows. | 16JAN – 27MAR 2016 (weekends only) | all flights | "special flow" LFPG-EDDF city pair | |
| | | | DEM-002-08 | LIPMI | Maastricht UAC Langen ACC | | X | | | Handover from Maastricht to Langen DIXAT at FL260<br>After passing LIPMI traffic is descended to FL240 or lower as soon as possible<br>Handoff to Approach at ETARU FL100 or OSPUL FL120 (depending on landing runway) | Handover from Maastricht to Langen LIPMI at FL260 (12 NM later)<br>Descend when ready to meet ETARU/OSPUL restrictions (for landing direction 25 only). Possibly coordination with Lippe and/or Rhein required | as of 03MAR16 | all flights | implemented, will stay implemented | |
| | | | DEM-002-09 | RIMET | Maastricht UAC Karlsruhe UAC Langen ACC | X (both landing directions) | | | | Handover from Maastricht SOLO to Langen GED at RIMET at FL250<br>Flights have to be at FL240 or below clear of the Rhein FUL1-sector within the delegated HILFE-area<br>Handover to EDDF-Approach at KERAX at FL110 or 120 (depending on | Flights are handover in the descend out of FL290 to FL240, to reach FL240 at a new waypoint 'ODPI' 5 NM prior the crossing N858 via ERSIL.<br>Handover to Approach remains unchanged.<br>This means the A/Cs are higher by 2.000ft feet for 11 NM than today. | n/a | all flights | There is a FTS report, see FTS report (ref. [13]). | |

| Scenario ID | Exercise Title / Airport | Exercise ID | Demonstration ID | Routing | Relevant ATC Units | Fast Time Simulation | Tactical Live Trials | Operational Flight Trials | | Public Live Trial | todays situation | ODP trial description | Time of trial | Participant | Remarks | Deviation from DP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | landing runway), integrated into arrivals from the north (via FUL) and from the east (via DEMAB-SOLVU) | | | | | |
| | | | DEM-002-10 | RIMET | Maastricht UAC Karlsruhe UAC Langen ACC | | | X (RWY 25 only) | | | Handover from Maastricht SOLO to Langen GED at RIMET at FL250<br>Flights have to be at FL240 or below clear of the Rhein FUL1-sector within the delegated HILFE-area<br>Handover to EDDF-Approach at KERAX at FL110 or 120 (depending on landing runway), integrated into arrivals from the north (via FUL) and from the east (via DEMAB-SOLVU) | Flights are handover in the descend out of FL290 to FL240, to reach FL240 at a new waypoint 'ODPI' 5 NM prior the crossing N858 via ERSIL.<br>Handover to Approach remains unchanged.<br>This means the A/Cs are higher by several thousand feet for 11 NM than today. The trail was only for RWY 25. | 28APR16-26MAY16 | all flights | The Public Live Trail was suspended after 1 day of trial due to safety issues. More details in performance analysis chapter 6.2.15. | |
| SCN-0103-003 | Geneva (LSGG/GVA) | EXE-0103-003 | DEM-003-01 | NATOR | Karlsruhe UAC Zürich ACC Geneva ACC | | X | | | | Handover from Rhein to Zurich: NATOR at FL310<br>Handover from Zurich to Geneva LUTIX at FL250 | Handover from Rhein to Zurich at FL350<br>Descend when ready within Zurich airspace<br>Handover from Zurich to Geneva in descend depending on runway in use.<br>No change between Geneva to Zurich because | 13+14FEB16 | all flights | Change of Handover from Zürich to Geneva will not be trialed, after safety assessment showed negative result | |

| Scenario ID | Exercise Title / Airport | Exercise ID | Demonstration ID | Routing | Relevant ATC Units | Fast Time Simulation | Tactical Live Trials | Operational Flight Trials | | Public Live Trial | todays situation | ODP trial description | Time of trial | Participant | Remarks | Deviation from DP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | of safety assessment not possible to change. | | | | |
| SCN-0103-004 | Munich (EDDM/MUC) | EXE-0103-004 | DEM-004-01 | BEGAR | Zürich ACC München ACC | | X | | | | Handover from Reims to Zurich BEGAR at FL350 Early descend through M5 and M4 to M3 sector Handover from Zurich to Munich NUNRI at FL270 | Shift of Top of Descend out of FL350 by 50-60 NM (Descend when ready) Handover from Zurich to Munich at FL310 | 15OCT15 | all flights | Permanent implementation of ODP improvements between Reims ACC and Zurich ACC and Munich ACC (cross-border). CDO-procedure within München ACC delayed due to issue in separating flights to inbounds from the south. München ACC will start a new trial in 2016. | |
| | | | DEM-004-02 | ELMOX-DKB | Karlsruhe UAC München ACC | | | | | X | tactically given descend already close to optimum, ending on downwind abeam the airport (DM425) at FL090 | Plannable CDO-Profiles will be published, one starting at ELMOX in FL320-370, one starting at LEVBU at FL250-270 to increase predictability of descend profile for both pilots and ATCOs | 02FEB17 | all flights (trial with DLH only ongoing for CDO starting at ANORA) | earlier implementation planned, had to be postponed due to delay within publication process. Outside of ODP timeframe but all preparations continues for the publication. Permanent implementation planned. | |
| | | | DEM-004-03 | KORED via NUNRI | Geneva ACC Zurich ACC Munich ACC | | X | | | | Handover from Marseille to Geneva: CFL Handover from Geneva to Zurich: FL320 Handover from Zurich to Munich: FL270 | Handover from Geneva to Zurich at CFL Handover from Zurich to Munich at FL310 | 15OCT15 | all flights | Permanent implementation of ODP improvements. CDO-procedure within München ACC delayed due to issue in separating flights to inbounds from the south. München ACC will start a new trial in 2016. | |
| | | | DEM-004-04 | ALOSO - SODRO - ARMUT – LULAR | Munich ACC | | X | X (CDO starting LULAR) | | | FL230 from FRK to RDG when RWY26 in use | FL250 instead of FL230 from FRK to RDG when RWY26 in use CDO-Procedure starting at | 17SEP15 | authorized users only | Implementation for authorized users only, extension to all flights foreseen for 02FEB17 | |

| Scenario ID | Exercise Title / Airport | Exercise ID | Demonstration ID | Routing | Relevant ATC Units | Fast Time Simulation | Tactical Live Trials | Operational Flight Trials | | Public Live Trial | todays situation | ODP trial description | Time of trial | Participant | Remarks | Deviation from DP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | LULAR for RWY08 | | | | |
| | | | DEM-004-05 | NAPSA | Vienna ACC Munich APP | | | X | FMS coding for authorized users only | | An operational flights trial, involving selected aircraft operators only. The procedure is usable for landing direction 08 only. Aircraft are transferred from Vienna ACC directly to Munich Approach, the level restrictions are intended to increase the predictability of the aircraft during descend. | An improvement of the STARs under trial is being evaluated. The aim is to find a filable procedure that might be used for both landing directions | NOV 2014 - 26MAY16 | DLH | There will be further investigations on how to integrate the CDO in the Free Route Airspace. | |
| | | | DEM-004-06 | SODRO | Karlsruhe UAC München ACC | | X (modified transfer) | | | | Handover from Rhein to Munich: 25 NM prior SODRO at FL320. | Handover from Rhein to Munich 15 NM prior SODRO at FL320 (shift by 10 NM). | implemented since 17SEP15 | all flights (modified transfer) | permanent implementation since 17SEPT15. | |
| SCN-0103-005 | Strasbourg (LFST/SXB) | EXE-0103-005 | DEM-005-01 | Flights from Amsterdam | Brussels ACC Maastricht UAC Reims ACC | | Trial cancelled | | | | flights are subject to a level capping at FL230 | Raise of level capping, to allow flight in upper airspace (no CDO procedure) | no longer forseen | | City pair EHAM-LFST via GTQ: seen the effort required, the possible confusion for only 4 flights a week and the fact that there is no guarantee for permanent implementation, the partners decided to withdraw that flow from ODP. | X |
| | | | DEM-005-02 | EPL | Paris ACC Reims ACC Strasbourg APP | | X (higher CFL) | | | X (CDO) | Level Capping at FL250 | Raising of level capping to FL290 Late top of descend Publication of CDO-procedures starting at BERUG | 16JAN-31MAR16 (the late top of descend only on weekend, the CDO-procedures to remain in use) | all flights | | |

| Scenario ID | Exercise Title / Airport | Exercise ID | Demonstration ID | Routing | Relevant ATC Units | Fast Time Simulation | Tactical Live Trials | Operational Flight Trials | | Public Live Trial | todays situation | ODP trial description | Time of trial | Participant | Remarks | Deviation from DP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCN-0103-006 | Stuttgart (EDDS/STR) | EXE-0103-006 | DEM-006-01 | ABESI | Zurich ACC | | X | | | | Handover from Milano to Zurich: ABESI at FL320 Handover from Zurich to Langen: ARSUT descending FL120 out of FL140 | on paper none since Milano is not part of ODP, it is intended to raise the handover from Milano by individual coordination | 28 and 29 NOV2015 | all flights | | |
| | | | DEM-006-02 | KORED | Geneva ACC Zurich ACC | | X | | | | Handover from Marseille to Geneva: CFL Handover from Geneva to Zurich: KORED at FL280 Handover from Zurich to Langen: ARSUT descending FL120 out of FL140 | Handover from Geneva to Zurich at CFL | 28 and 29 NOV2015 | all flights | possible during MIL OFF only | |
| | | | DEM-006-03 | LUPEN | Reims ACC Langen ACC | | X | | | | During military activity in France handover from Reims to Langen LUPEN at FL160 Outside of military activity handover from Reims to Langen LUPEN at FL220 | Handover from Reims to Langen LUPEN at FL240 (outside of military activity)<br><br>Will not be trialed because DSNA decided to have it outside of ODP and in FABEC VFE | in progress | all flights | | X |
| SCN-0103-007 | Vienna (LOWW/VIE) | EXE-0103-007 | DEM-007-01 | GAMLI | Karlsruhe UAC Vienna ACC | | | | | X | Transfer from B1-Sector to N1-Sector (near waypoint OGRUB) at FL290 Transfer from N-Sector to LOWW-Approach (at waypoint BARUG) at FL170 | A CDO-STAR starting at NEMAL is published containing level restrictions Handover from B2-sector to N1-sector will take place descending FL310 out of FL330 | starting 03MAR2016 | all flights | permanent implementation | |
| | | | DEM-007-02 | VENEN | Karlsruhe UAC Vienna ACC | | | | | X | Handover from Rhein to Vienna at FL330 Handover to Vienna | Traffic will be handed over from Rhein to Vienna at CFL. Handover to APP Vienna at | starting 03MAR2016 | all flights | permanent implementation | |

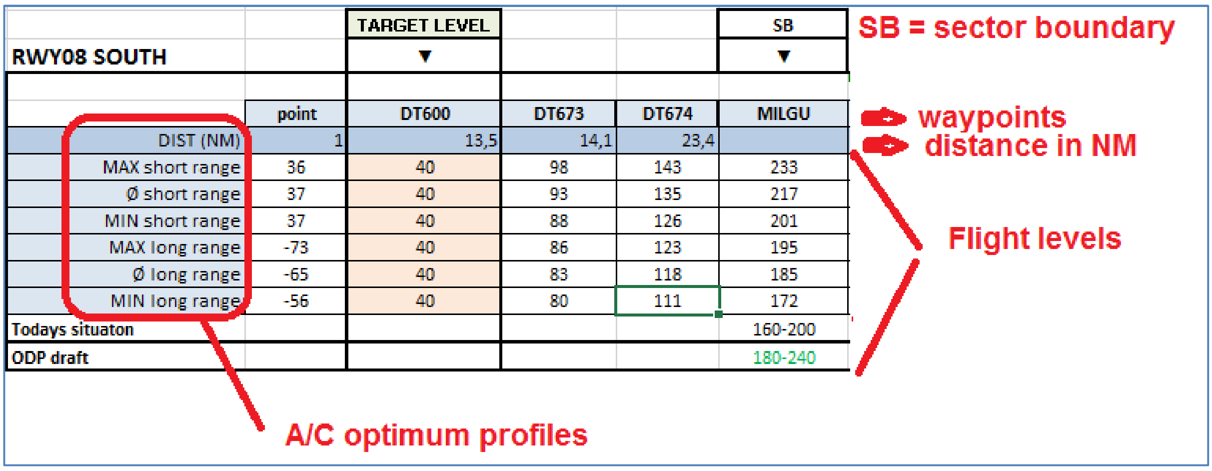
| Scenario ID | Exercise Title / Airport | Exercise ID | Demonstration ID | Routing | Relevant ATC Units | Fast Time Simulation | Tactical Live Trials | Operational Flight Trials | | Public Live Trial | todays situation | ODP trial description | Time of trial | Participant | Remarks | Deviation from DP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Approach at FL170 | MASUR remains unchanged | | | | |
| SCN-0103-008 | Zurich (LSZH/ZRH) | EXE-0103-008 | DEM-008-01 | BLM | Reims ACC Zürich ACC | | | | | X | 9 NM prior BLM at FL190 or above Additional restriction 6.5 NM prior BLM Handover from Reims to Zurich BLM at FL190 | The restriction is shifted to 13 NM prior BLM at FL190+ The restriction at 6.5 NM prior BLM is removed | 03NOV2016 | all flights | permanent implementation (03.11.2015) | |
| | | | DEM-008-02 | GUDAX | Geneva ACC Zürich ACC | | | X | authorized user only, Company-NOTAM | | Handover from Marseille to Geneva at FL300/320 Handover from Geneva to Zurich at GUDAX FL220 | Handover from Marseille to Geneva higher after individual coordination Handover from Geneva to Zurich GUDAX descending FL260 out of FL280 | 30APR/ 01MAY16 | all SWR A320 flights | | |
| | | | DEM-008-03 | LAMGO | Karlsruhe UAC Langen ACC Zürich APP | | X (modified transfer) | X | Company-NOTAM | | Handover from Rhein to Langen LAMGO at FL250 Handover from Langen to Zurich at IBINI at FL150 | Handover from Rhein to Langen 20 NM prior SUL at FL250 (shift by 10 NM) Speed 250 at IBINI RILAX at FL110 | 17SEP15 (modified transfer) finished 05OCT15 for one week (speed limit) | all flights (modified transfer) SWR (speed limit) | permanent implementation (except speed limit) | |
| | | | DEM-008-04 | TEDGO | Langen ACC Zürich APP | | | X | Company-NOTAM | | Aircraft often arrive with too much energy. Handover from Langen to Zurich at IBINI at FL150 | at RILAX speed limit 250KT at IBINI and EMKIL | 05OCT15 for one week | SWR | | |

**Table 12: Overview of complete ODP Demonstration activities**

#### 4.2.2.1 WP 2 considerations based on "ODP Trial Descent Profile Calculator" and input from WP 1 results

The calculator is a guidance tool for an approximate calculation of an optimum profile based on WP1 delivery calculated to gradients. This tool enabled the ODP development team to cross check the optimum profiles and the current profiles against the ODP optimised profiles. It is for guidance only and becomes unrealistic the greater the distance gets from the aerodrome.

The following figure shows a sample from the ODP Trial Descent Profile Calculator for EDDT CDO for RWY08 South. The complete calculator can be found as separate reference [20].



| RWY08 SOUTH | | TARGET LEVEL ▼ | | | SB ▼ |
|---|---|---|---|---|---|
| | point | DT600 | DT673 | DT674 | MILGU |
| DIST (NM) | 1 | 13,5 | 14,1 | 23,4 | |
| MAX short range | 36 | 40 | 98 | 143 | 233 |
| Ø short range | 37 | 40 | 93 | 135 | 217 |
| MIN short range | 37 | 40 | 88 | 126 | 201 |
| MAX long range | -73 | 40 | 86 | 123 | 195 |
| Ø long range | -65 | 40 | 83 | 118 | 185 |
| MIN long range | -56 | 40 | 80 | 111 | 172 |
| Todays situaton | | | | | 160-200 |
| ODP draft | | | | | 180-240 |



*Figure 15: "ODP Trial Descent Profile Calculator" Example with comparison between today's situation and ODP trial based on WP1 delivery with description*

### 4.2.3 AMAN support for CDO (WP3)

The purpose and the objective of WP 3 "AMAN Support for CDO" was to analyse the applicability of existing AMAN / XMAN functionalities for Continuous Descent Operations.

As a result of this assessment requirements for future developments and enhancements for AMAN / XMAN systems have been collected which would further improve the system support for CDO operations.

These investigations were planned with the emerging XMAN implementations for Frankfurt and Munich airports and were therefore targeted on ODP demonstrations for Frankfurt and Munich arrivals.

#### 4.2.3.1 AMAN / XMAN Tool Description

Arrival Management Systems (AMAN) are well established ATC arrival planning tools which are already in operation for the main hubs in Europe. Depending on the dimensions of the TMA and surrounding airspace they plan the sequence of the arrival traffic in a horizon of about 50 to 100 NM.

Extended Arrival Management Systems (XMAN) constitutes a newly developed SESAR Solution which starts to be rolled out for the main hubs in Europe. XMAN extends the planning horizon into the airspace of adjacent ATS units to about 200 NM or even beyond. It provides controllers in the adjacent ATS units with relevant arrival information for the arrival flights (e.g. Time-to-lose (TTL), Speed advice) to support the correct sequencing of the flight as calculated by the XMAN System. This sequence generally matches the most efficient average arrival profile with required capacity.

### AMAN/XMAN Support for Frankfurt Arrivals:

An AMAN System for Frankfurt arrivals is already established for more than 10 years. It plans the arrival sequence within the Langen FIR in a horizon up to 100 NM. The implementation of XMAN with extension of the planning horizon into UAC Maastricht and UAC Karlsruhe airspace was planned for 2015, but was then shifted into the second half of 2016. Therefore XMAN for Frankfurt arrivals was not in place in order to support ODP trials for Frankfurt arrivals with adjacent ATS units.

This is a deviation from the A1 Demonstration Plan and proposal and already communicated in A2 Demonstration Plan 2nd review edition.

### AMAN/XMAN Support for Munich Arrivals:

An AMAN System for Munich arrivals is established for several years. It plans the arrival sequence within the Munich FIR in a horizon up to 100 NM. The implementation of XMAN with extension of the planning horizon into ACC Vienna airspace for arrivals via NAPSA was realised in 2009 within a horizon of about 100 NM: Controllers in the exit sectors of ACC Vienna receive arrival information (TTL) and can act accordingly. XMAN was also implemented with UAC Karlsruhe as of April 28th, 2016, within a horizon of about 100 NM for specific arrival flows from the west and northwest through DKB and GESLU. Karlsruhe Controllers receive TTL information to act on the flights, if necessary. This is shown in the following figure, where the 100 NM planning horizon reaches about 50 NM into UAC Karlsruhe airspace. For Munich arrivals therefore some support through the AMAN/XMAN System was available for ODP trials.

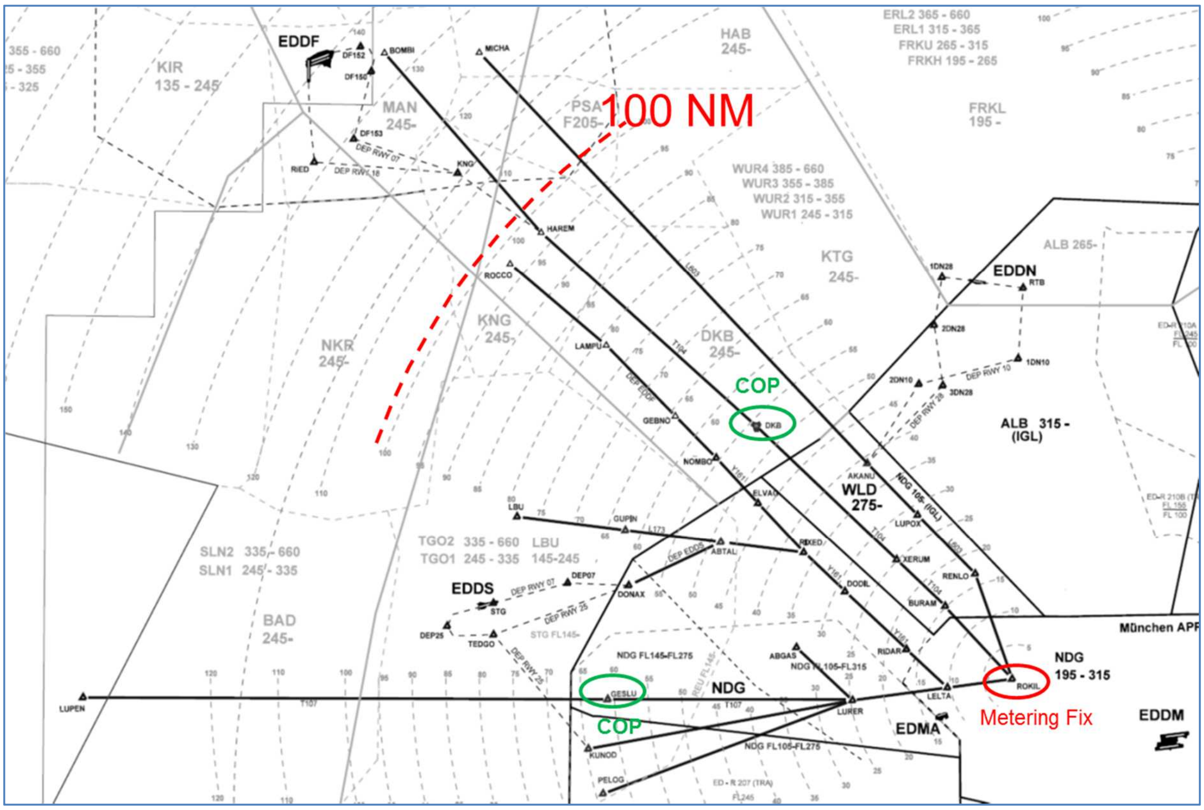



*Figure 16: Planning horizon of 100 NM of XMAN Munich projected on the airspace of ACC Munich and UAC Karlsruhe; also the relevant COPs for the arrival flows are shown.*

### 4.2.3.2 XMAN support to ODP Trials

With the available XMAN implementation for arrivals to Munich the focus was on the support of the Demonstration Exercise EXE-0103-004 – Munich with the arrival flows into Munich via

- NAPSA (ACC Vienna), and
- ELMOX/DKB (UAC Karlsruhe)

The objective was to

- assess, if and how the existing AMAN/XMAN functionalities (with the current 100 NM planning horizon) could be used as a support tool for conducting ODP operations
- derive future requirements for the AMAN/XMAN tool for enhanced system supported ODP operations
- specify concrete future improvements for the ACC Munich – ACC Vienna and ACC Munich – UAC Karlsruhe interfaces related to XMAN

The geographical horizon of the XMAN tool is shown in the following figure with the related arrival flows which were under consideration and trial for optimized descent profiles. Arrival information was available through XMAN messages in the adjacent ACC Vienna and UAC Karlsruhe. This information, conveyed as Time-to-lose (TTL) for individual flights, was to be assessed in terms of usability for decisions related to ODP operations.

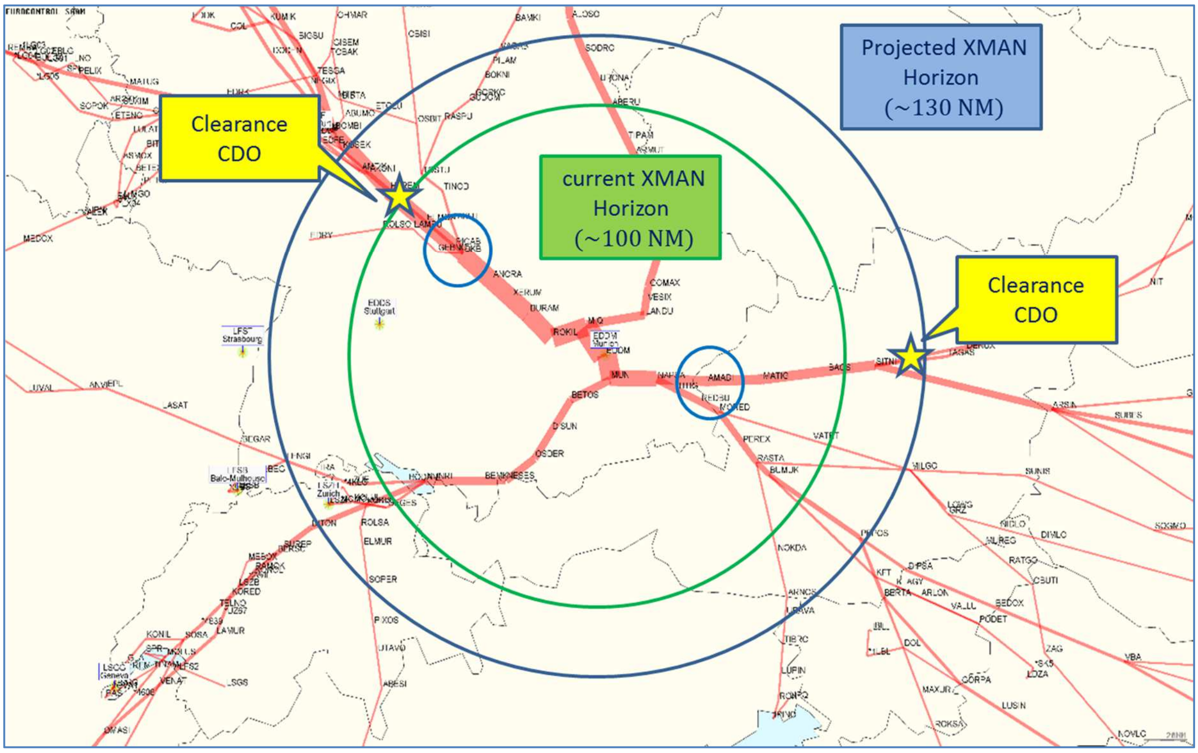



*Figure 17: Arrival flows into Munich with current (100 NM) and future projected XMAN horizon (130 NM) superimposed. Current decision points for ODP/CDO clearance are not fully covered with the current set-up.*

Standard arrival procedures and profiles are usually designed in order to optimise the arrival capacity and are applied in order to maintain highest capacity values. ODP or CDO operations will be usually triggered when there is enough capacity available, which would then also allow for better individual flight efficiency. Availability of related information is important to be able to make an informed decision.

## ODP project findings:

The following findings have been identified:

- Appropriate information tools and/or data provision with a look-ahead capability of the predicted arrival situation at the destination airport (and the related flow to the arrival metering fix) is desirable. The decision for clearing a CDO or an optimized descent profile is strongly related to the knowledge of the arrival situation and capacity at the arrival airport.
- Current XMAN/AMAN planning horizon of about 100 NM is generally too small to use the calculated delay information (Time-to-lose) for an assessment of ODP or CDO operations, since the decision point to trigger ODP/CDO is usually in the range of 100 – 150 NM (s. Figure 17).
- Nevertheless, TTL values can be used as an indication if ODP/CDO can be cleared or should not be cleared or not be maintained, because TTL values precisely reflect the current delay situation at the arrival airport which is a measure of current capacity

situation at the arrival airport. This means, XMAN could serve as a simple automated (collaborative) decision tool.

- A threshold of TTL values of about 10 minutes can be taken as an indication for a dense and capacity constrained situation at the arrival airport, which may be close to the situation where holdings have to be applied. In turn this is a criteria for a preference for normal arrival procedures and no ODP/CDO operations.
- ODP/CDO procedures and XMAN procedures have a potential mutual dependency. A clear description and possible priorities of these procedures need to be laid down on the LoA between the concerned ATS units.

**Requirements:**

From these findings the following requirements for future enhanced AMAN/XMAN support for ODP/CDO operation have been derived:

- AMAN/XMAN planning horizon needs to be extended to at **least 130 NM** in order to cover the Top of Descent (TOD) of flights and the "decision horizon" to clear ODP/CDO
- A further **extension of the AMAN/XMAN planning horizon up to the entrance sector of the flight in the upstream ATC unit** (e.g. to 200 NM) would improve the usability of the XMAN information for ODP/CDO clearances considerably
- For the sector responsible for the ODP/CDO clearance it could be helpful to have enriched information of the **arrival situation at the destination airport**, e.g. for the concerned flow, in order to increase the confidence for a decision for ODP/CDO clearances.
- A more sophisticated **traffic prediction tool, including a complete view of the arrival situation at the destination airport, and with CDM capability** for e.g. ODP/CDO operations would be desirable for the supervisor position of the upstream ATC unit

#### 4.2.3.3 Future XMAN Evolutions

The ODP Trials will make a contribution to improve the AMAN/XMAN System. Future steps will be taken to completely roll out the SESAR Solution for Extended Arrival Management.

In view of the collected requirements as presented above the following recommended solutions are expected and partly already planned to be developed and implemented:

- Extension of the AMAN/XMAN planning horizon for Munich to 130 NM in 2016
- Further extension of the XMAN/AMAN planning horizon for Munich to 200 NM in 2017
- Full implementation of XMAN/AMAN with planning horizon of 200 NM for Frankfurt
- Export of the complete view of the arrival situation as planned by the AMAN/XMAN System to upstream ATC units
- Development of an XMAN Information Portal with enhanced information provision to all concerned ATC units

These next steps to improve the AMAN/XMAN system in general and to improve the AMAN/XMAN support to ODP/CDO operations in particular will be taken in the next 2 years. They are related to an inclusion of more surveillance sources to pick up arrival flights earlier for extending the planning horizon and a general update of the XMAN functionality.

Given the current practice, that descents are generally initiated about 30 to 80 NM earlier for the main airports studied in ODP compared to an optimum descent profile, a tool support to allow for more CDO clearances or optimised descent profiles is desirable. One option could be to further develop XMAN/AMAN to give relevant information to ATCOs in order to support the most efficient arrival procedure which is feasible for a given capacity situation at the concerned TMA/Airport, thereby reducing the number of early descents.

A complete view of the arrival situation could be provided to upstream ATS units by introducing WebServices to export sequence displays which are already used at the local ATS unit. An example of this display is provided in Figure 18 (2nd separate window).

A future development would concern a complete XMAN Information Portal based on WebTechnology which would provide the relevant arrival information of various airports to all concerned actors.

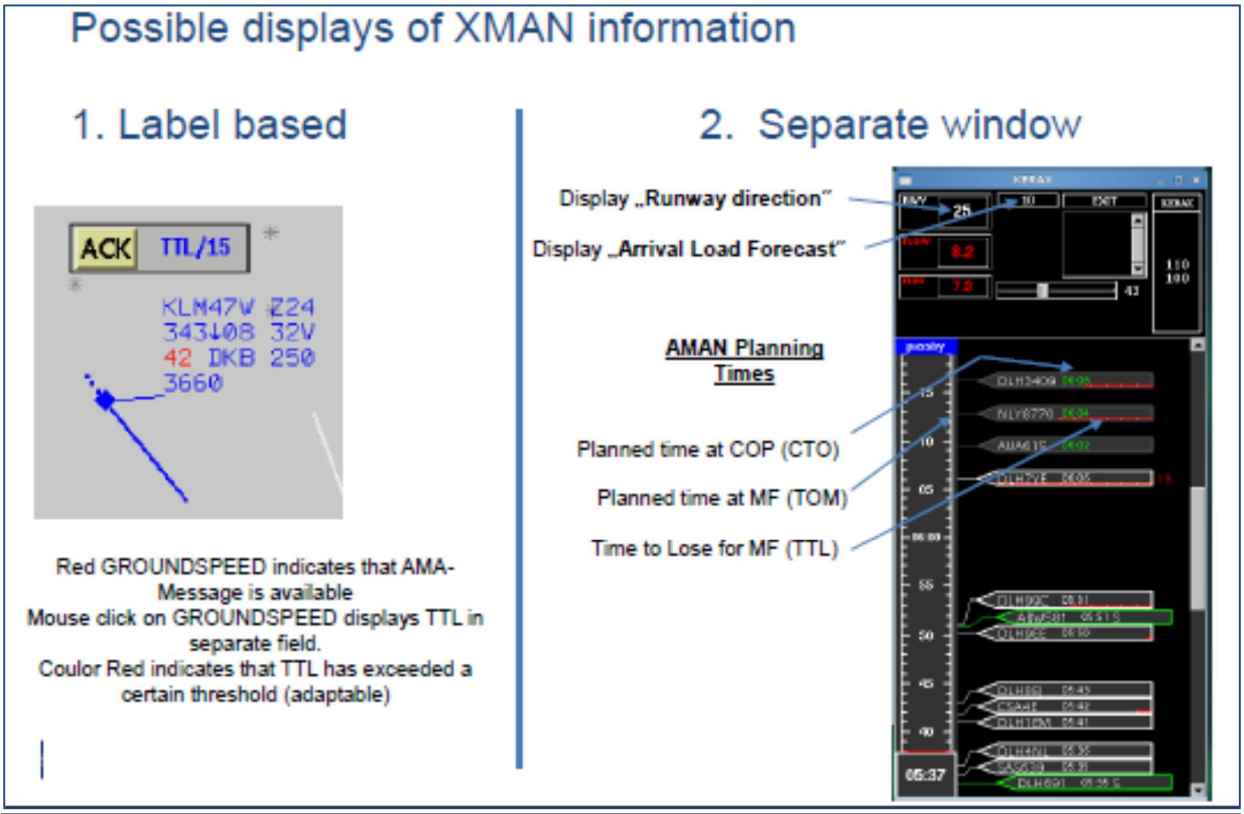



*Figure 18: Currently used displays of XMAN Information: 1. Individual flight TTL display in the a/c label. 2. Complete arrival sequence display (can be exported as separate window). The latter may be a solution also for upstream ATS units.*

### 4.2.4 Safety Assessments (WP6)

In order to ensure a smooth and timely accurate safety process, the Work Package 6 (Safety) Leader together with the ODP members aim for the following safety documentation structure and strategy.

This WP 6 Safety document delivery is based on the agreement with Serge Bagieu (Programe Manager SESAR ODP) and was confirmed at the Technical Kick-off Meeting dated January 15th 2015. No further delivery, post-assessment or analysis is needed within the ODP project for Safety.

The objective of Safety Management in ODP was to capture and define all activities and plans needed for high level safety documentation (Common Part) on the changes introduced for the various scheduled ODP Demonstration Exercises (for any kind of trial or exercise, e.g. operational live trial, or tactical trial, or even public live trail).

All ANSPs and Airline Operators assessed and documented their own results according to their national regulatory requirements (e.g. NSA or EASA). All results are summarised in the Common Part. The scope of hazards found in this Common Part will be a summary of all locally identified hazards as well as any existing hazards related to multi-ANSP operations linked to the ODP arrival flows.

The scope of change to be considered by safety documentation is the optimising of the arrival flows for the above mentioned airports and their procedure or route design including personnel, technical equipment, procedures and ATM stakeholders' interfaces as follows:

- Geographical scope: Arrival flows starting e.g. at cruising level to TMA level

  Interfaces with other organisational entities or changes
- Personnel scope: All operational personnel affected by the change
- Procedural scope: All affected airspaces and LoAs

  All new or modified procedures and working methods

  All changes to procedures at the interfaces between ATM stakeholders
- Technical scope: All changes to technical systems

  All changes to technical interfaces between ATM stakeholders

The Safety Documentations and local Assessments can be found in reference [18] and [19].

## 4.3 Deviations from the planned activities

The following Demonstration Exercises deviate from the A2 Demonstration Plan 2nd review edition 00.01.01, 30/10/2015.

| Scenario ID | Exercise Title / Airport | Exercise ID | Demonstration ID | Routing | Relevant ATC Units | Remarks | Deviation from DP |
|---|---|---|---|---|---|---|---|
| SCN-0103-002 | Frankfurt (EDDF/FRA) | EXE-0103-002 | DEM-002-02 | EMPAX | Karlsruhe UAC, Langen ACC | publication for all flights in preparation but performance analysis is outside of ODP timeframe. | X just publication will be outside of ODP timeframe |
| | | | DEM-002-04 | GIMAX | Karlsruhe UAC München ACC | effective of LoA from 18AUG 2016, but unfortunately outside of ODP performance analysis timeframe. | X |
| SCN-0103-004 | Munich (EDDM/MUC) | EXE-0103-004 | DEM-004-02 | ELMOX-DKB | Karlsruhe UAC München ACC | earlier implementation planned, had to be postponed due to delay at NSA. Unfortunately outside of ODP timeframe but all preparations continues for the publication. Permanent implementation planned. | X (publication outside ODP timeframe) |
| SCN-0103-005 | Strasbourg (LFST/SXB) | EXE-0103-005 | DEM-005-01 | Flights from Amsterdam | Brussels ACC Maastricht UAC Reims ACC | City pair EHAM-LFST via GTQ: seen the effort required, the possible confusion for only 4 flights a week and the fact that there is no guarantee for permanent implementation, the partners decided to withdraw that flow from ODP. | X |
| SCN-0103-006 | Stuttgart (EDDS/STR) | EXE-0103-006 | DEM-006-03 | LUPEN | Reims ACC Langen ACC | This flow was already implemented and can't be further improved between Reims ACC and Langen ACC. The Reims ACC AoR part will be further improved and is part of the FABEC VFE project. | X |

*Figure 19: List of Demonstration Exercises that deviate from A2 Demonstration Plan 2nd review edition*

After the project team started to work on the details and development of the various Demonstration Exercises some tasks or internal deliverables didn't make sense (expensive, no real benefit). As a consequence the following deviations from the A2 Demonstration Plan, 2nd review edition can be listed as follows:

- Communication Plan: List of deviations of communication activities showing all not performed press releases or other communication activities proposed in "A2 Demonstration Plan 2nd review edition" document can be found in chapter "7 Summary of Communication Activities"

# 5 Exercises Results

## 5.1 Summary of Exercises Results

The results of the Demonstration Exercises are summarised in the following tables. Each result is compared to the concerned success criteria identified within the Demonstration Plan per Demonstration Objective. The results are assessed according to the following criteria:

- OK: the concerned result achieved the expectations (expressed by means of the success criteria associated to the Validation Objective);
- NOK: the success criteria associated to the Validation Objective should be further investigated, in the sense that the concerned results do not achieve the expectations or no clear results are obtained.

The following table shows the results per objective, more details about the savings can be found in Table 13.

| Objective ID | Description | Success Criterion | result |
|---|---|---|---|
| OBJ-0103-001 | Flight Efficiency of Cross-Border CDO<br>It is to be demonstrated that wherever possible published CDO provide higher overall efficiency than existing procedures.<br>The improved efficiency positively affects fuel burn and $CO_2$ emission. | To demonstrate benefits for better flight efficiency (fuel burn saving and less $CO_2$ emission), the ODP Team used the following solutions:<br>• optimizing cruising levels<br>• reducing level-offs<br>• speed constraints to improve energy mgmt.<br>• changing transfer conditions (e.g. later ToD, higher hand over level)<br>• Usage of "DESCEND WHEN READY (continuous descent)<br>• Published descend profile procedures / CDOs | OK |
| OBJ-0103-002 | Capacity related to Cross-Border CDO<br>It is to be demonstrated that the airspace Capacity is not negatively affected by Cross-Border CDO. | To demonstrate no decrease of capacity in Cross-Border CDO operations. | OK |
| OBJ-0103-003 | Operational Feasibility of Cross-Border CDO<br>It is to be demonstrated that Cross-Border CDO provide a sufficient feasibility for operational usage. | To demonstrate that there is no adverse operator feedback regarding Cross-Border CDO operations. | OK |
| OBJ-0103-004 | Operator Workload related to Cross-Border CDO<br>It is to be demonstrated that the execution of Cross-Border CDO will not negatively affect operator workload and | To demonstrate, that the designed Cross-Border CDO is not negatively affecting operators workload and situational awareness of both ATCOs and flight crews and can be applied | OK |

| | | | |
|---|---|---|---|
| | situational awareness of both ATCOs and flight crews. | most time of the day up and ideally 24/7. | |

Table 13: Summary of Demonstration Exercises Results

## 5.2 Choice of metrics and indicators

The overview in "Table 14: Summary of metrics and indicators" provides an overview of all metrics and indicators used in the framework of ODP demonstration activities.

The results of each demonstration per KPA and KPI can be found in Table 15.

## 5.3 Summary of Assumptions

There are no issues to be reported regarding to the assumptions specified in the Demonstration Plan. However during the execution of the demonstration exercises and preparation of assessment methods possible factors that have or may have a major impact on the uncertainty of the result have been identified. Those are listed below:

**Demonstration exercises executions:**

- Weather conditions should allow try to take place
- ATCO and/or Pilots should be briefed
- Traffic windows should be found
- List of agreed flights participating the trials is available (for some trials at least)

**Assessment methods:**

- Wind speed and directions
- Air situational circumstances
- Human factors (ATC, aircraft operating crew)
- Aircraft type (airframe and engine) depending performance
- Airline operator specific parameters (e.g. cost index, procedures)
- Actual operational aircraft weight

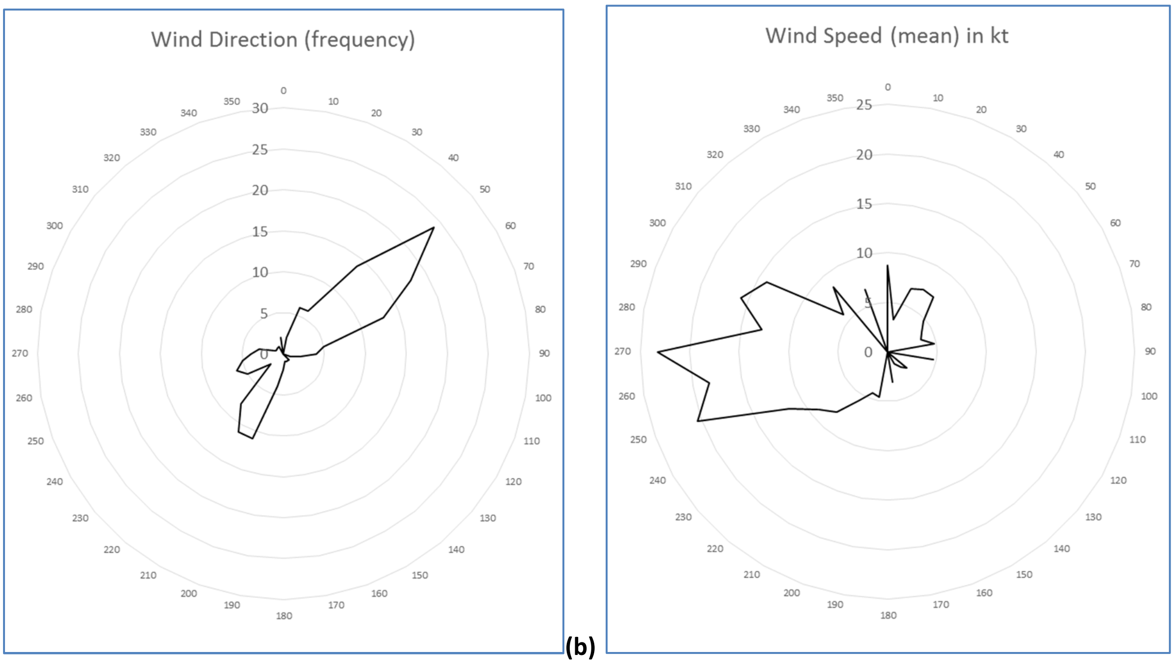
Although those factors had been identified, those could only be addressed in the project to some extent due to limited scope and resources of the project. However, a sensitivity analysis has been conducted by TU Dresden that that gives an idea on how several of the variables mentioned above may influence the fuel burn and length of an optimal descent (CDO length). The analysis has been conducted for the last 200NAM before the final approach fix (FAF) for a reference trajectory of an A321-200 (Scenario 0) with scenario variants with off-sets of several parameters. The effects on changes in fuel burn and CDO length by varying the gross mass, the QNH at the arrival aerodrome, wind speed and air temperature are given in Table 15. These figures show on one hand the impact of those parameters on fuel consumption estimation and thus any probable assessment method on vertical flight efficiency. On the other hand variation of CDO length shows the impact on CDO length and thus the optimal descent flight path and guidance for probable procedures designs.

| Parameter | Variation (compared to Scenario 0) | | | | [] |
|---|---|---|---|---|---|
| **Delta Gross mass** | ***-20*** | ***-10*** | ***+10*** | ***+20*** | [%] |
| ***Delta fuel burn*** | -16.1 | -8.5 | +9.5 | +20.4 | [%] |
| ***Delta CDO length*** | -3.2 | -1.4 | +0.9 | +2.3 | |
| **Delta Temperature at field elevation** | ***-30*** | ***-10*** | ***+10*** | ***+30*** | [K] |
| ***Delta fuel burn*** | -3.9 | -1.1 | +2.1 | +5.6 | [%] |
| ***Delta CDO length*** | +9.2 | +3.3 | -3.2 | -10.0 | |
| **Delta QNH** | ***-20*** | ***-10*** | ***+10*** | ***+20*** | [hPa] |
| ***Delta fuel burn*** | +1.4 | +1.0 | -0.1 | -0.6 | [%] |
| ***Delta CDO length*** | -2.3 | -1.4 | +0.9 | +2.3 | |
| **Wind direction at field elevation** | ***N*** | ***E*** | ***S*** | ***W*** | [90°] |
| ***Delta fuel burn*** | -0.1 | -0.3 | -0.1 | -0.3 | [%] |
| ***Delta CDO length*** | -3.2 | -3.2 | +2.8 | +3.3 | |
| **Wind speed at field elevation** | ***10*** | ***20*** | ***30*** | ***40*** | [kt] |
| ***Delta fuel burn*** | 0.0 | -0.1 | -0.4 | -0.3 | [%] |
| ***Delta CDO length*** | -2.8 | -3.2 | -5.5 | -6.8 | |

*Table 14: Expected variation of fuel calculations based on the a sensitivity analysis by TU Dresden on approximately nine thousand aircraft trajectories within the descent phase (source [25])*

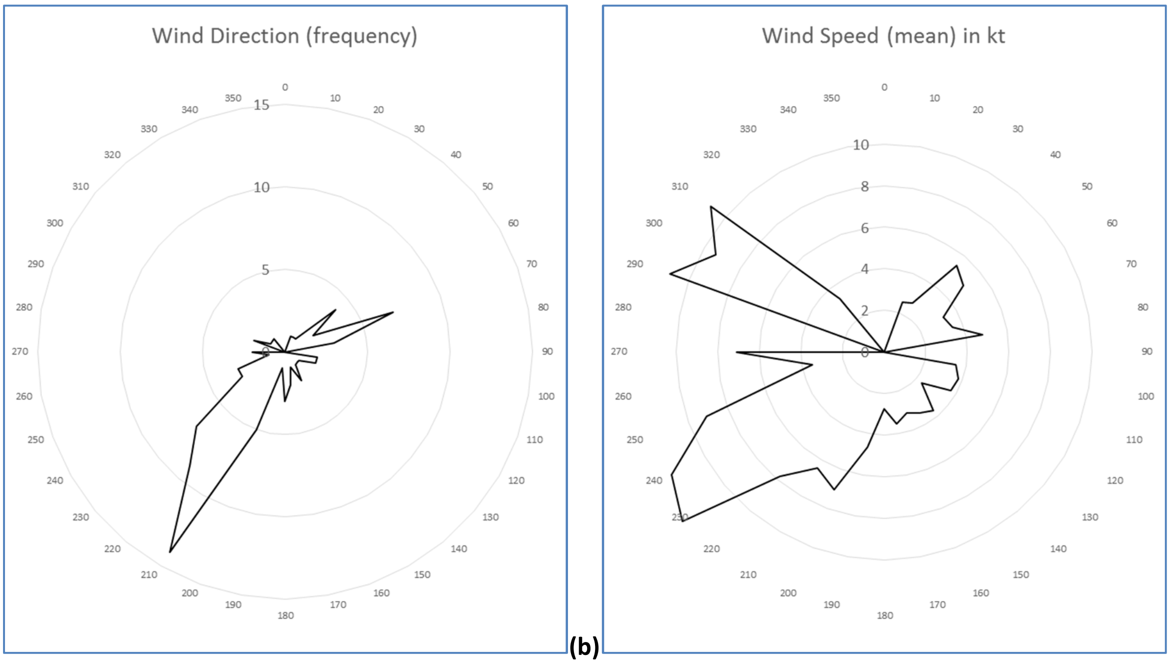
## Impact of Wind

During the preparation of the assessment methods it has become clear that wind speed and direction has a major impact for the assessment of efficiency. This has been exemplarily investigated for DEM-002-001 (1st and 2nd EMPAX-EDDF trial). As it can clearly be seen in Figure 20 and Figure 21 wind vectors vary highly for the two periods as well as compared to a longer time period of about 16 month (Figure 22).
Due to the complexity of this topic this could only be respected to some extent within this study. Albeit this is a major factor to the uncertainty of the efficiency assessment and should be kept in mind while interpreting the results.




**(a)** **(b)**

*Figure 20: Frequency of wind direction (hourly mean) (a) and direction depending mean wind speed (b) in 10 degrees steps for 08-13h (LT), 05th March till 01st April 2015 at aerodrome EDDF (1st trial period EMPAX-EDDF, DEM-002-01) based on DWD hourly samples*




**(a)** **(b)**

*Figure 21: Frequency of wind direction (hourly mean) (a) and direction depending mean wind speed (b) in 10 degree steps for 08-13h (LT), 24th August till 06th September 2015 at aerodrome EDDF (2nd trial period EMPAX-EDDF, DEM-002-01) based on DWD hourly samples*

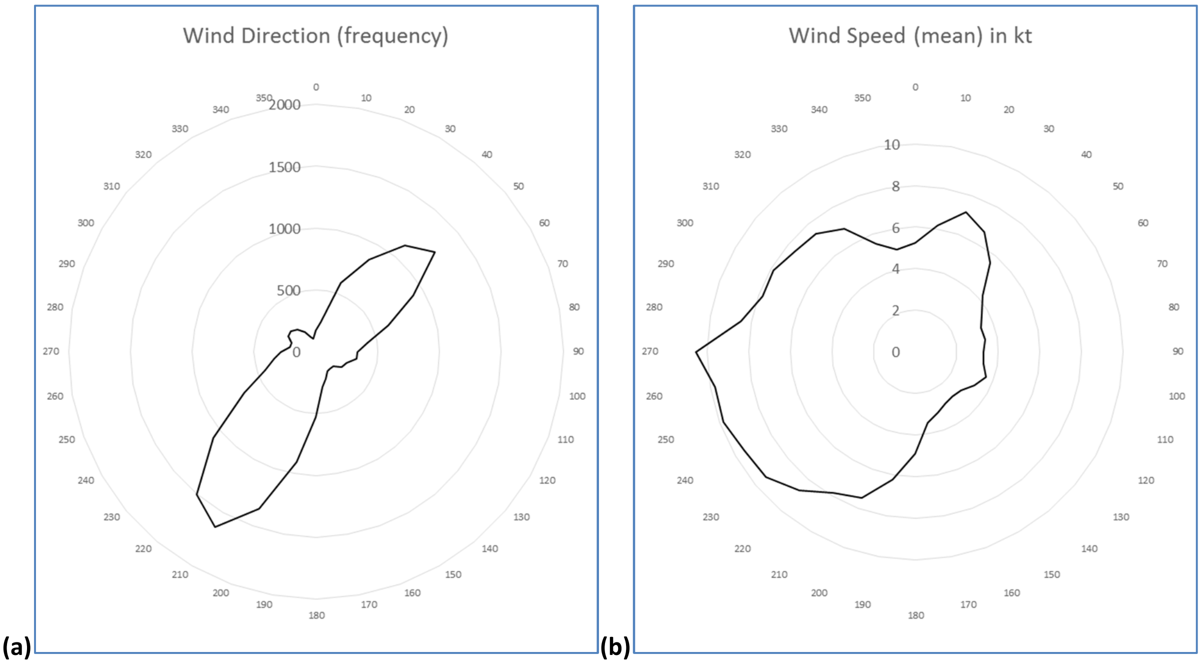



*Figure 22: Frequency of wind direction (hourly mean) (a) and direction depending mean wind speed (b) in 10 degrees steps for 01st October 2014 till 21st February 2016 (UTC) at aerodrome EDDF based on DWD hourly samples*

### 5.3.1 Results per KPA

Results per KPA for OBJ-0103-001 can be found in Table 15. All other Objectives are summarised as no measurable results in Table 13.

### 5.3.2 Impact on Safety, Capacity and Human Factors

For Safety content please check the Common Safety Document in REF [19] and for Capacity and Human Factors please check each demonstration exercises details in Chapter 6.

### 5.3.3 Description of assessment methodology

Regarding the assessment of Environmental Sustainability the project has been supported by SESAR EIA members from DFS.

#### 5.3.3.1 Trajectory based Analysis

Since information on fuel consumption is generally not directly available for ANSPs for legal reasons, analysis conducted by ANSP regarding fuel efficiency can only be based on trajectory (radar) or flight plan information.

Trajectory based analysis are based on geometric measures as extensively done for horizontal flight efficiency in general (see [26] in annex 1 section 1 and 2 paragraph 2 Environment) and in the framework of an ongoing German working group between several Airlines and DFS, that has been working on an improved fuel efficiency with German Airspace since summer 2013 (AG Optimiertes Fliegen). During the period of the ODP project it has become clear, that a single geometric indicator for vertical flight efficiency is difficult to define. Although several parameters were tried to be defined, they all lag the possibility to quantify fuel consumption.

Further the uncertainty of monitoring towards a qualitative assessment based on pure geometrical criteria could not be fully estimated.

Due to the fact of several influences, as described at the beginning of chapter 5.3, it has been concluded during the project period, that adequate performance indicators can only be based on fuel data itself.

One approach would be to use the widely known BADA model developed by Eurocontrol. However, despite the uncertainties due to the underlying data itself, such as the limited number airframe engine combination for each aircraft, for instance, using pure BADA data inherits similar problems as a geometric approach, in case one tries to apply this on actual aircraft trajectories. This becomes immediately evident when applying a trajectory based analysis based on BADA as it has exemplarily conducted for DEM-002.01 (EMPAX to EDDF, see section 6.2.3.1.1.1.4).

Therefore, two possible approaches have been followed:

- Derive information on fuel consumption derived from flight plan data using SAAM/NEST for instance
- Assessment on actual fuel data

A third approach that had been concentrated on from the start of the project, was to derive fuel information based on aircraft trajectories, using an advance method, taking additional information into account, such as actual atmospheric conditions, airframe engine combinations and actual aircraft weight. However, due to the development and implementation process, that had to be stretched several times, the tool did not become available for the ODP project.

### 5.3.3.2 Pre-Analysis

#### 5.3.3.2.1 Estimation of Vertical flight Efficiency using SAAM/NEST

EUROCONTROL NMD evaluation tool and validation methodology to estimate the potential benefit of the ODP solution scenarios:

SAAM (System for traffic Assignment & Analysis at Macroscopic level) is a European airspace design evaluation tool which is typically used by airspace planners and designers to improve airspace and sector capacity. It was used to model, simulate, analyse & visualise route network and vertical profile (cruise/descent profile constraints) developments for the SESAR ODP scenarios.

Each result was DEL-ODP A2 Demonstration Plan presented with a SAAM screenshot whereas the prior ODP scenario is shown as the red line, and represents the reference profile in relation to the scenario improvement proposed which is ODP solution scenario in green. Note where reference and ODP scenario are coincident the route will be marked in red.

SAAM Scenario Economy module is aimed at comparing route length, flight duration time, fuel consumption, CO2 and NOx emission of reference and solution simulated traffic samples.

This module is using a model derived from BADA model and data. This is a simplified model aimed at providing reliable and consistent results regarding airspace changes and reference/solution scenario comparisons.

Example for scenario economy results:

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 45 | 1155,681 | 44 | 191,245 | 55 | 22627,880 | 55 | 71502,430 | 54 | 456,059 |
| Equal | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 26 | -1317,092 | 27 | -185,619 | 16 | -12690,740 | 16 | -40102,130 | 17 | -237,787 |
| Total | 71 | -161,411 | 71 | 5,627 | 71 | 9937,140 | 71 | 31400,300 | 71 | 218,272 |

*Figure 23: BADA sample of scenario economy results*

EUROCONTROL NMD evaluation tool and validation methodology for the performance analysis:

The SAAM was used to analyse, assess and display the recorded live operational data.

The reference is given by the prior ODP situation shown as a red line and the ODP solution is given by the ODP proposal situation shown as a green line. Both the reference and the ODP solution situations are based on the live operational data as recorded by the Situation and Information Centres and the Airline Operations Centres respectively, taking into account daytime, day of the week, day of the year for the matching of flights to compare.

The matching rules are based on Flight identifiers such as:

- Origin,
- Destination,
- Aircraft Type,
- Callsign,
- Departure time within 1.5 hours.

Both the reference and solution recorded traffic samples were visually analysed by the SAAM tool by pair of matched flights which list of flights was provided to the consortium airline operators, and then the qualitative performance measurements were done.

In order to focus on the ODP solution scenario only, an individual measurement window was devised for each ODP trial in accordance with the local subject matter experts who supported EUROCONTROL NMD to identify the horizontal and vertical scales of the measurement windows.

An example for the measurement window with profile comparison

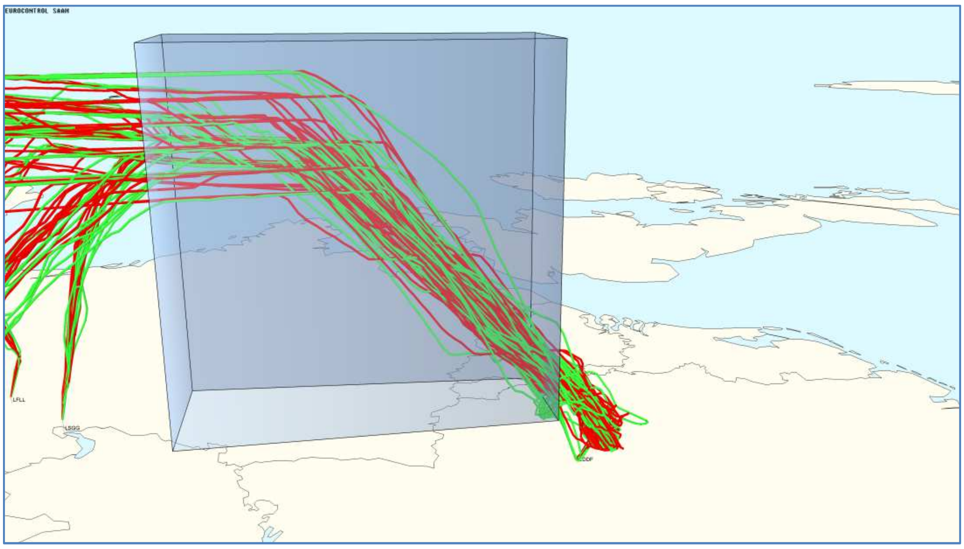


*Figure 24: An example for the 2D view of the measurement window*

### 5.3.3.2.2 Fast Time Simulations (FTS)

In the ODP project Fast Time Simulations were conducted using CAPAN and AirTOp[8].
The criterias for the FTSs basically vary from simulation to simulation and can be assessed on the basis of the following topics:

- Sector movements
- Workload
- Traffic density
- Capacity calculations
- Distance flown
- Further criteria for detailed evaluation
    - e.g. conflicts

For the FTS RIMET for example the processing was based on a Reference Scenario. Then through the operational input a step-by-step development guaranteed that all various areas of ATC are covered to reach the targeted optimized structure. Finally the results of the optimized simulation model will be compared with the Reference Scenario. More details on the method can be found in the Fast Time Simulation Report [13].

Beside RIMET the ARR flows to Vienna were simulated with CAPAN and details on the methods and simulation model can be found in Annex 2 of the final CAPAN report [14].

[8] AirTOp (Air Traffic Optimization) is an open and modular fast-time simulation platform that can be used in the context of Departure, En-Route, Approach simulations as well as for Airport Ground Movements studies.

### 5.3.3.3 Post Analysis

n/a

#### 5.3.3.3.1 Flight data based analysis (flight planning tool, Flight Data recorder information analysis, …)

##### 5.3.3.3.1.1 Methods used by Air France

ODP trial required the capability to study precisely the actual trajectory of the aircraft as well as planned trajectory. In order to answer the project need, AF developed a tool for trajectory analysis.

This tool is fed with flight planning data (coming from LIDO flight planning tool) and with actual data (coming from ACARS and ADS-B).

This tool allows to analyze in particular actual altitude, actual position (lat/long), actual overflight time of the aircraft, actual level off of the flown trajectory (time, distance and FL of level off). Further, it allows the user to compare it with planned data. On ODP trial on which AF was involved, the modification to be analysed was FL constraint on waypoint that was changed

Air France focused then the studies on altitude distribution evolution at the concerned waypoints.

**Concerning the Fuel assessment of ODP improvement:**

AF has no access to its FDR so can't perform complete study of Fuel Flow evolution or fuel burnt evolution before and after the trial. However, as shown by Swiss and LH, it is very difficult to come to a conclusion with those data as fuel burnt is influenced by wind, aircraft weight, aircraft speed, known constraint is the FMS…and thus, isolate savings coming from ODP is not that easy.

AF can have access to total trip fuel used per flight. However, on top of the limitations previously explained, actual trip fuel amount reflects also the fuel saved thanks to Nautical Miles savings (coming from QFU change and directs negotiation between pilots and ATCOs). For the flows on which AF was involved, it was a will not to mix the horizontal and vertical savings in order to value only the vertical change.

For fuel efficiency assessment, experts decided to use several different tools:

- LIDO – flight planning tool:
- Advantage: it allows the definition of a reference and an "ODP" profile that are comparable. You can define same wind, weight, speed and same horizontal profile in order to evaluate only the change introduced by the vertical profile. This method allows the calculation of average figure of fuel and time savings.
- Limitations: in the flight planning tool, it is not possible to define a constraint as "to be at FLXXX at WAYPOINT". So, descent has to be anticipated to a previous waypoint allowing the aircraft to be levelled at the targeted waypoint. Depending of the distance between those two waypoints, this could have an impact on the fuel assessment. This implied that fuel assessment comes with an error (please see the example on Vienna arrivals in chapter 6.7).
- Airbus aircraft performance tables:
    - Advantages:
        - validated table by manufacturers and table used by the pilots.
        - Common between airlines.
        - As in LIDO, it allows the definition of a reference and an "ODP" profile that are comparable.
    - Limitations:
        - there are marched tables so they give average figures

Further Details of this method used can be found from chapter 6 on for each demonstration exercise.

### 5.3.3.3.2 Monitoring based analysis (Omega/Aviaso, FODA)

#### 5.3.3.3.2.1 Methods used by SWISS

Due to the scope of the project being a large scale demonstration the following considerations have been made:

- The focus is not on single flights.
- Concepts and improvements need to be validated for entire traffic flows.
- Analysis of real measured flight data whenever the trial setup allowed it.

For the analysis, suitable filters have been used for each data analysis according to the particularities of the traffic flow (e.g. when pilots expect to receive long vectors or to join a holding, they will in most cases reduce the ROD and ask to reduce speed. When analysing the impact of an ODP improvement on a straight-in approach, flights subject to a high GCD versus GTD-ratio have to be disregarded).

Furthermore an optimised path for each flow has been determined. The least amount of descent fuel is burned when flying the optimum descent path only. This optimum path can normally not be achieved due to mandatory constraints (ATC, airport, noise, terrain etc.).The measured average crossing altitudes shall be compared to this optimised path.

In addition to fuel and flight path data, the following parameters influencing descents have also been measured and analysed in order to put the fuel analysis in perspective:

- <u>Type of aircraft</u> (e.g. A321 / A320 / A319) on a flow due to different engine idle settings: A larger aircraft model carries engines with a thrust rating delivering more power which in turn increases the fuel burn due to a higher idle setting. However, individual engine idle performance factors have not been considered.
- <u>Variance in GW</u> (gross weight) at TOD: Heavier aircraft fly longer descent paths (more NM) at a shallower angle which leads to=lower crossing altitudes at a given waypoint. If the optimised descent profile is based on a hard lower limit unknown to the FMS (ATC LoA, noise, terrain etc.), this means a higher probability for intermediate level-off leading to more fuel burn.
- <u>Average True Altitude</u> (TA): Comparing TA and PA (Pressure Altitude which correlates with FL) provides some basic indication about the comparability of the atmosphere during measuring periods, whereas PA represents ISA (International Standard Atmosphere) as incorporated in the design of altimeters.
    - (a) If atmosphere is warmer than ISA and/or QFF is higher than 1013.25hPa, TA is higher than PA.
    - (b) If atmosphere is colder than ISA and/or QFF is lower than 1013.25hPa, TA is lower than PA.

- Average Head- or Tailwind component: Normally, a flight facing headwind will aim to descend later than a flight being pushed by tailwind. Due to today's ATCO working habits, pilots are normally instructed to descend regardless of the wind conditions. When being instructed to descend by ATC before intercepting the FMS calculated profile, thrust has to be added during descent and the probability for an intermediate level-off is increased.
- Average CAS (calibrated air speed): CAS provides an indication of the kinetic energy at a certain waypoint. Faster aircraft with more energy "invested" before the measuring point can sustain longer periods at idle power during speed reduction and/or shallow descents with the result of achieving a potential fuel gain.

The fuel analysis provides measured gains or losses regarding 2 or more traffic and/or trial periods. They are established to evaluate the effect of the changes tried and/or implemented during ODP. These fuel figures are first of all trend indicators showing if the changes are in accordance with the project's objectives.

#### 5.3.3.3.3 Methods used by Lufthansa

One of the main focuses during the project has been on changing LoA's established between two adjacent sectors. All changes led to a more efficient profile and whence a greater flight altitude overhead the sector boundary during the descent. Changes could be permanent or runway/traffic dependent. Therefore not all of the arriving traffic could receive the more efficient profile. In order to find actual data for the ODP analysis, DLH's analysis tool, named OMEGA was used to find out any raise in average flight altitudes due to LoA changes.

During the FRAMaK result calculations, two similar flights (similar in terms of A/C type, daytime, etc.), one being the trial flight, were compared. However this method did not suit the ODP project. There are just too many variables of an aircraft's descent parameters to prove any fuel difference to a LoA change. Therefore DLH used a semi-theoretical approach in using the actual average altitude difference in the profile multiplied with theoretical fuel values taken out of the A/C operators performance handbook.

Generally an aircraft flying constantly at some higher altitude during the descent than before has stayed a certain distance longer at the last cruising level. This distance and the respective fuel used is calculated and compared with the same distance flown at a lower level which usually needs more fuel. The resulting fuel difference is the ODP gain. The last cruising level is the last level flight prior the new LoA waypoint, and the compared flight level is the first levelling altitude after the LoA waypoint. Both flight levels have not been changed by the ODP project. To calculate this distance the A/C type's corresponding descent angles were used, which have been results of ODP WP1.

By analysing the numbers of flights on the new average profile with regards to different A/C types we have been able to get a sum of the total fuel saved for a certain period due to the specific LoA change.

Error cross checks included that the average profile is well distributed amongst all fleets and that average weight and cost Index during descent did not change significantly during the course of the project. Besides the altitude difference between the old and the new profile had to be checked to be constant for the relevant portion of the descent. Otherwise the fuel numbers had to be corrected for.

#### 5.3.3.3.4 Trajectory based Estimation of Fuel Consumptions and Emissions

At the beginning of the ODP project it had been intended to use advanced algorithms of the so call Enhanced Jet Performance Model (EJPM). However, its requirement definition, procurement process and final integration has taken far longer than originally expected at the start-up of ODP. Currently a first usable version for all phase flights i.e. climb, cruise and descent is expected to be ready for testing by the end of September 2016. This implementation of the EJPM algorithms, call EJPM based Trajectory AnalySis tool (ETAS) will allow the calculation of fuel flow with a temporal resolution of 4s for trajectories monitored with FANOMOS. Additionally, the tool will be enhanced with algorithm for the estimation of various fuel combustion products including CO2 and NOx by the end of the year 2016. This will be followed by extensive model validation and verification of calculation results. It is the intention to use the model for follow-up analysis of the upcoming implementation of the EMPAX trial via PSA to Frankfurt (EDDF) and the trial ELMOX via DKB to Munich (EDDM).

#### 5.3.3.3.5 BADA / SAAM based analysis

The SAAM screenshots in each Demonstration Exercise of chapter 6 showing the CPR (correlated position report) recordings of a selected traffic by date or by consortium airline (most of the cases agreed with the local ANSP). Therefore the trajectories show a snapshot which was valid on the target date only. An overall benefits cannot be quantified based on a representative day. The recordings made by the airline operators may differ from the CPR recordings, because those measurement based on a different interrogation time (NM has an update in every 30 second) and the airline data was taken from each individual aircraft from the trial period which provide a higher accuracy. The only exceptional case was for Vienna whereas 15 seconds interrogation time was applied based on the request of the client.

In case of the CPR recordings were not complete or the long distance trajectories are significantly different in terms 2D profile due to environmental circumstances (e.g. wind), the trajectories are displayed within the measurement window only.

In some trial cases the measurement window had to be updated or adjusted due to the changes on the route network or due to the different distribution of traffic between the reference and the ODP period.

#### 5.3.3.3.6 FANOMOS based analysis

Despite the fact of uncertainties of geometrical analysis, it has been tried find some evidence for some cases. Thus gradient analysis has been conducted for the following flows:

- DEM-001-001 (Bale-Mulhouse)
- DEM-002-001 (Frankfurt)
- DEM-002-007 (Frankfurt)

Furthermore, flight-time within a defined spatial envelope has been measured to account for any possible effects in horizontal flight efficiency.

Additional analysis could not be conducted, since some features in FANOMOS are currently in final implementation. It is expected that the new FANOMOS release at DFS will be put into operation by the end of September/ beginning of October 2016. It will allow additional analysis functions such as flight phase detection (climb, cruise, and descent), detection of number and length of level segments and number of level changes during cruise for each flight. The detection criteria may be adopted as need by the user. It is intended to use the new functionality for the upcoming ODP implementations of the EMPAX flow via PSA to Frankfurt (EDDF) and the ELMOX flow via DKB to Munich (EDDM).

#### 5.3.3.3.7 Qualitative Assessments

##### 5.3.3.3.7.1 ATCO feedback

Table on Exercises and where feedback is available -> Reference to each flow chapter in 6

##### 5.3.3.3.7.2 Pilot feedback

SWISS has gathered pilot feedback with help of a questionnaire during the following trials: SCN-0103-008 EXE-0103-008 DEM-008-02 (via GUDAX), SCN-0103-008 EXE-0103-008 DEM-008-03 (via LAMGO), SCN-0103-008 EXE-0103-008 DEM-008-04 (via TEDGO). Additionally, pilots affected by the trials via LAMGO and TEDGO have answered general questions regarding their use of FG-modes. The questionnaires were treated confidentially and only 1 questionnaire could be handed-in for every descent flown. With regard to the general questions, it was made sure that any SWISS pilot’s viewpoint was only considered once.

The ATCOs feedback for the Vienna publication can be found in the chapters 6.7.3.1.1.1.2 and 6.7.5.1.1.1.2.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | the flight stayed more or less on profile and could be continued normally despite the short-cut | | the flight was suddenly well above profile and the use of speed brakes unavoidable | | the flight was slightly above profile and the new profile could easily be intercepted without the use of speed brakes by temporarily increasing ROD (assumption: no ATC-speed assignment) | | other | |
| 7 | The profile calculation of ERMUS 1T is based on the constraint at ZH801 (+FL130). IF your flight received a short-cut by ATC: | 17 | 5 | 29% | 6 | 35% | 4 | 24% | 2 | 12% |
| | Conclusion: Although short-cuts and "direct to"-clearances do have the most positive effect on overall flight efficiency, they interfere with optimised descent profiles | | | | | | | | | |
| | Remark: 61% of answering pilots received a short-cut! Statistics should be considered when defining altitude windows and crossing levels in order to cater for possible short-cuts | | | | | | | | | |
| | Remark: the 2 flights answering with "other" received a short-cut for sequencing before holding entry. They were able to loose the excess altitude in the holding pattern | | | | | | | | | |
| | | | useful since it helped with optimising energy management and contributed to a suitable profile | | not applicable due to short-cut | | not applicable due to different speed assignment by ATC well before ZH802 | | too restrictive | |
| 8 | The speed limit point at ZH802 (max. 230kts) has been introduced with the purpose of preventing thrust increase after a level-off at FL130 until being clear of conflicting traffic (better energy management). This speed limit was... | 23 | 2 | 9% | 8 | 35% | 11 | 48% | 1 | 4% |
| | Conclusion: Most flights obtain either a shorter routing (free speed to regain profile) or speed assignment from ATC. | | | | | | | | | |
| | | | is an unambiguous clearance to comply with all published constraints unless explicitly cancelled by ATC | | may lead to misunderstandings because: | | | | | |
| 9 | The new phraseology "descend via ERMUS 1T"... | 24 | 20 | 83% | 4 | 17% | | | | |
| | ...because: "via" is a very short word and might be missed / "descend according to profile" would be better | | | | | | | | | |
| | Conclusion: Most pilots agree with the new phraseology developed by the ICAO ATM-OPS panel | | | | | | | | | |
| | | | a suitable solution for permanent implementation | | to be improved | | | | | |
| 10 | Considering that the lateral flight path cannot be changed (politics!), the suggested profile (LAMUR.ERMUS 1T) is... | 24 | 20 | 83% | 4 | 17% | | | | |
| | Remarks: short-cut up to 40NM destroy profile / TCAS TA at ZH801 if closure rate not monitored according OM-A | | | | | | | | | |
| | **Conclusion: for a majority of SWISS-pilots, the suggested STAR constitutes a suitable solution for vertical optimisation** | | | | | | | | | |

*Figure 25: Pilots Questionnaire feedback on Trial DEM-008-02*

**Pilots Questionnaire ODP / TRIAL SCN-0103-008 EXE-0103-008 DEM-008-03**

05 October - 11 October 2015

A32X (number of feedbacks) 27

**#of trial flights 84 / #of returned questionnaires 27 / feedback-rate ~32%**

| | | TOTAL | | % | | % | | % | | % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ATC ("descend to…") | | Pilot ("requesting descent") | | | | | |
| 1 | Who initiated descent to leave cruise-flight level? | 27 | 25 | 93% | 2 | 7% | | | | |
| | | | less than 2minutes prior Pilot's TOD (<15nm) | | 2 to 5minutes prior Pilot's TOD (~15 – 35nm) | | more than 5minutes prior Pilot's TOD (>35nm | | | |
| 1a | **If ATC** initiated descent: How much "too early" compared to your own descent planning were you asked to leave cruise-FL? (approximate answer) | 25 | 4 | 16% | 12 | 48% | 9 | 36% | | |
| | | | it was according to the FMS calculated TOD | | it was before the FMS calculated TOD | | it was after the FMS calculated TOD | | | |
| 1b | **If Pilots** initiated the request for descent: | 2 | 2 | 100% | 0 | 0% | 0 | 0% | | |
| | | | descent was initiated earlier for smoother transition to descent phase (less initial ROD) | | descent was initiated earlier/later because of unreliable FMS predictions | | no FMS TOD calculation available | | | |
| 2 | If descent was NOT requested according FMS TOD: | 0 | 0 | | 0 | | 0 | | | |
| | | | I put it in the FMS as constraint to optimise FMS descent profile calculation | | I considered it for my own descent planning without putting it in the FMS | | I disregarded it | | No answer | |
| 3 | How did you deal with "Descent Planning Information" (e.g. 20NM to SUL expect FL250): | 27 | 26 | 96% | 0 | 0% | 0 | 0% | 1 | 4% |
| | | | generally useful information improving profile anticipation because it is based on standard ATC procedures and experience | | superfluous information because it doesn't constitute restrictions I have to comply with | | No answer | | | |
| 4 | "Descent Planning Information" is: | 27 | 18 | 67% | 4 | 15% | 5 | 19% | | |

Conclusion:
Descent Planning information is appreciated and used by most pilots. ATCOs mostly start descending aircraft based on their own needs only. The aircraft's profile calculation is not considered.

Recommendation:
Whenever possible, handover conditions during descent should be defined as altitude windows and coded in the FMS. Pilots may then request descent based on the FMS calculated optimised descent profile.

*Figure 26: Pilots Questionnaire feedback on Trial DEM-008-03*

**Pilots Questionnaire ODP / TRIAL SCN-0103-008 EXE-0103-008 DEM-008-04**

05 October - 11 October 2015

**A/C Type:**
A320 78 flights / 32 feedbacks
A330 / A340 21 flights / 13 feedbacks

**#of trial flights 99 / #of returned questionnaires 45 / feedback-rate ~45%**

| | | TOTAL | | % | | % | | % | | % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ATC ("descend to…") | | Pilot ("requesting descent") | | | | | |
| 1 | Who initiated descent to leave cruise-flight level? | 45 | 43 | 96% | 2 | 4% | | | | |
| | | | less than 2minutes prior Pilot's TOD (<15nm) | | 2 to 5minutes prior Pilot's TOD (~15 – 35nm) | | more than 5minutes prior Pilot's TOD (>35nm | | | |
| 1a | **If ATC** initiated descent: How much "too early" compared to your own descent planning were you asked to leave cruise-FL? (approximate answer) | 43 | 4 | 9% | 17 | 40% | 22 | 51% | | |
| | | | it was according to the FMS calculated TOD | | it was before the FMS calculated TOD | | it was after the FMS calculated TOD | | | |
| 1b | **If Pilots** initiated the request for descent: | 2 | 1 | 50% | 1 | 50% | 0 | 0% | | |
| | | | descent was initiated earlier for smoother transition to descent phase (less initial ROD) | | descent was initiated earlier/later because of unreliable FMS predictions | | no FMS TOD calculation available | | | |
| 2 | If descent was NOT requested according FMS TOD: | 1 | 1 | 100% | 0 | | 0 | | | |
| | | | I put it in the FMS as constraint to optimise FMS descent profile calculation | | I considered it for my own descent planning without putting it in the FMS | | I disregarded it | | No answer | |
| 3 | How did you deal with "Descent Planning Information" (e.g. 20NM to SUL expect FL250): | 45 | 35 | 78% | 6 | 13% | 0 | 0% | 4 | 9% |
| | | | generally useful information improving profile anticipation because it is based on standard ATC procedures and experience | | superfluous information because it doesn't constitute restrictions I have to comply with | | No answer | | | |
| 4 | "Descent Planning Information" is: | 42 | 35 | 83% | 6 | 14% | 1 | 2% | | |

Conclusion:
Descent Planning information is appreciated and used by most pilots. ATCOs mostly start descending aircraft based on their own needs only. The aircraft's profile calculation is not considered.

Recommendation:
Whenever possible, handover conditions during descent should be defined as altitude windows and coded in the FMS. Pilots may then request descent based on the FMS calculated optimised descent profile.

*Figure 27: Pilots Questionnaire feedback on Trial DEM-008-04*

For AF pilots, report was available to express themselves about ODP changes.

Note: it is to be noted that on AF flows, introduced changes had no impact on pilot procedure. Most of the changes are tactical changes. Tactical changes of that matter are daily business for the pilots (e.g. FL constraint on a waypoint). Therefore we didn't get any comments from Pilots.

### 5.3.4 Results impacting regulation and standardisation initiatives

ODP illustrated the complexity of vertical efficiency evaluation and the complexity of its implementations.

**Issues found during ODP Demonstration Exercises or Simulations:**

1. **Issues with CDOs with "AT or ABOVE" constraints can lead to Selected Altitude alarms**

In the context of a validation for Arrivals to Zurich, an exercise took place in an Airbus 320 simulator at SAT (SWISS Aviation Training) in Zürich. The exercise had been designed to contain intermediate altitude steps and altitude windows in order to evaluate possible descent corridors linking airways with the TMA. Thanks to the exercise, it was possible to confirm the feasibility of the suggested CDO-profiles and to identify improvements to the drafted procedures. However, with regards to flight guidance and altitude-alerting setting procedures, it was noted that not only cleared altitudes but also intermediate altitudes will be set by the pilot on the altitude alerting device. The method of how to set limiting altitudes on the Flight Control Unit (FCU) or Mode Control Panel (MCP) is prescribed to the pilot by mandatory company procedures that are in turn based on strong recommendations given by aircraft manufacturers.

In some ATC-centres, modern ATM systems use data downlinked via mode S transponder to compare the altitude set by the pilot on his flight guidance panel with the "cleared level" entered into the system by the controller. If the setting and the entry don't match, the system identifies a potential level-bust and ATCOs receive an alert message at their Controller Working Positions (CWP). However, cockpit procedures regarding flight guidance handling are not designed to interact according to the closed loop principle with ATM systems. This altitude-crosscheck can therefore lead to false alerts when the flight crew is cleared to navigate along and descend on a CDO-profile because pilots will not set the "cleared FL" in the altitude-alerting device window in all cases. The details of this issue affecting current settings in the ATC-centres can be found in [16]. In the ICAO Aeronautical Surveillance Panel (ASP) Technical Sub Group Meeting from 27 January to 30 January 2014 in Fort Lauderdale they refer to current situation in Europe and future solutions, like Source [24] extract:

> *"The first Selected Altitude application used in Europe is the digital read back application.*
>
> *Today systems are directly using the MCP/FCU selected altitude in Register 4016 and do not use the mode bits.*
>
> *In the future it is envisaged to use the target altitude to monitor the conformance of the aircraft to the PBN/RNAV procedure however this will require the aircraft to correctly transmit the information and the ground systems to be modified to support new functionality.*
>
> *For information between 10 and 15 % of flights operated in Europe provide information in the FMS selected altitude provided in Register $40_{16}$ and a very limited proportion of them provide information about the mode the aircraft is flown."*

London Gatwick[9] have had the same issue with their SID with step climb back in 2014 with no short term solution. The conclusions or recommendations on this issue can be found in chapter 8.

**2. <u>Automatic Deletion of Altitude Constraints in FMS</u>**

After the CDO publication for Vienna in the context of ODP, we faced automatic deletions of altitude constraints in FMS. Although the publication and coding of new NEMAL1W was correct, some pilots failed to comply with the NIMDU restriction and pass the point significantly too high. The reason is that Flight Management Systems immanent logic deletes unnecessary constraints above, at and even below CFL. This issue is known by Airbus and was published in the Flight Operations Transmission (FOT), REF.: 999.0058/15 Rev 00 dated 06-JUL-2015. More details on this topic can be found in the reference [15].

Today, no technical correction is overseen and it is asked to the pilot to cover this bug by a manual check. A reminder on this was done in the framework of ODP. To solve it on short notice ACC Vienna order issued internally and adapted the phraseology.

The conclusions or recommendations on this issue can be found in chapter 8.

## 5.4 Analysis of Exercises Results

For an overview of results related to Key Performance Indicators, please refer to 5.3.1.

### 5.4.1 Unexpected Behaviours/Results

Bremen ATCOs saw overflying traffic in the descent with a “CFL” of FL240, assuming this traffic had a restricting clearance to stay above Bremen ACC. However Bremen experienced an uncoordinated entry by one aircraft as explained above. On airway Q230, only 3NM north of the RIMET Area, traffic frequently operates up to FL240 within Bremen ACC.

Therefore the operational trial for ARR to Frankfurt via RIMET was suspended because of the mentioned safety issue in Bremen FIR, details can be found in chapter 6.2.15.

Other unexpected behaviours or results are described in chapter 5.3.4.

## 5.5 Confidence in Results of Demonstration Exercises

### 5.5.1 Quality of Demonstration Exercises Results

AO are confident in the quality of results achieved in the framework of ODP. However the complexity of vertical fuel assessment is to be reminded. For more details, please check section 5.3.

[9] New ATC procedures - unintended effects on the flight deck? HindSight 20, p. 58ff by Colin Gill

### 5.5.2 Significance of Demonstration Exercises Results

In general it is to be noted that statistical significance (in the scientific meaning) has not been tested in this framework which was as a Live Trial activity – other than a laboratory experiment – operationally driven thus showing a variety of uncontrollable influencing factors. AO are confident in the significance of results achieved in the framework of ODP.

Overall the 29 ODP demonstrations based on Fast Time Simulations, operational Flight Trials and Public Live Trials provided fruitful results which are relevant for further steps via optimized descending profiles options towards a better cross-border vertical profiles and CDOs in future. Regarding the significance of individual exercises please refer to the respective sub-chapters in chapter 6.

### 5.5.3 Conclusions and recommendations

The recommendations from Airline Operators can be found in chapter 4.1 and 4.2.1.5.

# 6 Demonstration Exercises reports

The following table shows the overall summary of the Demonstration Exercises realized. Details about the calculations, conclusions etc. can be found in each sub-chapter as of chapter 6.1 – 6.9.

| | | | | KPA / KPI | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Horizontal Flight Efficiency (HFE) | | Environmental Sustainability | | | Vertical Flight Efficiency (VFE) | |
| Exercise Title / Airport | Demonstration ID | Source | Nbr, of flights for the exercises | Distance in NM | Time in min | Fuel in kg | $CO_2$ in kg | NOX | Average feets higher | Remarks (e.g. results source) |
| Bale-Mulhouse (LFSB/BSL) | DEM-001-01 | SAAM | 10 | -99,144 | -7,983 | -427,912 | -1352,21 | -6,441 | n/a | simulation |
| | | FANOMOS | 86 | n/a | -82,56 | n/a | n/a | n/a | 465 | measurement, uncertain (variance is of comparable magnitude as results) |
| Frankfurt (EDDF/FRA) | DEM-002-01 | SAAM | 48 | 0,16 | 1,359 | -446,36 | -1409,12 | -8,995 | n/a | simulation |
| | | BADA | 30 | n/a | n/a | -4287,09 | n/a | n/a | n/a | calculation, uncertain (variance per flight is of comparable magnitude as results) |
| | DEM-002-02 | SAAM | 48 | 0,16 | 1,359 | -446,36 | -1409,12 | -8,995 | n/a | simulation |
| | DEM-002-03 | SAAM | 48 | 0,16 | 1,359 | -446,36 | -1409,12 | -8,995 | n/a | simulation |
| | | Aviaso (DLH) | 1559 | n/a | n/a | > -10 (per flight) | n/a | n/a | 737 | measurement |
| | DEM-002-04 | SAAM | 116 | 0,12 | -15,704 | -1615,23 | -5102,12 | -31,3 | n/a | simulation |
| | | Aviaso (DLH) | 200 | | | -2600 | | | 2050 | measurement, A320 family only (65% of DLH aircraft), flights from southeast over ERNAS excluded |
| | DEM-002-05 | SAAM | 116 | 0,12 | -15,704 | -1615,23 | -5102,12 | -31,3 | n/a | simulation |
| | DEM-002-06 | SAAM | 116 | 0,12 | -15,704 | -1615,23 | -5102,12 | -31,3 | n/a | simulation |
| | DEM-002-07 | SAAM | 15 | -501,652 | -87,058 | -3557,992 | -11243,13 | -34,084 | n/a | simulation |
| | | SAAM | 11 | 0 | -24,706 | -946,41 | -2990,67 | -0,822 | n/a | simulation |
| | | FANOMOS | 187 | n/a | -40,52 | n/a | n/a | n/a | 1010 | measurement, uncertain (variance is of comparable magnitude as results) |
| | | HPO!, AF | 38 | n/a | n/a | -418 | -1316,7 | n/a | 5000 | measurement, VFE, Embraer Ejet only |
| | | HPO!, AF | 38 | n/a | n/a | -3344 | -10533,6 | n/a | n/a | measurement, HFE, Embraer Ejet only |
| | | Aviaso (DLH) | 260 | 2080 | n/a | -6500 | n/a | n/a | n/a | measurement, A320 family only, for flights above FL230 |
| | DEM-002-08 | SAAM | 36 | -0,120 | 31,825 | 1268,956 | 4012,44 | -0,132 | n/a | simulation |
| | | Aviaso (DLH) | n/a | n/a | n/a | n/a | n/a | n/a | 575 | measurement |
| | DEM-002-09 | AirTOp | n/a | n/a | n/a | n/a | n/a | n/a | n/a | only fast time simulation, no environmental KPA |
| | DEM-002-10 | SAAM | 55 | 0,214 | -12,665 | -1190,85 | -3763,77 | -20,962 | n/a | simulation only |
| | | Aviaso (DLH) | 22 | n/a | n/a | -330 | n/a | n/a | -429 | measurement, uncertain (variance is of comparable magnitude as results), short range (B737, A320 family) |
| | | Aviaso (DLH) | 22 | n/a | n/a | -220 | n/a | n/a | 2120 | calculation, short range (B737, A320 family) |
| Geneva (LSGG/GVA) | DEM-003-01 | SAAM | 19 | -0,02 | -0,374 | -72,51 | -229,06 | -1,408 | n/a | simulation |
| | | SWISS | 53 | -29,7 | n/a | -1643 | n/a | n/a | 625 | measurement, higher altitude (GPS) values for NATOR |
| | | SWISS | 53 | n/a | n/a | -1849,7 | n/a | n/a | 4000 | calculation (potential) |
| Munich (EDDM/MUC) | DEM-004-01 | SAAM | 16 | -0,03 | -2,371 | -272,899 | -862,19 | -5,847 | n/a | simulation |
| | | HOP!, AF | 146 | n/a | n/a | 700 | n/a | n/a | 3000 | measurement |
| | | Aviaso (DLH) | 2578 | n/a | n/a | 14776 | n/a | n/a | 2343 | measurement |
| | DEM-004-02 | SAAM | 4 | -0,03 | 0,14 | 2,099 | 6,62 | 0,019 | n/a | simulation |
| | DEM-004-03 | SAAM | 43 | 0,04 | 0,831 | -2306,273 | -7287,53 | -48,384 | n/a | simulation |
| | | SWISS | 1 | n/a | n/a | -123,6 | n/a | n/a | 7000 | calculation, A340-600 potential gain |
| | | SWISS | 1 | n/a | n/a | -46,6 | n/a | n/a | 7000 | calculation, A320 potential gain |
| | DEM-004-04 | SAAM | 39 | 0,04 | 0,753 | -223,35 | -705,6 | -3,629 | n/a | simulation |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Aviaso (DLH) | n/a | n/a | n/a | > -10 (per flight) | n/a | n/a | 1166 | measurement, the variance if fuel measurement is of comparable magnitude as the results. |
| | DEM-004-05 | SAAM | 120 | -0,76 | -75,159 | -3106,253 | -9815,687 | -31,222 | n/a | simulation |
| | DEM-004-06 | SAAM | 39 | 0,04 | 0,753 | -223,35 | -705,6 | -3,629 | n/a | simulation |
| | | Aviaso (DLH) | 5800 | n/a | n/a | n/a | n/a | n/a | 576 | measurement, A320 family, the variance if fuel measurement is of comparable magnitude as the results. |
| Strasbourg (LFST/SXB) | DEM-005-01 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | simulation |
| | DEM-005-02 | SAAM | 3 | 0 | -2,863 | -35,948 | -113,59 | 2,221 | n/a | simulation |
| Stuttgart (EDDS/STR) | DEM-006-01 | SAAM | 1 | 0 | 0,159 | -37,06 | -117,1 | -0,757 | n/a | simulation |
| | DEM-006-02 | SAAM | 26 | 0,03 | 2,867 | -807,457 | -2550,879 | -17,91 | n/a | simulation |
| | DEM-006-03 | SAAM | 5 | 0 | -727 | -25,521 | -80,62 | -0,274 | n/a | simulation |
| | | HOP!, AF | 259 | n/a | n/a | -0,50% | n/a | n/a | 1000 | measurement, no absolute value for fuel |
| Vienna (LOWW/VIE | DEM-007-01 | SAAM | 40 | -0,06 | 1,364 | -353,52 | -1118,9 | -7,199 | n/a | simulation |
| | | SWISS | 81 | n/a | n/a | -2532 | n/a | n/a | 556 | measurement, altitude change for UNKEN and fuel measurement for improvement of inter-sector handover copmared to reference |
| | | SWISS | 87 | n/a | n/a | -2949,3 | n/a | n/a | 286 | measurement, altitude change for UNKEN and fuel measurement for full implementation NEMAL 1W copmared to reference |
| | | HOP!, AF | 140 | n/a | n/a | 5600 | n/a | n/a | 2500 | measurement, altitude change for NIMDU and fuel measurement for improvement of inter-sector handover copmared to reference |
| | | HOP!, AF | 105 | n/a | n/a | 4600 | n/a | n/a | 1700 | measurement, altitude change for NIMDU and fuel measurement for full implementation NEMAL 1W copmared to reference |
| | DEM-007-02 | SAAM | 29 | 0,1 | 3,23 | -643,839 | -2034,36 | -12,496 | n/a | simulation |
| Zurich (LSZH/ZRH) | DEM-008-01 | SAAM | 41 | 0,2 | -1,219 | -62,461 | -197,33 | -0,806 | n/a | simulation |
| | | SWISS | 286 | 152 | n/a | -5411 | n/a | n/a | 0 | measurement |
| | DEM-008-02 | SAAM | 36 | 0,11 | -6,004 | -531,66 | -1679,69 | -9,497 | n/a | simulation |
| | | SWISS | 21 | 10,5 | n/a | -325,5 | n/a | n/a | 2147 | measurement |
| | DEM-008-03 | SAAM | 50 | 0,05 | -33,081 | -701,066 | -2215,26 | -2,029 | n/a | simulation |
| | | SWISS | 34 | 3,4 | n/a | -1360 | n/a | n/a | n/a | measurement |
| | DEM-008-04 | SAAM | 27 | -0,01 | -15,619 | -123,277 | -407,71 | 3,779 | n/a | simulation |
| | | SWISS | 42 | 11,8 | n/a | -564 | n/a | n/a | 100 | measurement |
| Berlin-Tegel (EDDT/TXL) | DEM-009-01 | SAAM | 178 | 0,06 | -35,61 | -2327,421 | -7355,1 | -34,377 | n/a | simulation |
| | DEM-009-02 | SAAM | 178 | 0,06 | -35,61 | -2327,421 | -7355,1 | -34,377 | n/a | simulation |
| | DEM-009-03 | SAAM | 178 | 0,06 | -35,61 | -2327,421 | -7355,1 | -34,377 | n/a | simulation |
| | DEM-009-04 | SAAM | 178 | 0,06 | -35,61 | -2327,421 | -7355,1 | -34,377 | n/a | simulation |
| | | SWISS | 109 | 43,6 | n/a | -327 | n/a | n/a | 0 | measurement |

*Table 15: ODP overall results of environmental measures*

## 6.1 Demonstration Exercise SCN-0103-001 / Bale-Mulhouse (LFSB/BSL) Report

### 6.1.1 Exercise Scope

The routing for the SCN-0103-001 was as follows:

- LFPG/LFPO – BUBLI – LUVAL – OKIPO – LUL – ARPUS

ATC-Sectors involved:

- Reims UF-sector
- Reims UH-sector (new)
- Reims SE-sector
- LFSB APP

Further routing details:

- Number of flights 50 per week
- Typical A/C-Types: RJ1000, E170

Status Quo:

- Restrictions: flights have to descend below UH-sector, therefor to cross OKIPO at FL225 or below
- Reasons for the restrictions: UH sector is the busiest sector in Reims ACC

Description of ODP trial changes:

- Handover to UH-sector at FL310
- Late top of descend
- Published CDO-procedure starting at ARPUS

Type of trial:

- Tactical live trial (for later ToD)
- Public live trial (for CDO from ARPUS)
- Participants in the trial: all flights on this routing (presently HOP!)

Details of trial:

- Starting 10.12.2015 (CDO from ARPUS)
- 07.01.-03.03.2016 (later ToD)
- Documentation of trial participants: all flights during trial
- Baseline for evaluation: flights prior start of trial
- Expected effects e.g. on non-trial flights: depending on workload of UH-sector

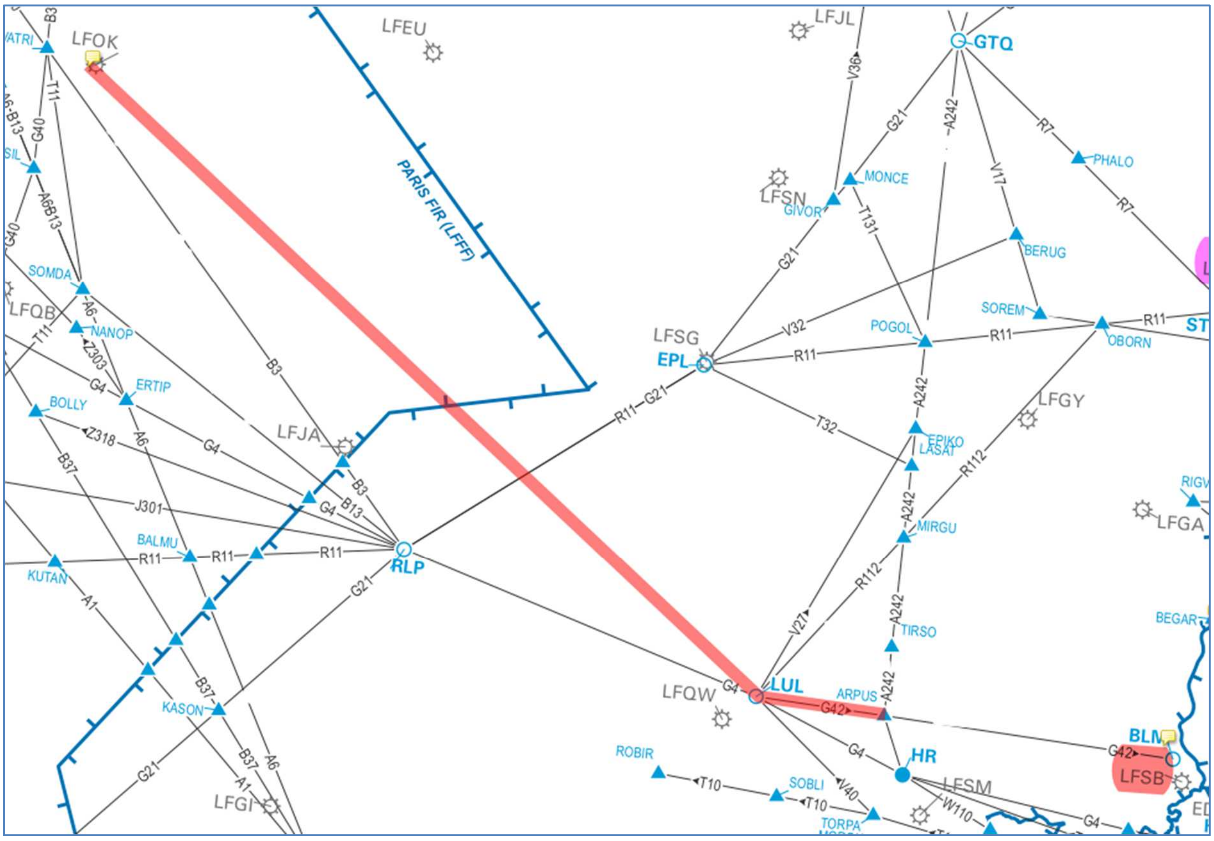



*Figure 28: Trial overview Paris (LFPO, LFPG) to Bale-Mulhouse (LFSB) SCN-0103-001/ EXE-0103-001/ DEM-001-01 (chart based on [21])*

Overall SAAM calculation results for EXE-0103-01 are as follows:

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 1 | 0,220 | 6 | 6,559 | 2 | 40,828 | 2 | 128,960 | 1 | 0,011 |
| Equal | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 9 | -99,364 | 4 | -14,542 | 8 | -468,740 | 8 | -1481,170 | 9 | -6,452 |
| Total | 10 | -99,144 | 10 | -7,983 | 10 | -427,912 | 10 | -1352,210 | 10 | -6,441 |

*Figure 29: Summary of potential gains for ARR to Bale-Mulhouse, EXE-0103-01*

## 6.1.2 Conduct of Demonstration Exercise EXE-0103-001 and DEM-001-01

Since there is just one Demonstration Exercise the Exercise and the appropriate Demonstration number are in a 1:1 relationship, meaning that EXE-0103-001 equals DEM-001-01.

### 6.1.2.1 Exercise Preparation

For details regarding the preparation of demonstration activities in chapter 4.1.

### 6.1.2.2 Exercise execution

For details regarding the preparation of demonstration activities in chapter 4.3.

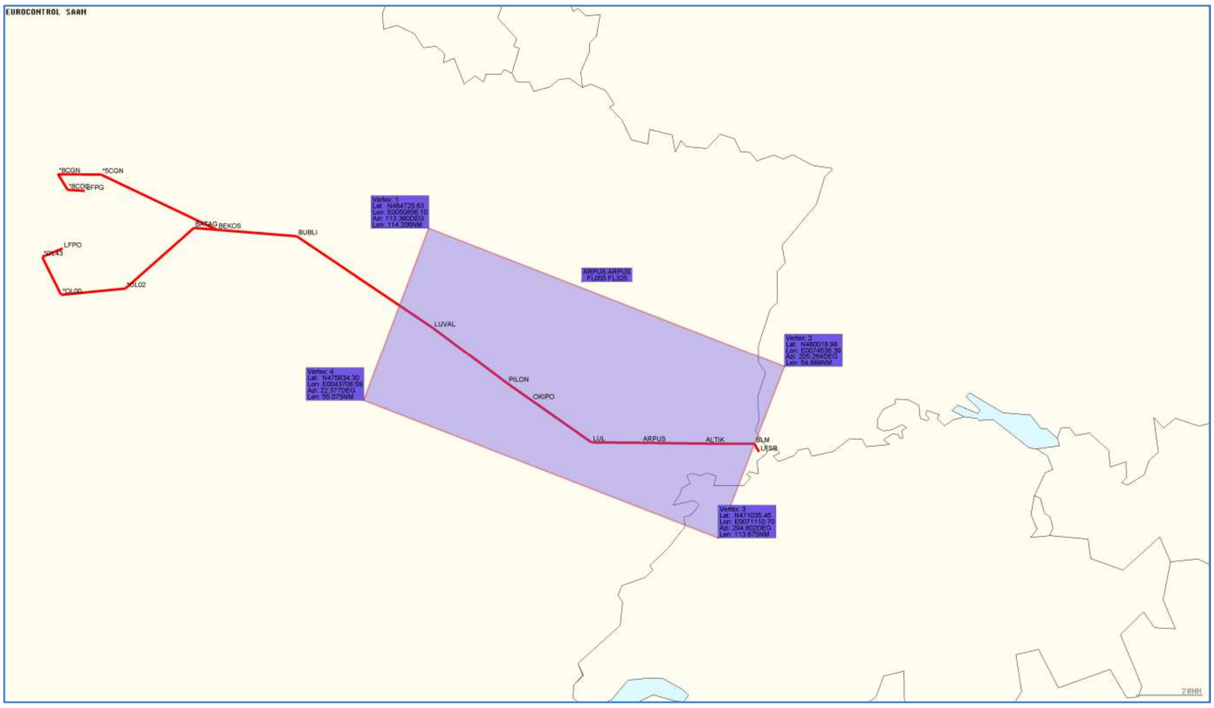



*Figure 30: Trial overview and the measurement window for city pair Paris (LFPO, LFPG) to Bale-Mulhouse (LFSB)*

### 6.1.2.3 Deviation from the planned activities

Please refer to chapter 4.3.

## 6.1.3 Exercise Results for DEM-001-01

### 6.1.3.1 Summary of Exercise Results

#### 6.1.3.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

##### 6.1.3.1.1.1 Assessment Results by ANSP and Eurocontrol

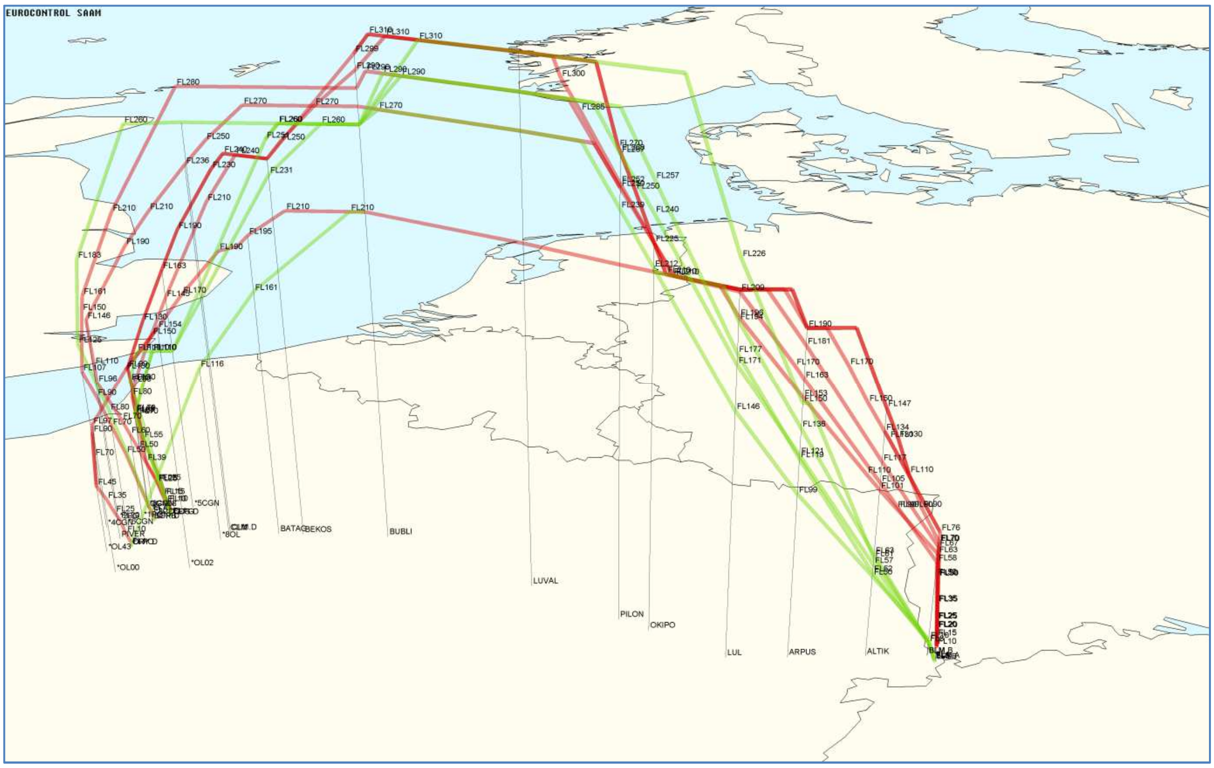



*Figure 31: Reference (red) and ODP (green) radar data recordings for the city pair Paris (LFPO, LFPG) to Bale-Mulhouse (LFSB), , EXE-0103-01*

#### 6.1.3.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-001-01 from SAAM perspective are summarized in Figure 29. The trial results can be found in each sub-chapter of a given trial under “Assessment Results by Airline Operator”. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

#### 6.1.3.1.1.1.2 Trajectory based Analysis with FANOMOS

For the trajectory based analysis with FANOMOS the spatial envelope which has been defined by Eurocontrol and which has been used for SAAM, was considered (see figure below). For the analysis two trial time frames (10$^{th}$ December 2015 to 15$^{th}$ January 2016 and 16$^{th}$ January to 31$^{st}$ March 2016) and one reference time frame (01$^{st}$ September 2015 to 09$^{th}$ January 2016) have been compared. The first trial period intents to inherit CDO starting from the waypoint ARPUS. The second trial period has been focused on late top of descent (ToD).

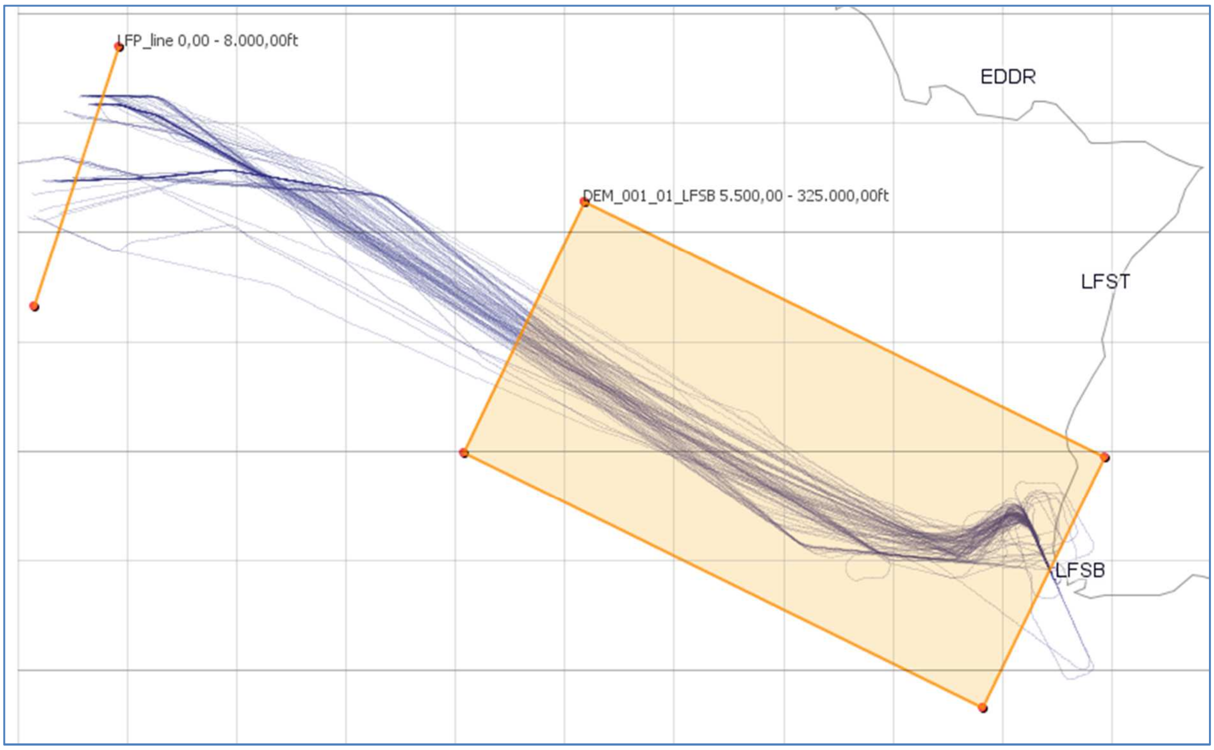



*Figure 32: Reference flight to LFSB from 01st September 2015 to 09th December 2015*

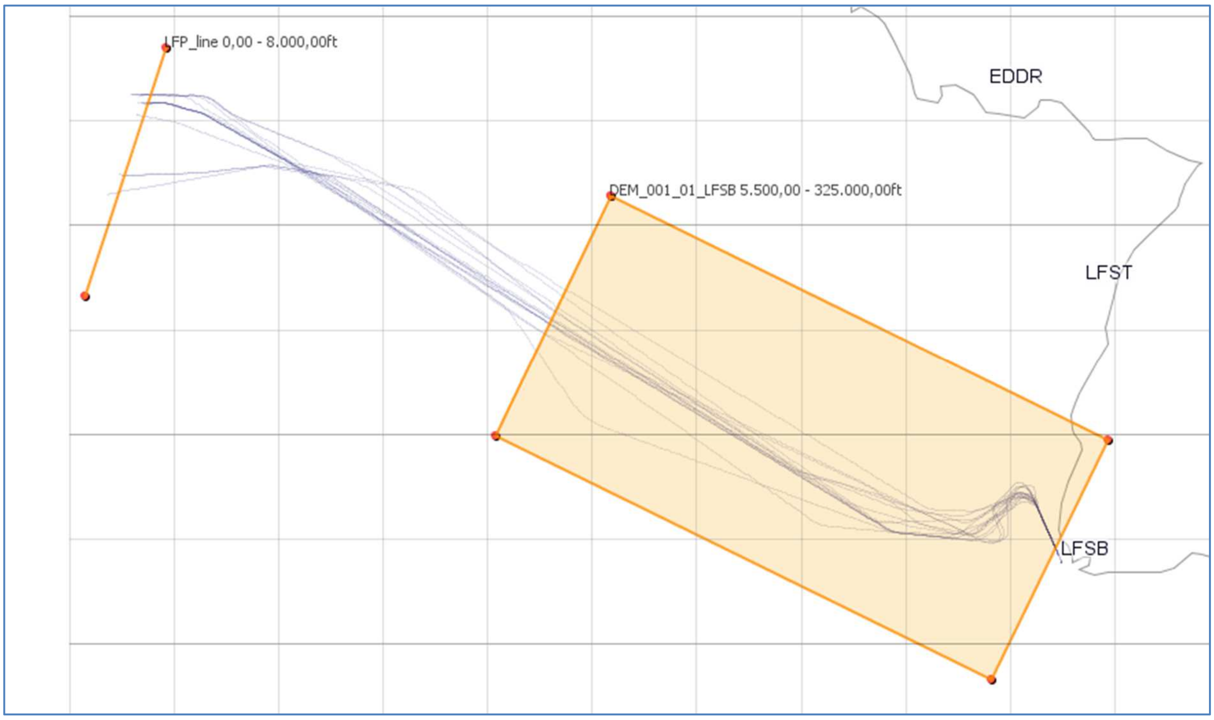



*Figure 33: First trial flights (CDO from ARPUS) to LFSB from 10th December 2015 to 15th January 2016*

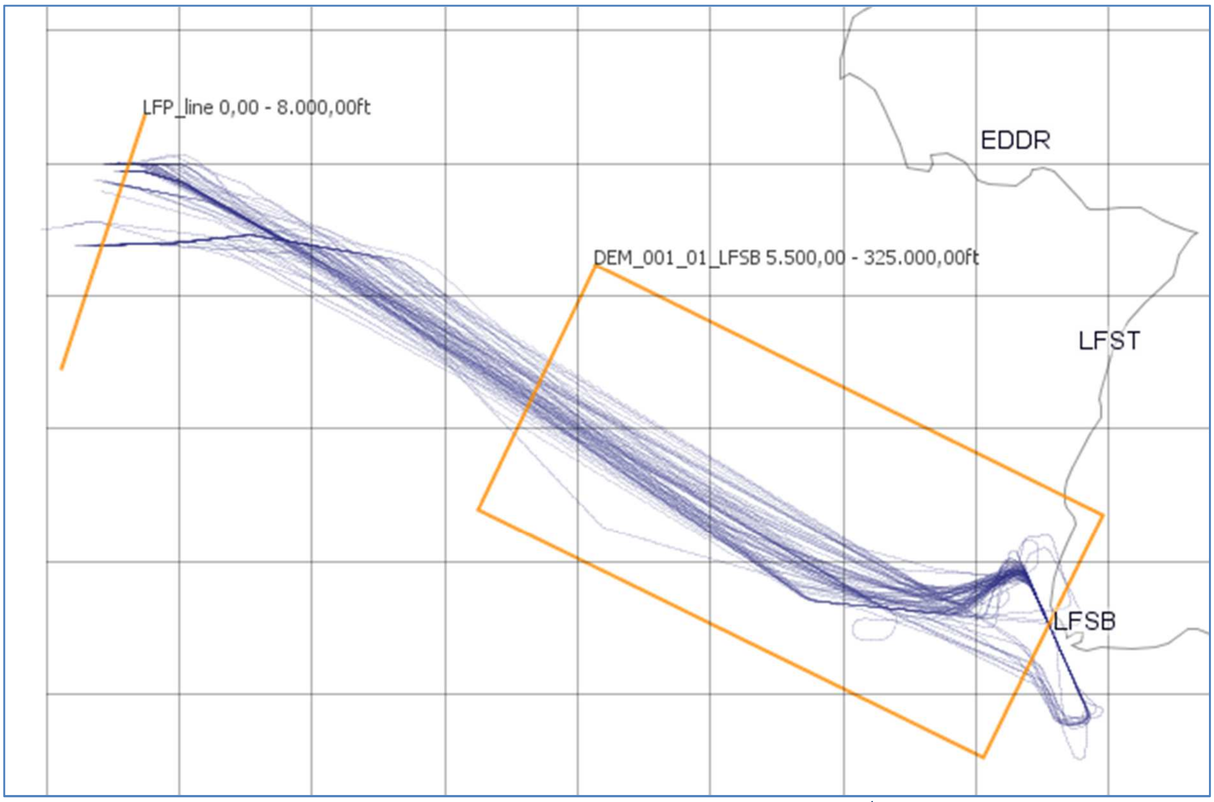



*Figure 34: Second trial flights (later ToD) during the evaluated trial period from 16th February to 31st March 2016*

The results of the analysis are shown in the tables below. Overall no significant change can be observed in horizontal flight efficiency which is indicated by the average flight time.

Furthermore, no appreciable difference in CDO could be observed. The relative high percentage for the first trial phase maybe caused by the low sample size of this trial phase.

What's more a slight increase of the average mean and maximum barometric altitude (ISA) within the defined spatial envelope is indicated. As with the flight time this change is not significant. However, the observed mean and maximum flight levels seem to be within a narrower altitude window compared to the reference, especially for the second trial.

| | refrence | trial 1 | trial 2 |
|---|---|---|---|
| **mean in s** | 1140 | 1078 | 1087 |
| **SD in s** | 236 | 166 | 145 |
| **N** | 93 | 15 | 71 |

*Table 16: flight time in s within the defined spatial envelope; N = number of flights (sample size)*

| | reference flights | | trial 1 flights | | trial 2 flights | |
|---|---|---|---|---|---|---|
| | count | in % | count | in % | count | in % |
| **2.0°** | 8 | 8,6 | 3 | 20,0 | 5 | 7,0 |
| **2.5°** | 4 | 4,3 | 1 | 6,7 | 2 | 2,8 |
| **2.7°** | 2 | 2,2 | 1 | 6,7 | 2 | 2,8 |
| **3.2°** | 2 | 2,2 | 1 | 6,7 | 2 | 2,8 |
| **N** | 93 | | 15 | | 71 | |

*Table 17: analysis results for CDO flights for various minimum vertical gradients related to ground distance within the defined spatial envelope; N = number of flights (sample size)*

| | refrence | trial 1 | trial 2 |
|---|---|---|---|
| **mean in ft** | 17823 | 18493 | 18082 |
| **SD in ft** | 2101 | 1797 | 1501 |
| **N** | 93 | 15 | 71 |

*Table 18: average barometric altitude (ISA) in ft within the defined spatial envelope; N = number flights (sample size)*

| | refrence | trial 1 | trial 2 |
|---|---|---|---|
| **mean in ft** | 26979 | 28095 | 28272 |
| **SD in ft** | 4864 | 4556 | 3789 |
| **N** | 93 | 15 | 71 |

*Table 19: maximum barometric altitude (ISA) in ft within the defined spatial envelope; N = number flights (sample size)*

##### 6.1.3.1.1.1.3 Operational subjective Feedback

Eurocontrol NM:

The screenshots above showing the recordings of a selected traffic by date or by consortium airline (most of the cases agreed with the local ANSP). Therefore the trajectories show a snapshot which were valid on the target date only. An overall conclusion of the trials cannot be stated based on a representative day. In case of the recording were not complete, the trajectories are displayed within the measurement window only.

#### 6.1.3.1.1.2 Assessment Results by Airline Operator

##### 6.1.3.1.1.2.1 Performance Analysis

##### 6.1.3.1.1.2.2 Operational subjective Feedback

No issue with the procedure. No airspace infringement reported. The flight profiles seem not to differ much during the trial. Overall no significant change can be observed in horizontal flight efficiency.


*Table 20: overall horizontal flight efficiency for the DEM-001-01 trial*

Benefits for better flight efficiency (fuel burn saving and less CO2 emission).

No decrease of capacity in Cross-Border CDO operations observed by operator.

We from my view demonstrate on this flow that there is no adverse operator feedback regarding Cross-Border CDO operations. We Show that designed Cross-Border CDO does not negatively affect operators' workload and situational awareness of both ATCOs and flight crews and can be applied most time of the day up and ideally 24/7.

#### 6.1.3.1.2 Results impacting regulation and standardisation initiatives

#### 6.1.3.1.3 Unexpected Behaviours/Results

n/a

#### 6.1.3.1.4 Quality of Demonstration Results

n/a

#### 6.1.3.1.5 Significance of Demonstration Results

n/a

## 6.1.4 Conclusions and recommendations

### 6.1.4.1 Conclusions

<u>HOP!:</u>

The demonstration exercise was satisfactory from HOP ! point of view.

It is clearly shown that the omission of pre-descents has a positive impact on the overall trip fuel consumption. Most of the changes are tactical changes. Tactical changes of that matter is daily business for the pilots (e.g. FL constraint on a waypoint). Therefore we didn't get any comments from Pilots.

It is to be noted that on HOP flows, changes introduced had no impact on pilot procedure.

- optimising cruising levels demonstrate benefits for better flight efficiency (fuel burn saving and less $CO_2$ emission)
- usage of "DESCEND WHEN READY (continuous descent) demonstrate benefits for better flight efficiency also
- On short city pairs, there are level capping restrictions, keeping flights on different CRZ FL than their optimised cruising FL. ODP took the opportunity to ease those constraints when possible (LoA or RAD update).

When possible, it is a real benefit to let the pilot descend when it is the optimum TOD from an aircraft point of view.

### 6.1.4.2 Recommendations

The CDO starting from 10.12.2015 via ARPUS remains implanted permanently, The later ToD between UH-sectors at FL310 are promising and will be further investigated by DSNA.

## 6.2 Demonstration Exercise SCN-0103-002 / Frankfurt (EDDF/FRA) Report

### 6.2.1 Exercise Scope

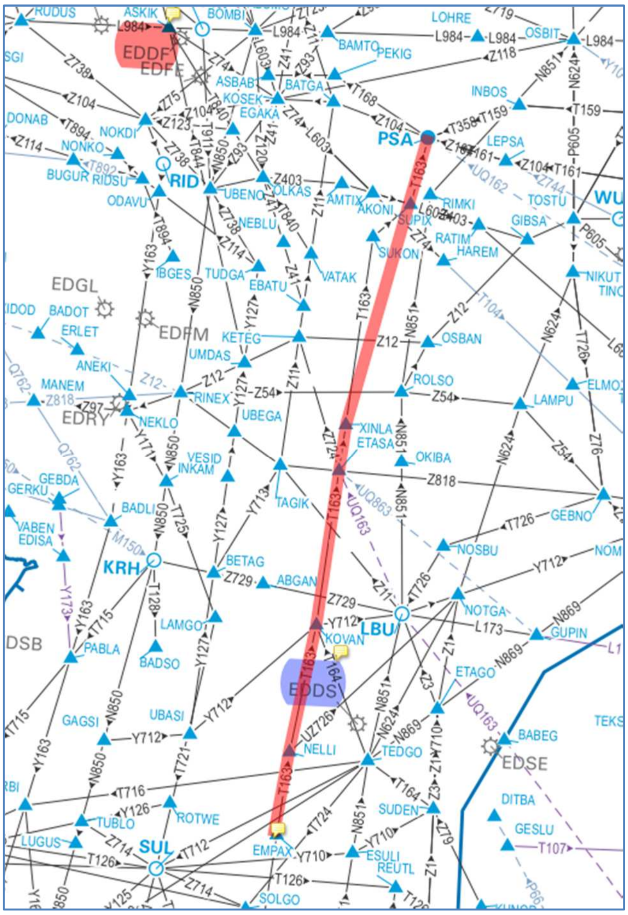



*Figure 35: Trial overview EMPAX to Frankfurt (EDDF) SCN-0103-002/ EXE-0103-002/ DEM-002-01, DEM-002-02 and DEM-002-03 (chart based on [21])*

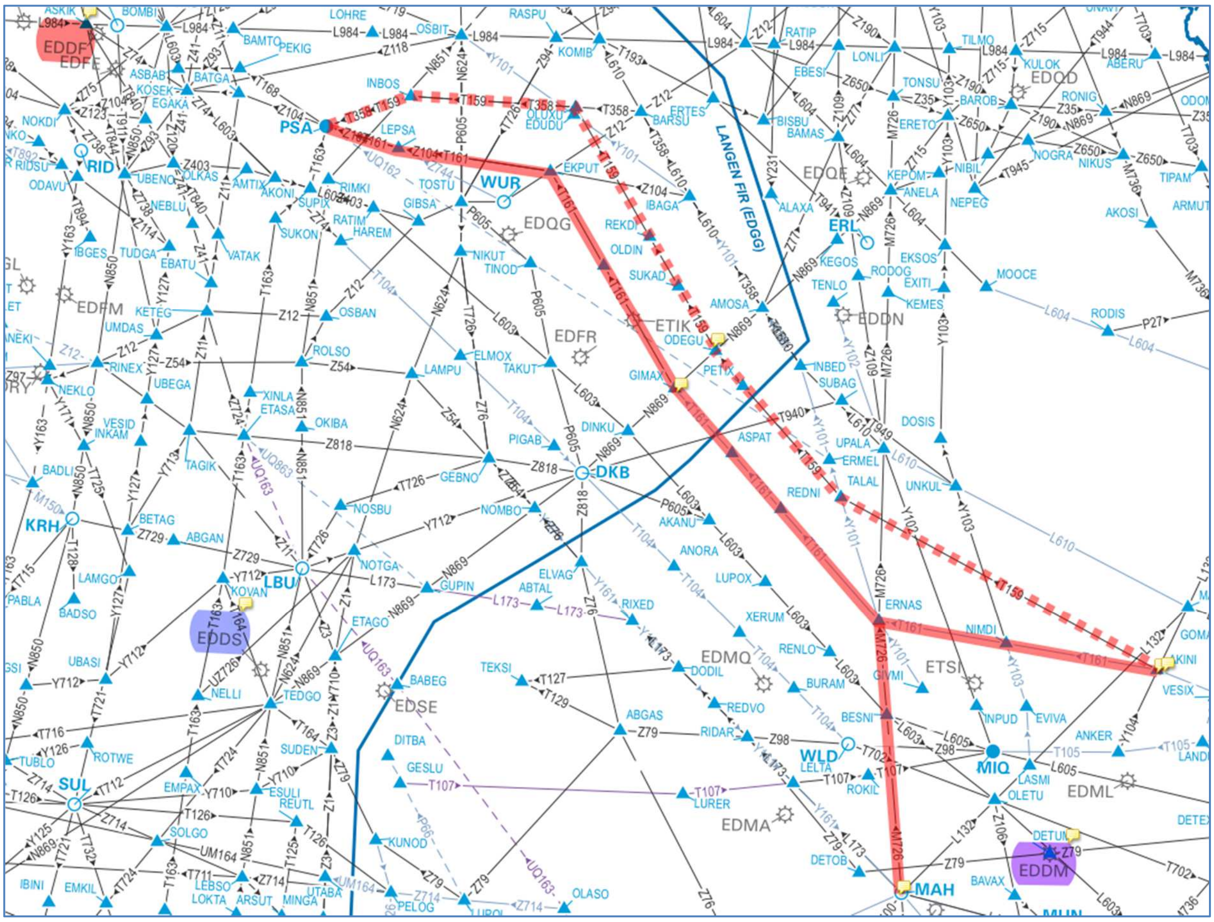



*Figure 36: Trial overview GIMAX to Frankfurt (EDDF) SCN-0103-002/ EXE-0103-002/ DEM-002-04, DEM-002-05 and DEM-002-06 (chart based on [21])*

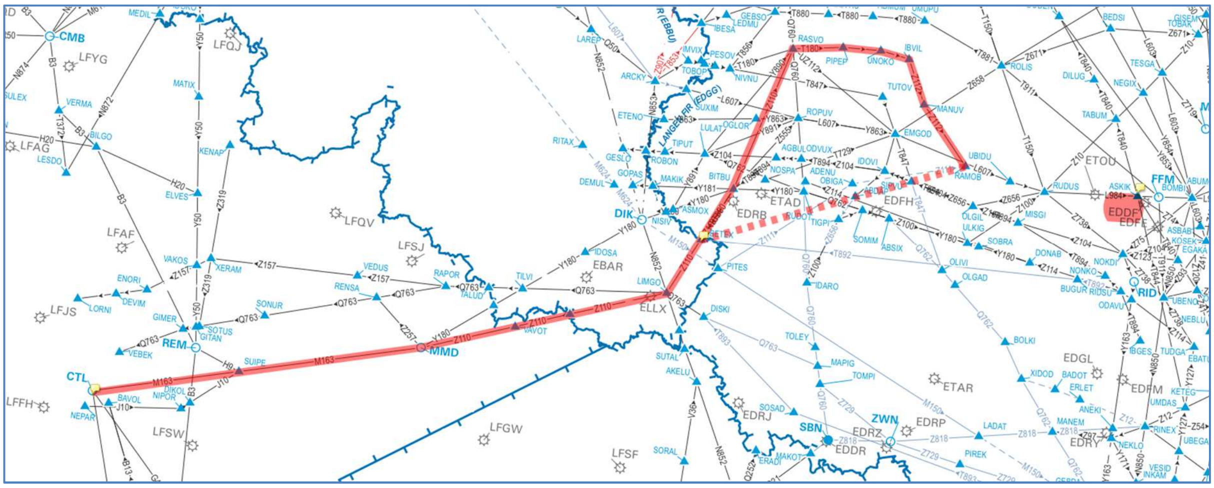



*Figure 37: Trial overview LIMGO to Frankfurt (EDDF) SCN-0103-002/ EXE-0103-002/ DEM-002-07(chart based on [21])*

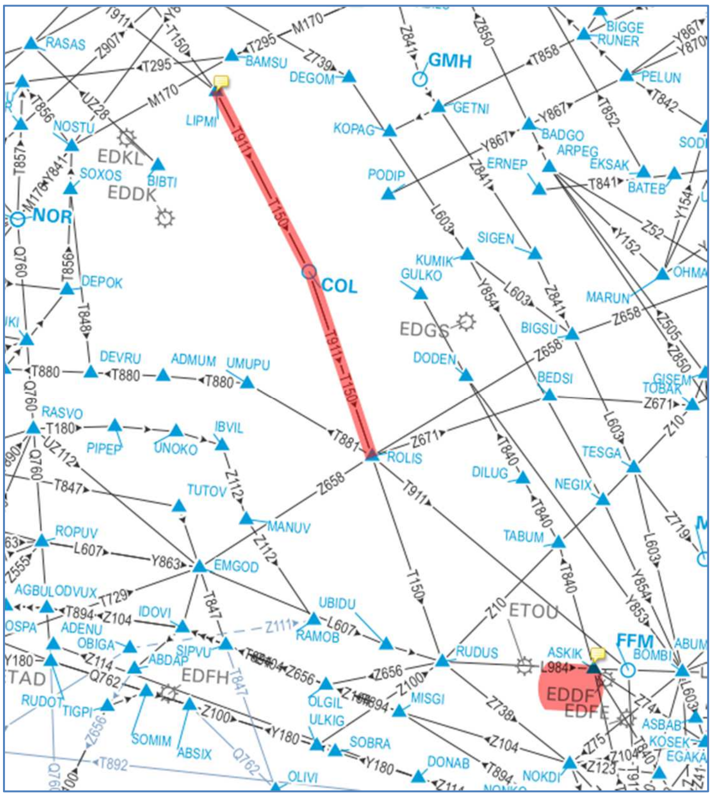



*Figure 38: Trial overview LIPMI to Frankfurt (EDDF) SCN-0103-002/ EXE-0103-002/ DEM-002-8 (chart based on [21])*

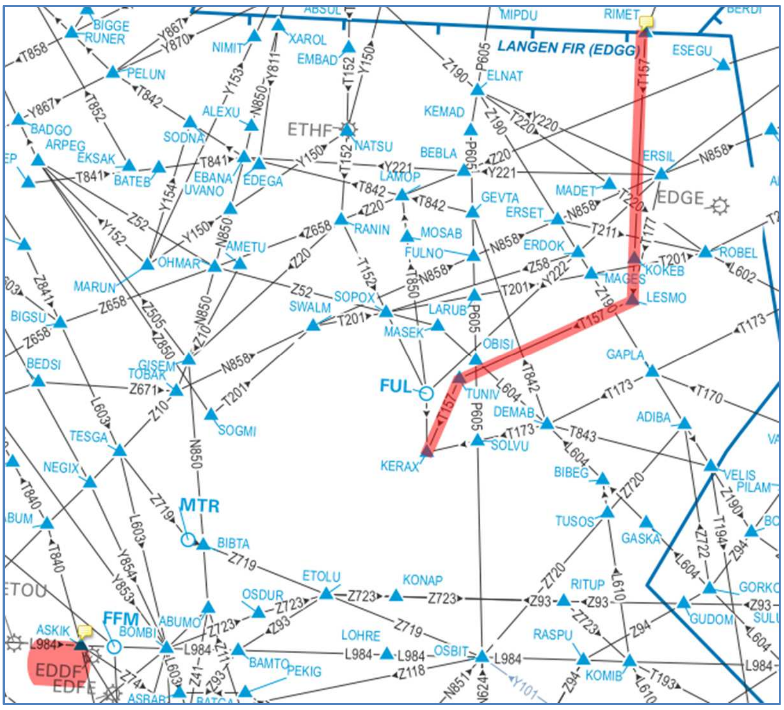



*Figure 39: Trial overview RIMET to Frankfurt (EDDF) SCN-0103-002/ EXE-0103-002/ DEM-002-09, DEM-002-10 (chart based on [21])*

Overall SAAM calculation results for EXE-0103-002, Arrival to Frankfurt are as follows:

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 48 | 1,359 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 48 | 0,160 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 0 | 0,000 | 48 | -446,360 | 48 | -1409,120 | 48 | -8,995 |
| Total | 48 | 0,160 | 48 | 1,359 | 48 | -446,360 | 48 | -1409,120 | 48 | -8,995 |

*Figure 40: Summary of potential gains for ARR to Frankfurt via EMPAX for DEM-002-01, DEMO-002-02 and DEMO-002-03*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 11 | 1,600 | 2 | 68,100 | 2 | 216,000 | 1 | 0,240 |
| Equal | 116 | 0,120 | 1 | -0,008 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 104 | -17,296 | 114 | -1683,330 | 114 | -5318,120 | 115 | -31,540 |
| Total | 116 | 0,120 | 116 | -15,704 | 116 | -1615,230 | 116 | -5102,120 | 116 | -31,300 |

*Figure 41: Summary of potential gains for ARR to Frankfurt via GIMAX for DEM-002-04, DEMO-002-05 and DEMO-002-06*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 1 | 1,530 | 1 | 0,500 | 1 | 10,358 | 1 | 32,730 | 1 | 0,220 |
| Equal | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 14 | -503,182 | 14 | -87,558 | 14 | -3568,350 | 14 | -11275,860 | 14 | -34,304 |
| Total | 15 | -501,652 | 15 | -87,058 | 15 | -3557,992 | 15 | -11243,130 | 15 | -34,084 |

*Figure 42: Summary of potential gains for ARR to Frankfurt via LIMGO, shortest route assigned traffic FL and route change summary for DEM-002-07*

**Detailed report**

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 7 | 1.608 |
| Equal | 11 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 | 0 | 0.000 |
| Decrease | 0 | 0.000 | 11 | -24.706 | 11 | -946.410 | 11 | -2990.670 | 4 | -2.430 |
| Total | 11 | 0.000 | 11 | -24.706 | 11 | -946.410 | 11 | -2990.670 | 11 | -0.822 |

*Figure 43: Summary of potential gains for ARR to Frankfurt via LIMGO, simulated traffic based on m1 - FL changed from FL230-FL290 no route change summary for DEM-002-07*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 36 | 31,825 | 29 | 1287,140 | 29 | 4069,970 | 17 | 13,435 |
| Equal | 36 | -0,120 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 0 | 0,000 | 7 | -18,184 | 7 | -57,530 | 19 | -13,568 |
| Total | 36 | -0,120 | 36 | 31,825 | 36 | 1268,956 | 36 | 4012,440 | 36 | -0,132 |

*Figure 44: Summary of potential gains for ARR to Frankfurt via LIPMI for DEM-002-08*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 55 | 0,210 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 55 | -12,665 | 55 | -1190,850 | 55 | -3763,770 | 55 | -20,962 |
| Total | 55 | 0,210 | 55 | -12,665 | 55 | -1190,850 | 55 | -3763,770 | 55 | -20,962 |

*Figure 45: Summary of potential gains for ARR to Frankfurt via RIMET for DEM-002-10 (DEM-002-09 was FTS only)*

## 6.2.2 Conduct of Demonstration Exercise EXE-0103-002

### 6.2.2.1 Exercise Preparation

The EMPAX transition allowed a continuous descent giving in spite of its fixed constraints some flexibility due to its window structure.

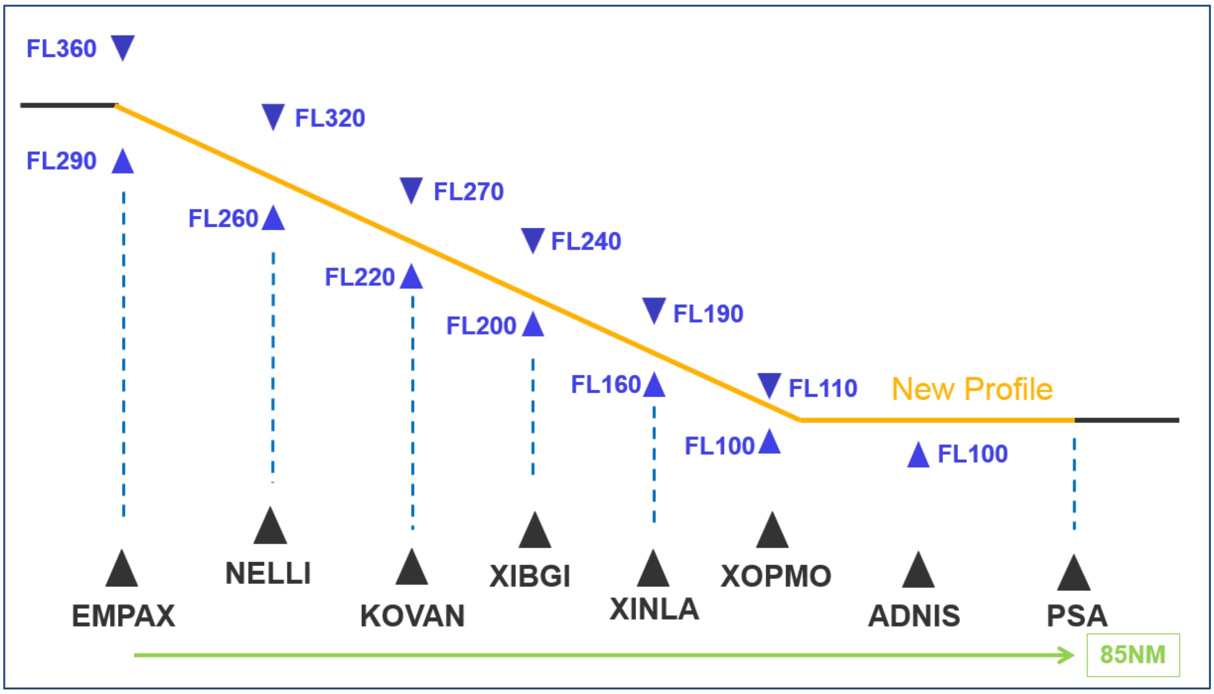



*Figure 46: EMPAX transition CDO vertical profile developed by ODP project team of DFS and DLH*

The following figures showing the trials overview.

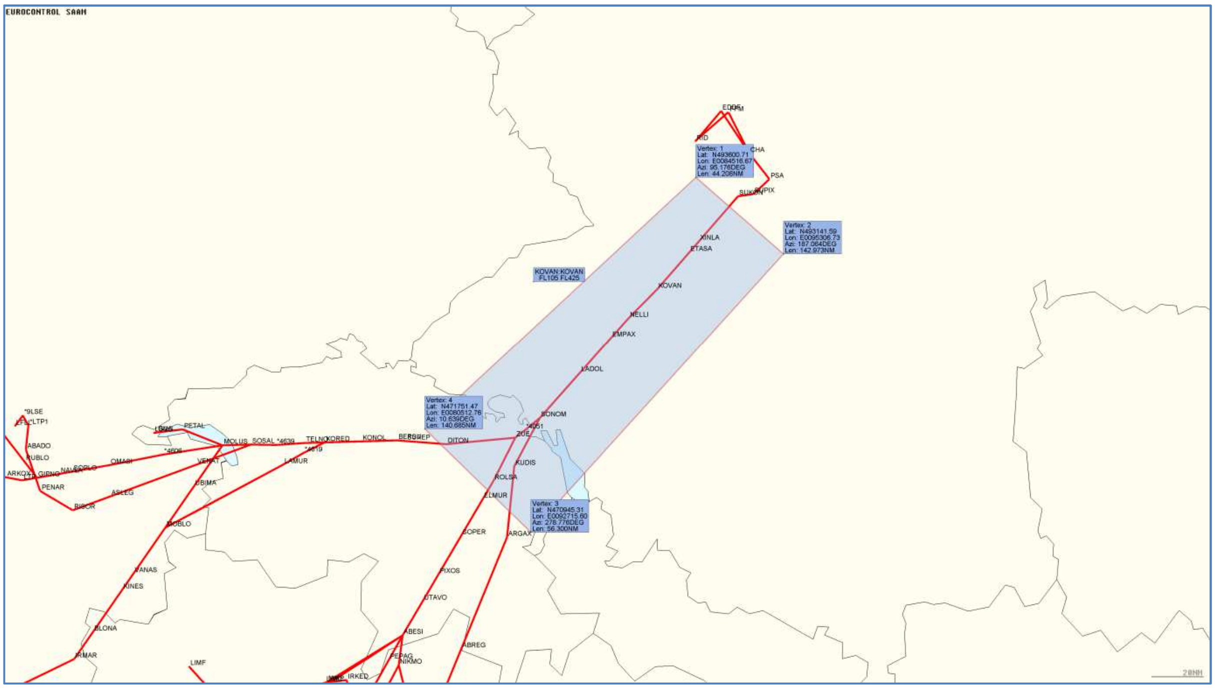


Figure 47: Trial overview and the measurement window to Frankfurt (EDDF) via EMPAX

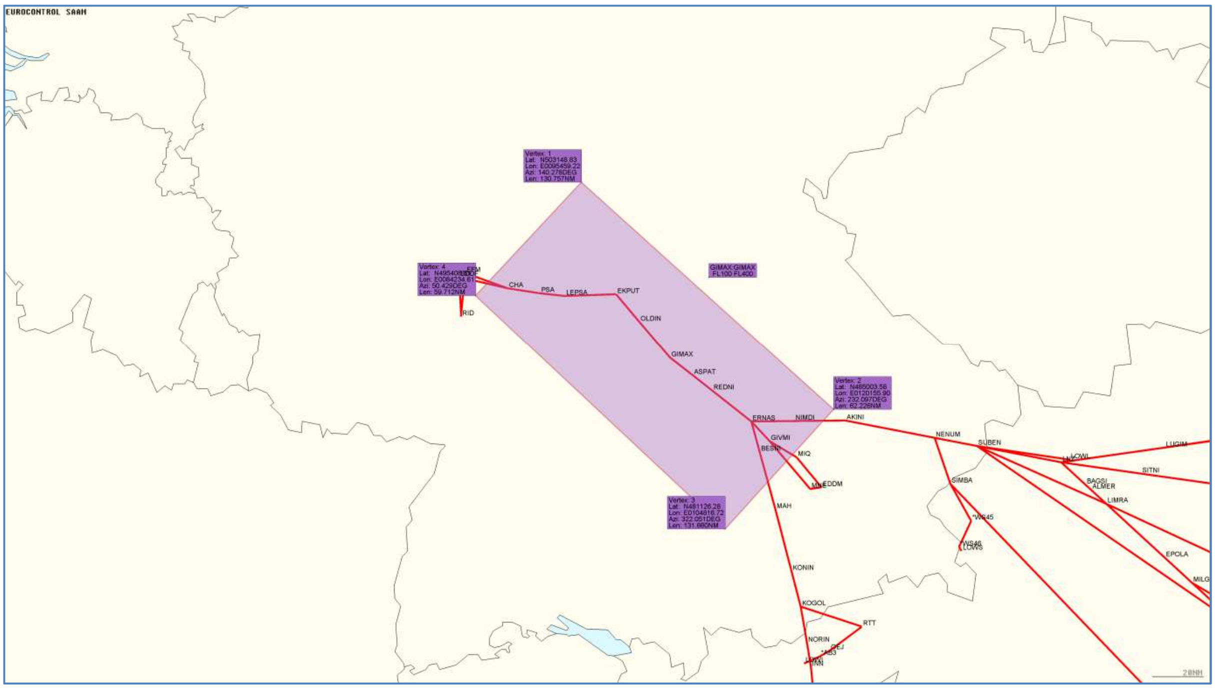



*Figure 48: Trial overview and the measurement window to Frankfurt (EDDF) via GIMAX*

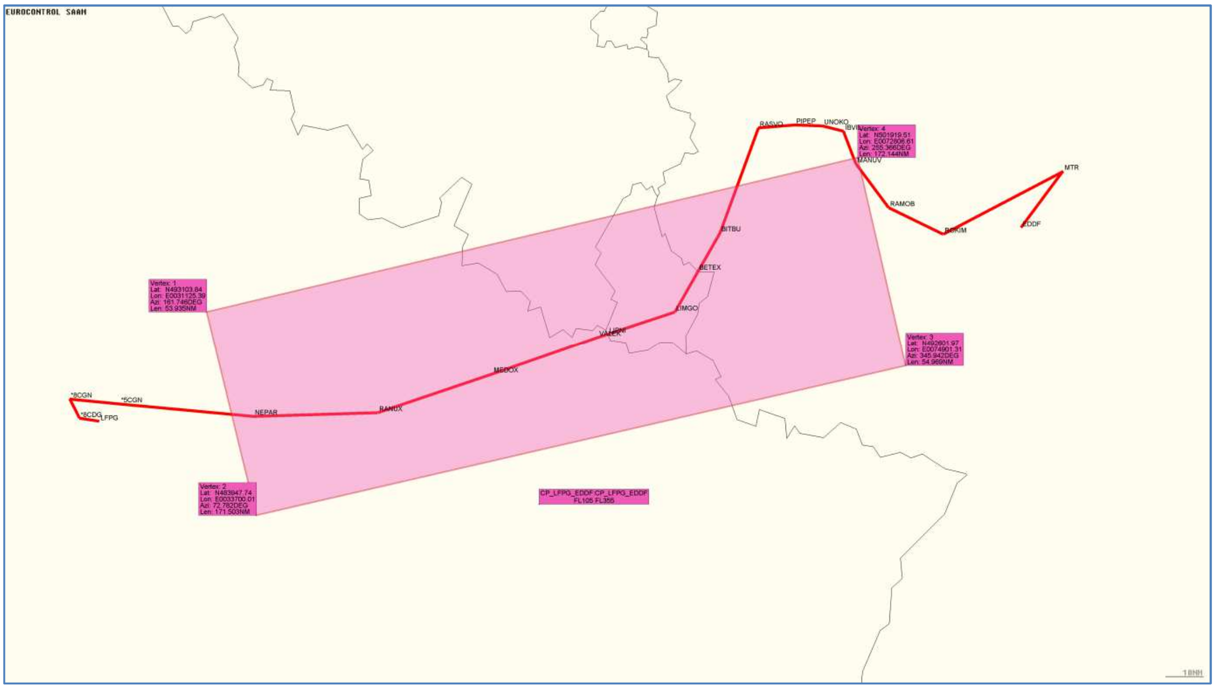



*Figure 49: Trial overview and the measurement window for the city pair Paris (LFPG) to Frankfurt (EDDF) via LIMGO*

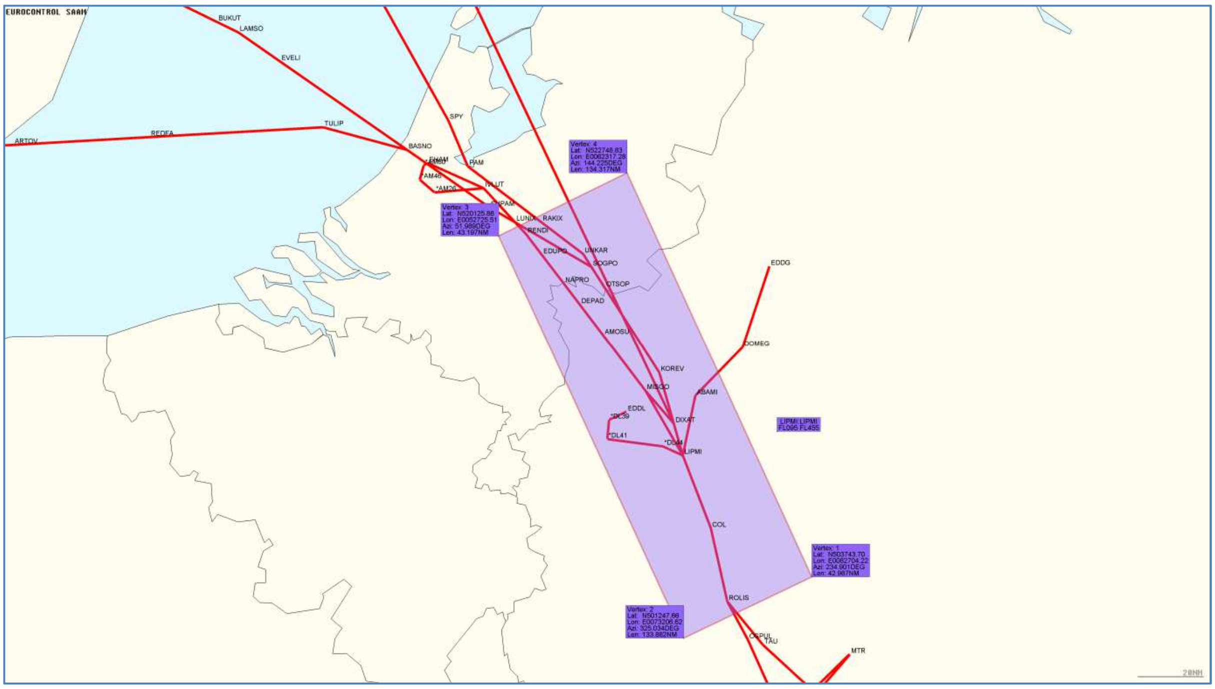



*Figure 50: Trial overview and the measurement window to Frankfurt (EDDF) via LIPMI*

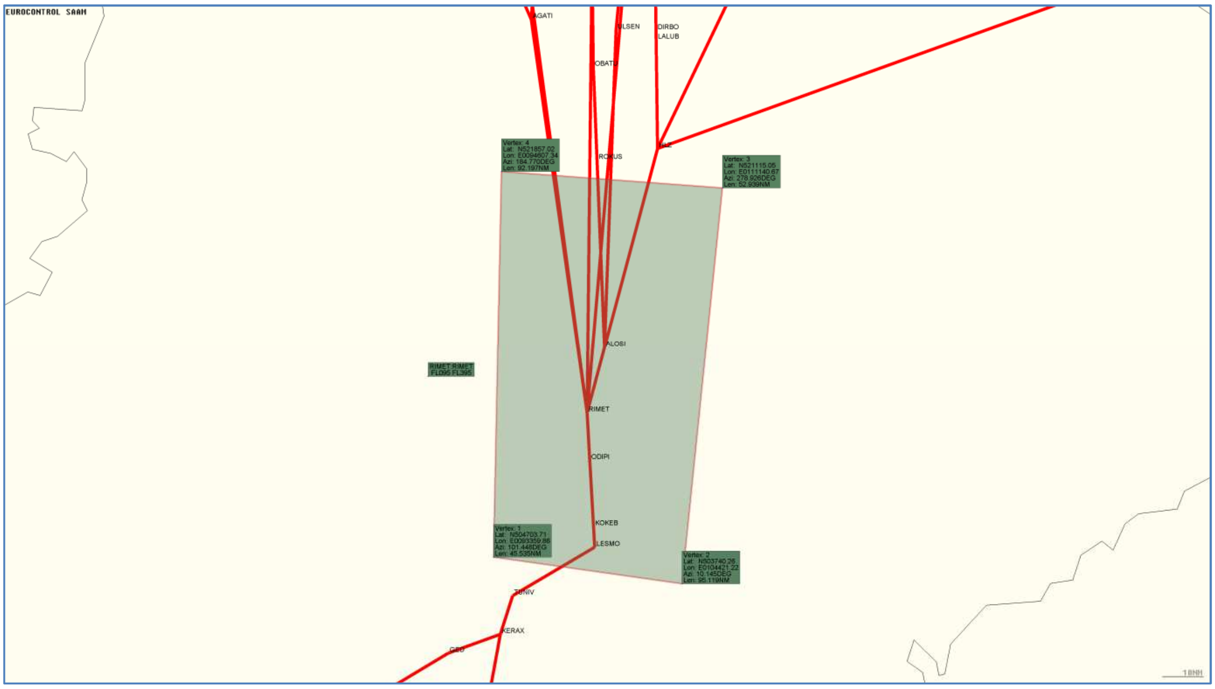



*Figure 51: Trial overview and the measurement window to Frankfurt (EDDF) via RIMET*

## 6.2.2.2 Exercise execution

## 6.2.2.3 Deviation from the planned activities

No deviation.

## 6.2.3 Exercise Results for DEM-002-01

### 6.2.3.1 Summary of Exercise Results

#### 6.2.3.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

##### 6.2.3.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.2.3.1.1.1.1 Performance Analysis

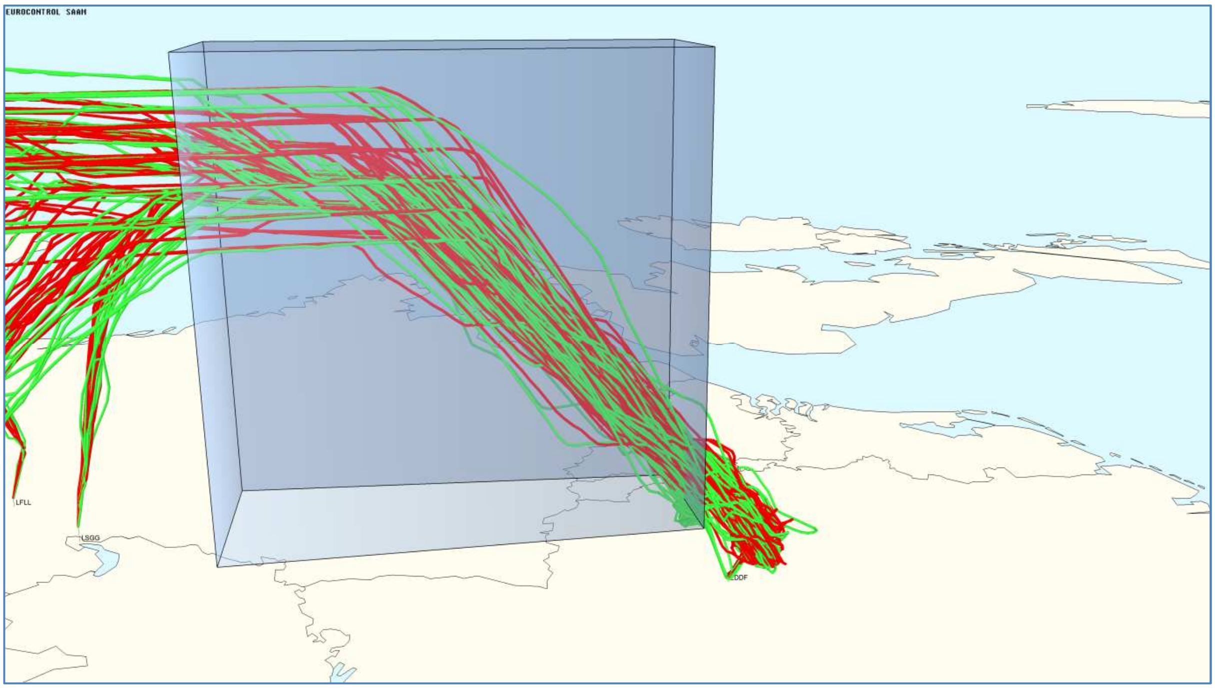



*Figure 52: Reference (red) and ODP (green) radar data recordings to Frankfurt (EDDF) via EMPAX*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-002-01 from SAAM perspective are summarized in Figure 34. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.2.3.1.1.1.2 Trajectory based Analysis using BADA

Due to the lack of other information it has been tried to conduct a trajectory based analysis using FANOMOS data and BADA look up tables. The Analysis has been conducted for the first trial which took place from 05th March to the 01st April 2015. During the trial ca, 43% of the flights potentially taking part in the trial were actually performing according the defined procedure. For the analysis flights that met the target were compared to those with a less optimal profile during this period.

Two flights were excluded from the analysis. One due to an unusual low flight level / cruising level at EMPAX below FL280 and the other due to unusual long flight track of more than twice the length of the distance between EMPAX and ADNIS (ca.155NM compared to 75NM).

The results for the aircraft types A333, A388 and B763 can be found in the following tables:

| | Trial | Reference | Delta |
|---|---|---|---|
| Mean in kg | 219,74 | 337,92 | 118,18 |
| SD in kg | 21,78 | 84,91 | 106,69 |
| N | 15 | 22 | |

*Table 21: calculated fuel consumption in kg based on BADA data between EMPAX-ADNIS for A333 from 05th March to 1st April 2015; N = number of flights, SD = standard deviation*

| | Trial | Reference | Delta |
|---|---|---|---|
| Mean in kg | 581,68 | 768,25 | 186,57 |
| SD in kg | 107,14 | 112,80 | 219,94 |
| N | 9 | 12 | |

*Table 22: calculated fuel consumption based in kg on BADA data between EMPAX-ADNIS for A388 from 05th March to 1st April 2015; N = number of flights, SD = standard deviation*

| | Trial | Reference | Delta |
|---|---|---|---|
| Mean in kg | 186,60 | 325,81 | 139,21 |
| SD in kg | 17,03 | 117,99 | 135,02 |
| N | 6 | 9 | |

*Table 23: calculated fuel consumption in kg based on BADA data between EMPAX-ADNIS for B763 from 05th March to 1st April 2015; N = number of flights, SD = standard deviation*

As it can clearly be seen, an indication of reduced fuel consumption for optimized profiles from EMPAX to ADNIS can be observed. However, it should be noted that the difference in fuel consumption between the flights that took actually part in the trial and the reference flights is of the same magnitude as the calculated uncertainties.

Furthermore, the conclusion drawn in chapter 5.3 should be kept in mind. Although references and trial flights have been taken from the same time period, thus reducing uncertainties regarding weather as much as possible, detailed weather information could not be taken into account, since the analysis is based mainly on trajectory information (position and time).

###### 6.2.3.1.1.1.3 Trajectory based analysis using FANOMOS

FANOMOS based trajectory analysis showed that ca 43% of the first trial (05th March to 01st April 2015) were able to meet the target, i.e. trajectories of those flights were within the predefined defined level constrains at given waypoints.

After the redesign of the procedure by adoption of the level constrains and reduction of number of waypoints within the procedure the target could be met for the 2nd trial to 100% for lateral constrains and ca. 98% for vertical constrains.

###### 6.2.3.1.1.1.4 Operational subjective Feedback

EDGG: The results of the trial show that the publication of a CDO procedure should be pursued. Most probably a decrease of controller's workload and thereby an increase in capacity can be achieved. The EMPAX-(CDO-) STAR (DEM-002-02) will be published WEF 13OCT2016.

Although the second trial showed excellent results regarding the compliance with the defined procedure it should kept in mind that the trial was only conducted during a portion of the day. Thus it cannot generally be concluded that this will be possible for 24h per day. However, the potential of meeting the target is clearly stated.

##### 6.2.3.1.1.2 Assessment Results by Airline Operator

###### 6.2.3.1.1.2.1 Performance Analysis

Lufthansa used its AVIASO tool to compare its fuel data with the FANOMOS data:
25 flights during the first trial month in March 2015 were used to compare actual and calculated fuel data.
Results: Real fuel data were greater at all flights (between 2 and 56%, in average 28,5%. The standard deviation was at 16%, whence no constant deviation between FANAMOS and actual data was detectable. Apparently short and undetected Level Offs or fuel consuming descent-rate reductions have a big influence on the total fuel used during the procedure.
Conclusion
The usage of todays FANAMOS data to assess a CDO initiative cannot be recommended due to the lack of descent rate sensitivity of the tool. As soon as new models are found these should be checked with airline operators' prior implementation.

###### 6.2.3.1.1.2.2 Operational subjective Feedback

#### 6.2.3.1.2 Results impacting regulation and standardisation initiatives

With the exception of the Aeronautical Information Publication and the corresponding German regulation (DVO, Durchführungsverordnung) no impact on regulation or standardisation initiatives are expected.

#### 6.2.3.1.3 Unexpected Behaviours/Results

For the first trial only 43% of the flights were able to comply the defined procedure, which was mainly caused by the number of waypoints and adhered constraints. However, the reduction of waypoints for the second trial led to a compliance of 100% for lateral and 98% for vertical constraints.

#### 6.2.3.1.4 Quality of Demonstration Results

The analysis of procedure monitoring/ compliance is based on radar data. Thus the uncertainties of radar information have to be considered.

#### 6.2.3.1.5 Significance of Demonstration Results

In order to measure the significance of the results three evaluation categories were used (see table below).

| Category | Description | Criteria |
|---|---|---|
| **A** | Result x is not sufficient for planning in a Large Scale Demo: more sample flights are needed | x < 68.26% (1σ) |
| **B** | The result x is sufficient for the planning in the Large Scale Demo | 68.26% (1σ) < x < 95.44% (2σ) |
| **C** | The result of the demo flight is excellent | x > 95.44% (2σ) |

*Table 24: Result evaluation scheme for the second EMPAX trial*

As it can clearly be seen from the table, all minimum requirements have been fullfilled for the second trial. Especially regarding the lateral and vertical criteria excellent results (category C) have been achieved.

| Parameter | | No of flights | percentage | min. requirement |
|---|---|---|---|---|
| **Actual clearances by ATC** | target | 149 | 100 | > 1σ of flights comply |
| | result | 124 | 83.22 | |
| **Number of entries in field 18** of the flight plan table | target | 149 | 100 | none |
| | result | 120 | 80.54 | |
| **Lateral compliance of the trajectory** | target | 124 | 100 | > 2σ of flights comply |
| | result | 124 | 100 | |
| Compliance of vertical **constrains with respect of waypoint tolerances** | target | 124 | 100 | > 2σ of flights comply |
| | result | 122 | 98.34 | |

*Table 25: Results for the second EMPAX trial*

## 6.2.4 Conclusions and recommendations

### 6.2.4.1 Conclusions

n/a

### 6.2.4.2 Recommendations

n/a

## 6.2.5 Exercise Results for DEM-002-02

### 6.2.5.1 Summary of Exercise Results

#### 6.2.5.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

###### 6.2.5.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.2.5.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-002-02 from SAAM perspective are summarized in Figure 34. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of *analysis tool.*

###### 6.2.5.1.1.1.2 Operational subjective Feedback

EDGG: The results of the trial DEM-002-01 showed that the publication of a CDO procedure should be pursued. Most probably a decrease of controller's workload and thereby an increase in capacity can be achieved. The EMPAX-(CDO-)STAR (DEM-002-02) will be published WEF 13OCT2016.

Karlsruhe UAC: As the implementation of the EMPAX STAR was delayed, no demonstration flights took place so far. According to the results of DEM-002-01 (Demo flights EMPAX Transition), it is expected that the CDO STAR will hamper the use of tactical directs.

###### 6.2.5.1.1.2 Assessment Results by Airline Operator

###### 6.2.5.1.1.2.1 Performance Analysis

During the procedure design and early trials the window constraints had to be adapted several times as it turned out that the FMS could not handle the closely stacked constraints under all conditions.

Due to the high amount of variables (WX, weight etc.) a pairwise evaluation of actual fuel data could not be performed. As comparable good profiles have been flown on a tactical basis before a fuel evaluation might not be meaningful. However the procedure will help to increase the amount of efficient descent profiles being flown into EDDF.

###### 6.2.5.1.1.2.2 Operational subjective Feedback

The HTO EMPAX procedure combines several advantages for the airlines once implemented:

- The procedure can be filed which means the planned fuel for the arrival will better match the actual fuel.
- The procedure gives the Flight Management and Guidance System (FMS) flexibility to fly an efficient profile through the usage of window constraints (see WP1 report).
- The procedure is once uploaded in the FMS easy to monitor for the pilot

#### 6.2.5.1.2 Results impacting regulation and standardisation initiatives

n/a

#### 6.2.5.1.3 Unexpected Behaviours/Results

n/a

##### 6.2.5.1.4 Quality of Demonstration Results
n/a

##### 6.2.5.1.5 Significance of Demonstration Results
n/a

### 6.2.6 Conclusions and recommendations

#### 6.2.6.1 Conclusions
The EMPAX-(CDO-)STAR (DEM-002-02) will be published WEF 13OCT2016.

#### 6.2.6.2 Recommendations
n/a

### 6.2.7 Exercise Results for DEM-002-03

#### 6.2.7.1 Summary of Exercise Results
n/a

##### 6.2.7.1.1 Results per KPA
A summary is provided in section 5 "Exercises Results" and 6 "Demonstration Exercises reports".

###### 6.2.7.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.2.7.1.1.1.1 Performance Analysis
The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-002-03 from SAAM perspective are summarized in Figure 34. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.2.7.1.1.1.2 Operational subjective Feedback
Feedback Karlsruhe UAC: Higher transfer level (raised from max FL340 to max FL360) from Zurich ACC to Karlsruhe UAC is possible when traffic demand is low. In high traffic situations it is hardly possible to descent the aircraft from FL360 to FL240 within the area of responsibility of Karlsruhe UAC. Additionally, in peak times Langen ACC requests the aircraft to be low earlier (NELLI at FL240 instead of standard handover KOVAN at FL240).

As a result, the transfer of traffic max FL360 during winter period is operational feasible and has no negative effects on KPA safety and KPA capacity.

###### 6.2.7.1.1.2 Assessment Results by Airline Operator

###### 6.2.7.1.1.2.1 Performance Analysis

The performance analysis had been done with the AVIASO tool. Actual flight statistics showed that the average altitude overhead SONOM has risen by 737ft, leading to the conclusion that approximately every third aircraft got the new altitude. Average fuel savings per flight are well below 10kg.

| Period | Average altitude overhead SONOM (ft) | # of flights |
|---|---|---|
| Summer (1.6.15-30.9.15 & 1.4.16-31.05.16) | 33186 | 2087 |
| Winter (1.11.15-31.3.16) | 33923 | 1559 |

###### 6.2.7.1.1.2.2 Operational subjective Feedback

With a remaining distance of around 125 NM to the clearance limit at PSA, where the aircraft has to be at FL110 all aircraft types would fly most efficient at CFL (according to WP1) overhead SONOM. The raise of the handover level during the winter time is therefore appreciated and should be checked again in future for further improvement.

#### 6.2.7.1.2 Results impacting regulation and standardisation initiatives

n/a

#### 6.2.7.1.3 Unexpected Behaviours/Results

n/a

#### 6.2.7.1.4 Quality of Demonstration Results

n/a

#### 6.2.7.1.5 Significance of Demonstration Results

n/a

## 6.2.8 Conclusions and recommendations

### 6.2.8.1 Conclusions

Transfer from Zurich ACC to Karlsruhe UAC is raised from max FL340 to max FL360 during winter period as permanent seasonal procedure.

### 6.2.8.2 Recommendations

n/a

## 6.2.9 Exercise Results for DEM-002-04

### 6.2.9.1 Summary of Exercise Results

#### 6.2.9.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

#### 6.2.9.1.1.1 Assessment Results by ANSP and Eurocontrol

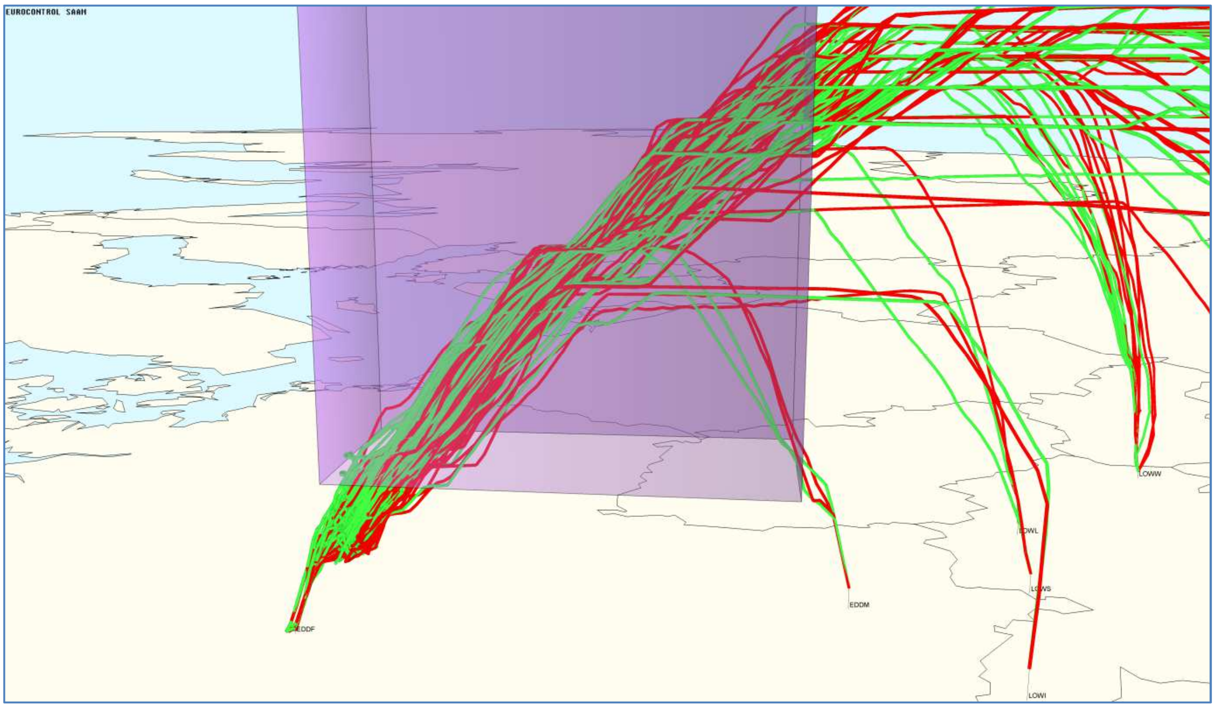



*Figure 53: Reference (red) and ODP (green) radar data recordings to Frankfurt (EDDF) via GIMAX*

##### 6.2.9.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-002-04 from SAAM perspective are summarized in Figure 35.

##### 6.2.9.1.1.1.2 Operational subjective Feedback

Feedback Munich ACC: With AIRAC 18AUG16 the new intersection GOLMO has been implemented on airway Y161. GOLMO is the new transfer point for ARR EDDF from the southeast via AKINI and the south via MAH from Karlsruhe UAC to Munich ACC. Flights via AKINI have a later descend by 10NM, flights via MAH have a later descend by 44NM. The responsibility for sequencing ARR EDDF from the southeast and south has been changed from the lower sector ALB (ALLERSBERG) to the upper sector DON (DONAU). Munich ACC has sometimes problems (especially in dense traffic situations with three or more ARR EDDF at the same time) to bring flights at the transferring point to Langen ACC which is 5NM after GIMAX at FL240 or below. Reason for this issue is that the distance between GOLMO and 5NM after GIMAX is only 36.3NM. An aircraft with 420kts IAS has approximately 5 minutes to loose 8000ft, in some cases 10000ft. Taking in consideration that the aircraft often need some time to establish the rate and reduce that rate already 1000ft before the cleared level, Munich ACC controllers have to work with rates of descend of 2500ft or more.

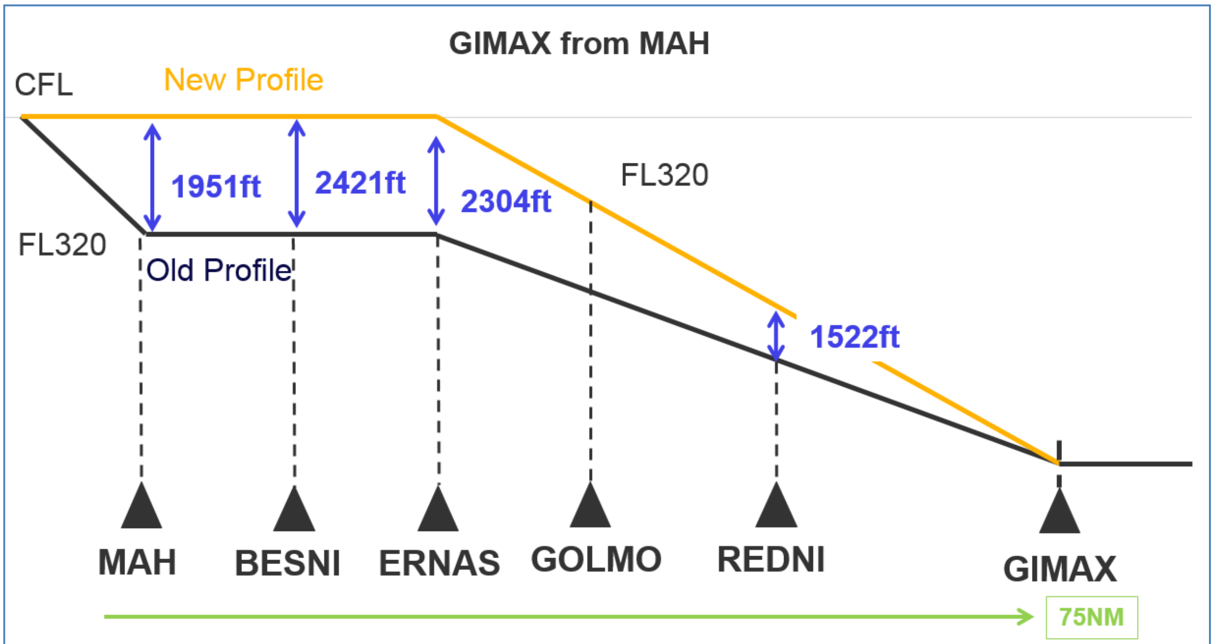
Feedback Karlsruhe UAC: The later handover from Karlsruhe UAC to Munich ACC (FL320 at GOLMO, i.e. 9 NM later for flights from the southeast, resp. 44 NM later for traffic via MAH) was implemented WEF 18AUG16. This generates additional traffic in the DON sector, but first feedback indicates that the workload is acceptable. There is clearly a conflict of aims between vertical flight efficiency on the one side and capacity on the other and fuel efficient flight operations shall not have negative effects on sector capacity.

Nevertheless, the ODP project was able to bring this Demonstration Exercises into implementation, unfortunately the official publication date is after ODP project close out.

##### 6.2.9.1.1.2 Assessment Results by Airline Operator

###### 6.2.9.1.1.2.1 Performance Analysis

Since implementation around 200 flights have been evaluated. In the graphics below one can see the raise of the average altitudes on the GIMAX flow. Aircraft coming from MAH had the greatest benefits and were actually raised by around two thousand feet, a difference held throughout the entire descent up to GIMAX.




| | | | | | | |
|---|---|---|---|---|---|---|
| **33813** | **32291** | **31383** | **30368** | **28448** | **new alt ft** | **23808** |
| 31862 | 29871 | 29079 | - | 26925 | old alt ft | 23555 |

*Figure 54: improved GIMAX profile via MAH*

Fuel calculations were done on a theoretical basis for the A320. 65 % of all flights on the MAH stream are this type of Aircraft. The calculation is split into two parts.

- One benefit is the later descent with the omission of the MAH constraint, which was found to take place around 35NM after MAH at ERNAS (the whole 44NM were not reached in the first flights (compare graphic). Aircraft OM-B performance tables calculate for an A320-211 at 90% MLAW and no wind conditions -8.6kg for 35NM at FL 340 instead of FL320

- The other benefit is a higher profile for the descent inbound GIMAX. In average the profile was 2050ft higher. With an A320 family average descent angle of 2.94° this leads to a theoretical level flight distance of 6,57NM. If this distance is flown at FL240 (GIMAX restriction) instead of being flown at CFL a surplus of 4,3kg of fuel is used.

In total the new MAH-ERNAS-GIMAX profile saves every A320 family Aircraft around 4,3kg+8,6kg= ~13kg of fuel.

Eurocontrol counted around 6400 DLH aircraft on the MAH routing during on year (1.9.2015 until 31.08.2016; 66% A320 family, 20% E95 and the rest other aircraft). The yearly gain of this improvement is roughly 70t.

The arrivals coming from the southeast towards ERNAS were only raised by 613ft overhead ERNAS, respective a 2NM later descent, leading to around 1,3kg fuel saved per A320 flight. The fuel calculation is based on actual flown altitudes combined with theoretical fuel values. As the day to day variation of the input parameters would boost the effort of a possible actual fuel value calculation, this mix gives already a good estimation of the expected actual benefits.

###### 6.2.9.1.1.2.2 Operational subjective Feedback

The removal of the early descent to comply with the MAH level capping was a big step towards the optimal profile on the GIMAX routing. The implementation of the GOLMO waypoint will pay off once the GIMAX restriction is handled more flexible (DEM-002-05 implementation).

#### 6.2.9.1.2 Results impacting regulation and standardisation initiatives

n/a

#### 6.2.9.1.3 Unexpected Behaviours/Results

n/a

#### 6.2.9.1.4 Quality of Demonstration Results

n/a

#### 6.2.9.1.5 Significance of Demonstration Results

n/a

### 6.2.9.2 Conclusions and recommendations

### 6.2.9.3 Conclusions

n/a

### 6.2.9.4 Recommendations

n/a

### 6.2.10 Exercise Results for DEM-002-05

#### 6.2.10.1 Summary of Exercise Results

##### 6.2.10.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

###### 6.2.10.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.2.10.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-002-05 from SAAM perspective are summarized in Figure 35. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.2.10.1.1.1.2 Operational subjective Feedback

EDGG: The publication of the respective STAR WEF 08DEC2016 is outside ODP timeframe. The use of the proposed procedure required a high amount of coordination workload and was therefore found to be not feasible.

###### 6.2.10.1.1.2 Assessment Results by Airline Operator

###### 6.2.10.1.1.2.1 Performance Analysis

WP1 results show that this restriction is up to 4000ft too low for A320 family aircraft.

###### 6.2.10.1.1.2.2 Operational subjective Feedback

DLH: With regards to capacity this restriction should, especially for short range aircraft be handled more flexible, which was not manageable within the timeframe of the project. If possible an airspace reallocation as discussed during the progress of the ODP project could be considered.

##### 6.2.10.1.2 Results impacting regulation and standardisation initiatives

n/a

##### 6.2.10.1.3 Unexpected Behaviours/Results

n/a

##### 6.2.10.1.4 Quality of Demonstration Results

n/a

###### 6.2.10.1.5 Significance of Demonstration Results

n/a

### 6.2.10.2 Conclusions and recommendations

### 6.2.10.3 Conclusions

n/a

### 6.2.10.4 Recommendations

n/a

## 6.2.11 Exercise Results for DEM-002-06

### 6.2.11.1 Summary of Exercise Results

#### 6.2.11.1.1 Results per KPA

A summary is provided in section 5 "Exercises Results" and 6 "Demonstration Exercises reports".

##### 6.2.11.1.1.1 Assessment Results by ANSP and Eurocontrol

n/a

###### 6.2.11.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-002-06 from SAAM perspective are summarized in Figure 35. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.2.11.1.1.1.2 Operational subjective Feedback

Feedback Karlsruhe UAC:

Only a few individual demo flights on tactical basis took place in the early morning hours when traffic was very low. The coordination workload between the three centres involved (Langen ACC, Munich ACC and Karlsruhe UAC) was very high and found not to be feasible.

##### 6.2.11.1.1.2 Assessment Results by Airline Operator

###### 6.2.11.1.1.2.1 Performance Analysis

None available from DLH.

###### 6.2.11.1.1.2.2 Operational subjective Feedback

Not applicable, since it was an ATC only trial test with some flights.

#### 6.2.11.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.2.11.1.3 Unexpected Behaviours/Results

None.

#### 6.2.11.1.4 Quality of Demonstration Results

Trials on a tactical basis make authoritative results difficult, as pilots might be in question of the intention of the open descent clearance.

#### 6.2.11.1.5 Significance of Demonstration Results

None.

### 6.2.11.2 Conclusions and recommendations

### 6.2.11.3 Conclusions

The checked profiles of this Demonstration Exercises were considered in the design and implementation of DEM-002-05 WEF 8DEC16.

### 6.2.11.4 Recommendations

See 6.2.11.3.

## 6.2.12 Exercise Results for DEM-002-07

### 6.2.12.1 Summary of Exercise Results

This Demonstration Exercises via LIMGO is for the city pair LFPG-EDDF. It has been identified and retained by the ODP partners as candidate for a higher flown cruising level (within upper airspace) in order to help assessing the benefits of ODP on the flight profiles of participating airlines (AFR ,operated by HOP under AFR callsign)

- The flow was flown on week-ends only (output of MUAC safety case, details see [19]) starting as from 16 January 2016 and extending till 27 March 2016 inclusive.
- Climbing > FL245 will be done based on ATC workload and complexity at the time of flight departure / coordination.
- The “standard” routing in upper airspace might have to be flown, but MUAC will check for DCTs with Langen ACC.
- There was no update to existing ATC publications.

No Pilots training was necessary for this ODP trial.

The scope of the ODP project is the following: “…to foster Continuous Descent Operations from the highest Flight Level possible (ideally this would be the Cruising Level) down to the destination airport allowing for a seamless and continuous descent across ACC/UAC boundaries and thereby improving Vertical Flight Efficiency”. This trial is going beyond this, in a very busy and complex airspace, by increasing the flown cruising level of certain flights on weekends.

#### 6.2.12.1.1 Results per KPA

A summary is provided in section 5 "Exercises Results" and 6 "Demonstration Exercises reports".

##### 6.2.12.1.1.1 Assessment Results by ANSP and Eurocontrol

The LIMGO trial for the city-pair LFPG-EDDF ended on 27 MAR 2016, in line with the agreed planning. The trial was run smoothly and no incidents were reported, which is already a very important and positive gain of this exercise.

| | | January | | | | | | February | | | | | | | | March | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date | 16 | 17 | 23 | 24 | 30 | 31 | 06 | 07 | 13 | 14 | 20 | 21 | 27 | 28 | 05 | 06 | 12 | 13 | 19 | 20 | 26 | 27 |
| C/S | EOBT | | | | | | | | | | | | | | | | | | | | | | |
| DLH8F | 06:05 | | X | | | | | X | X | X | | | | | | 270 | 290 | 290 | 310 | 270 | 270 | 380 | |
| AFR762G | 06:25 | | X | | X | X | | | | X | | 310 | 270 | 270 | 270 | 270 | 310 | | | | | 270 | |
| DLH6J | 07:55 | | | | X | | X | | | | X | 320 | 320 | 310 | 350 | | 300 | | 290 | | | | |
| AFR332X | 09:00 | | | | X | | X | | | | | | | | 270 | | 270 | | 290 | | | | |
| DLH9F | 10:00 | | | | | | X | | X | X | | | | | | | | | | | | | |
| AFR289F | 11:55 | | | | X | | | | | X | | | 270 | 270 | | | | 270 | | 290 | | 270 | |
| DLH1J | 13:40 | X | | | | X | X | | | X | | 290 | 290 | | 270 | | | | 290 | | | | |
| AFR221W | 16:15 | X | | | X | X | | X | X | X | X | 270 | 270 | | 290 | 290 | | 290 | 290 | 270 | 310 | | |
| DLH2F | 17:05 | | | | X | | | X | X | | X | | | | | 310 | | 270 | 290 | 270 | 290 | | |
| DLH1F | 18:30 | | | X | | | X | | | X | X | | | 270 | | 290 | | | | 290 | | 290 | |
| AFR277F | 20:00 | | | | | | | | | | | | 250 | | 250 | | | | 270 | | | | |
| | | 2 | 2 | 1 | 6 | 3 | 5 | 3 | 4 | 7 | 4 | 4 | 6 | 4 | 6 | 5 | 4 | 4 | 7 | 5 | 3 | 4 | |
| | | 22% | 18% | 11% | 55% | 33% | 45% | 33% | 36% | 78% | 36% | 36% | 55% | 36% | 55% | 45% | 36% | 36% | 64% | 45% | 27% | 36% | |

**Legend**

- (blank) = There is no evidence that the traffic was controlled by MUAC (according to available monitoring tools, including CHMI Archives)
- 270 = Traffic was taken at FL270 (done as from 20 FEB, as part of the follow-up)
- X = Aircraft was controlled by MUAC (according to available monitoring tools)
- (shaded) = Not scheduled on that day
- (orange) = MUAC supervisor suspended the trial (feedback)
- (red) = ATCO not able to accommodate traffic due to workload (feedback)

*Figure 55: city-pair LFPG-EDDF overview and % of successfully realised exercises*

| Day | Callsign | Participant | Description |
|---|---|---|---|
| 17.01.2016 | | MUAC | Trial suspended between 07.55 and 12.00 due to snow removal at EDDF |
| 17.01.2016 | AFR277F | MUAC | Could not be accommodated by ATCO due to heavy workload on LUX sector |
| 28.02.2016 | AFR277F | MUAC | Seen in CHMI climbing F250 but not controlled by MUAC |
| 28.02.2016 | AFR289F | AFR | Was the flight cancelled? No occurrence in CHMI (and no info to us) |
| 28.02.2016 | All day | Belgium | Severe turbulences whole day long in East part of Belgium (sector dealing with that traffic) |
| 05.03.2016 | All 07:40+ | MUAC | Severe turbulences in East part of Belgium (sector dealing with that traffic) --> trial suspended from 07:40 UTC till end of afternoon |
| 27.03.2016 | All | AFR/DLH | All callsigns changed.<br>6 a/c taken by MUAC: DLH7F, AFR718D, DLH2J, AFR1218, DLH6J, AFR518H |

*Figure 56: city-pair LFPG-EDDF trials occurrences*

###### 6.2.12.1.1.1.1 Performance Analysis

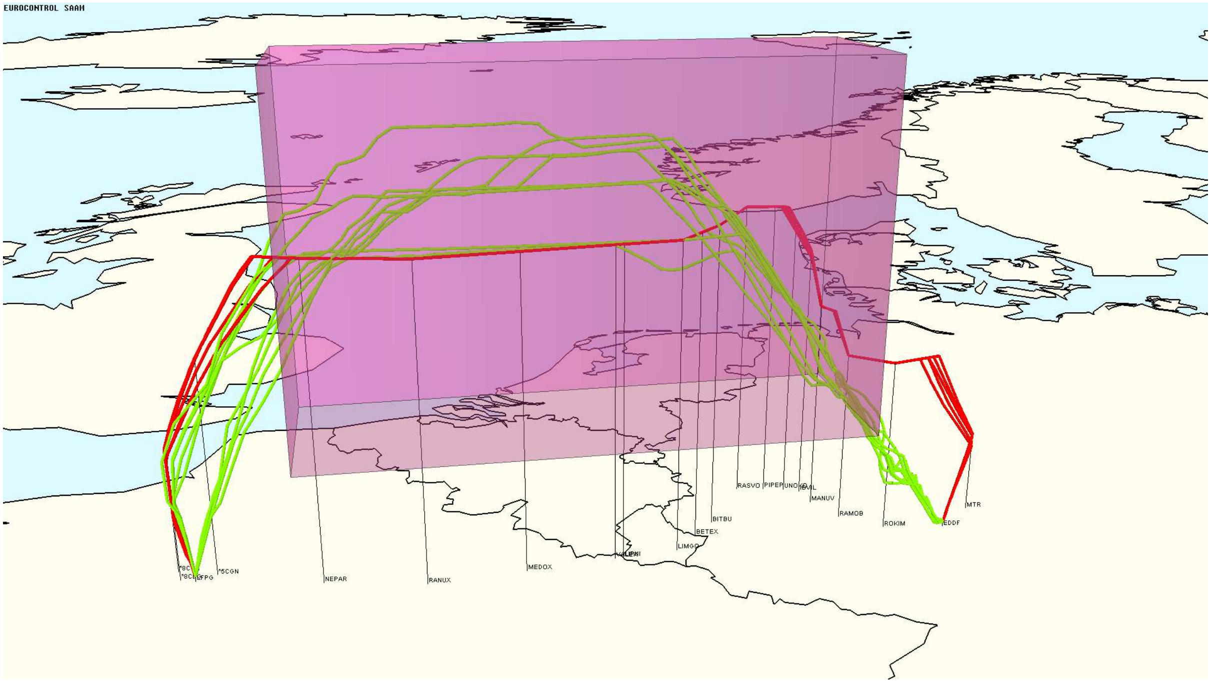



*Figure 57: Reference (red) and ODP (green) radar data recordings to Frankfurt (EDDF) via LIMGO*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-002-07 from SAAM perspective are summarized in Figure 43. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

### 6.2.12.1.1.1.2 Trajectory based Analysis with FANOMOS

For the trajectory based analysis with FANOMOS the spatial envelope which has been defined by Eurocontrol and which has been used for SAAM, was considered (see figures below). For the analysis one trial time frames (16$^{th}$ January to 27$^{th}$ March 2016) and one reference time frame (12$^{th}$ September to 22$^{nd}$ November 2015) have been compared. For both, the trail and the reference period only the weekends had been take into account, according to the flow definition.

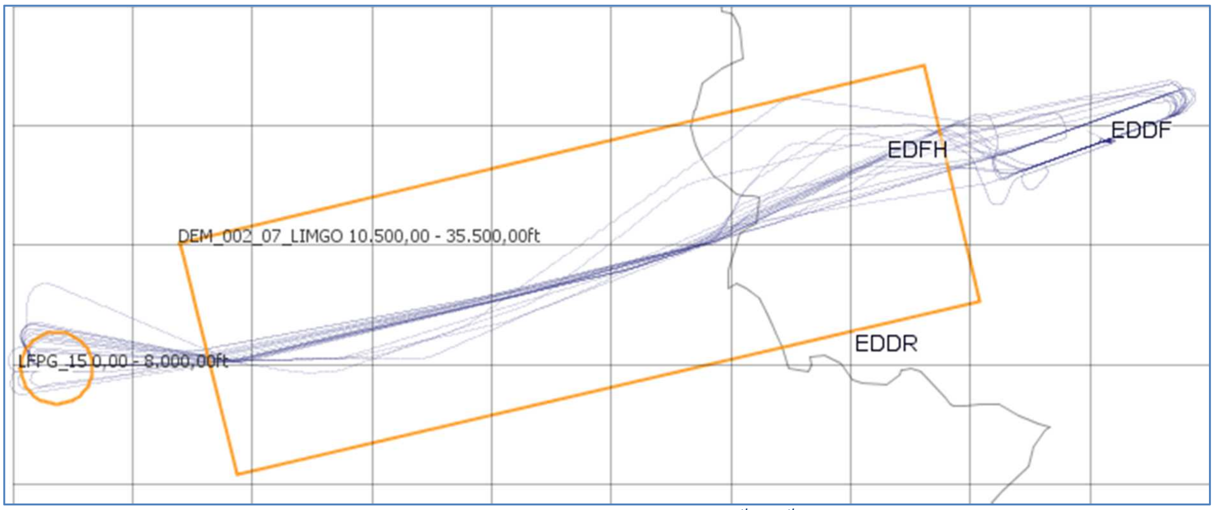



*Figure 58: Sample reference flights to EDDF for the weekend from 12th/13th September 2015*

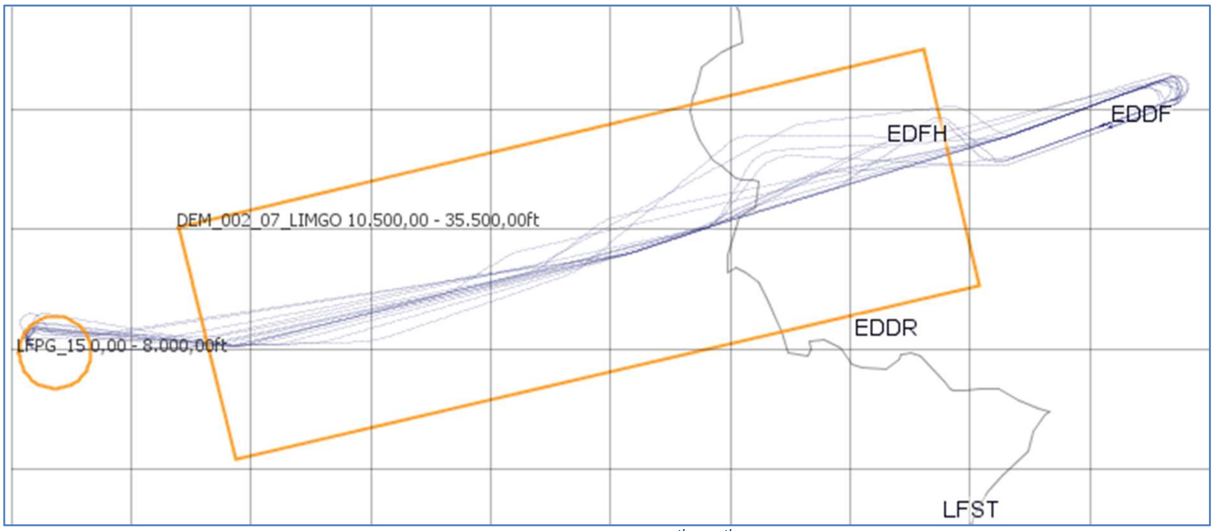



*Figure 59: Sample trial flights to EDDF for the weekend from 16th/17th January 2016*

The results of the analysis are shown in the tables below. Overall no significant change can be observed in horizontal flight efficiency which is indicated by the average flight time. Though a slight average decrease in indicated.

What's more a slight increase of the average mean and maximum barometric altitude (ISA) within the defined spatial envelope is indicated. As with the flight time this change is not significant. However, the observed mean and maximum flight levels seem to be within a wider altitude window compared to the reference.

| | reference | trial |
|---|---|---|
| **mean in s** | 1483 | 1470 |
| **SD in s** | 103 | 110 |
| **N** | 208 | 187 |

*Table 26: flight time in s within the defined spatial envelope; N = number of flights (sample size)*

| | reference | trial |
|---|---|---|

| | | |
|---|---|---|
| **mean in ft** | 21845 | 22855 |
| **SD in ft** | 1328 | 2015 |
| **N** | 208 | 187 |

*Table 27: average barometric altitude (ISA) in ft within the defined spatial envelope; N = number flights (sample size)*

| | reference | trial |
|---|---|---|
| **mean in ft** | 23816 | 25421 |
| **SD in ft** | 1944 | 3219 |
| **N** | 208 | 187 |

*Table 28: maximum barometric altitude (ISA) in ft within the defined spatial envelope; N = number flights (sample size)*

###### 6.2.12.1.1.1.3 Operational subjective Feedback

EDGG: No impact on EDGG.

EUROCONTROL Maastricht UAC: As per current operations, the option to tactically accept subject traffic in Maastricht airspace presented no operational issues for the MUAC ATCOs.

##### 6.2.12.1.1.2 Assessment Results by Airline Operator

###### 6.2.12.1.1.2.1 Performance Analysis

In total, the trial brought the following gains from HOP! point of view:

- FL OPTIMISED Savings of 4 % fuel by flight
- Descent OPTIMISED Savings of 0,58 % fuel by flight
- $CO_2$ ODP Savings of 0,58 % $CO_2$ emission by flight

The following special tasks were applied for this Exercises by HOP!:

- There was no safety assessment necessary needed from HOP! point of view for this Exercises.
- A Briefing on the operational workflow was given based on the following information:
  - Participating HOP! cockpit crews shall ask Paris ACC ATCO for a climb above FL>245.
  - Cockpit crew requests climb to Paris ACC.
  - Tactical routing via upper airspace (FL310 max) but FPL filed via lower airspace (as FPLs are filed today for this CP FL 230).
- A System FPL (SFPL) was created within the MUAC system containing the following route: RANUX UN858 VALEK UM163 DIK UT856 ADUSU T856 NIVNU T180 UNOKO

- Routing checked and validated
  - 68 HOP! AF flights INVOLVED
  - 55 % were operated > FL 245

**Performance Analysis and flight efficiency:**

1. Savings per flight:

(a) Methodology

To calculate the Flight efficiency savings, the following parameters have been considered:

- Embraer – Performance
- Filed Horizontal Routing
- statistical comparison between ODP flight and no ODP flight on the same day
- statistical comparison between ODP flight and no ODP flight on the same period weather
- Vertical profile:
- CDA or NO
- Time

| Baseline | "ODP" Profile |
|---|---|
| FL 230 | FL > 245 |

(b) Limitations

Fuel and time savings are depending of operational day conditions (FL, weight, wind, speed , DCT routing…. ). Using the flight planning editor, navigation log , CHMI profile, tools gives an average figure of the savings.

AF advised to HOP! not to use LIDO for this trial. The following three figures showing the different vertical profiles during and before the trial.

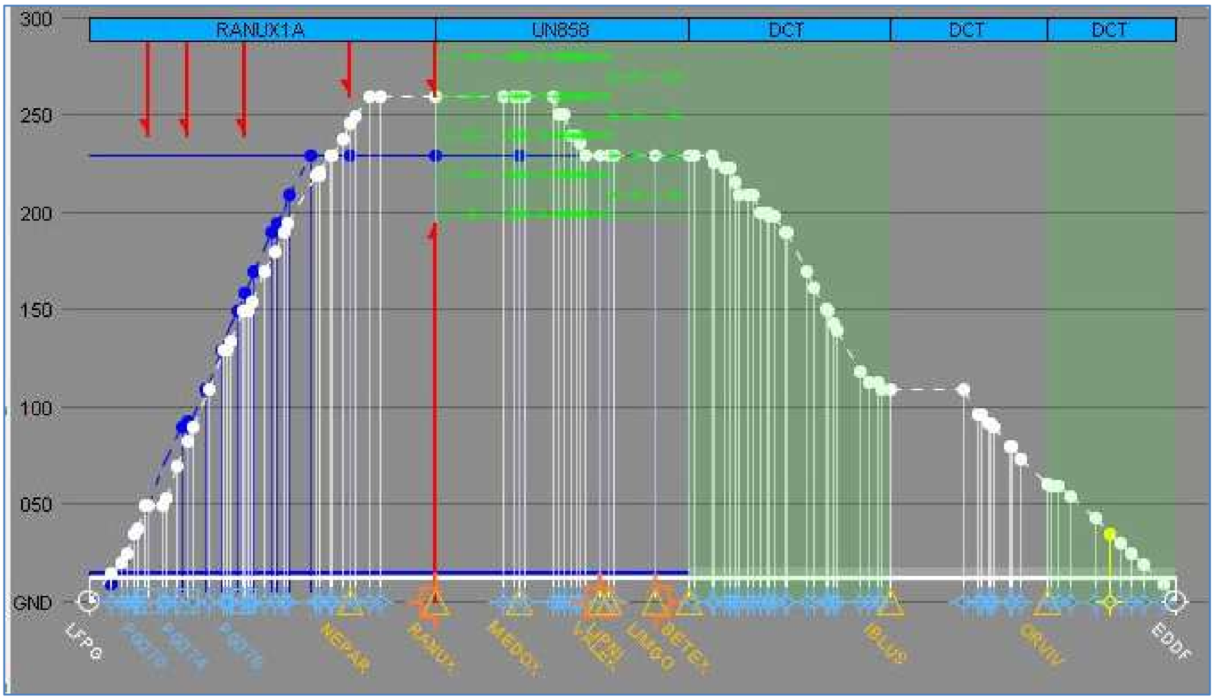



*Figure 60CDG-FRA FL 270, TOC: FL 270 and No 100% CDA*

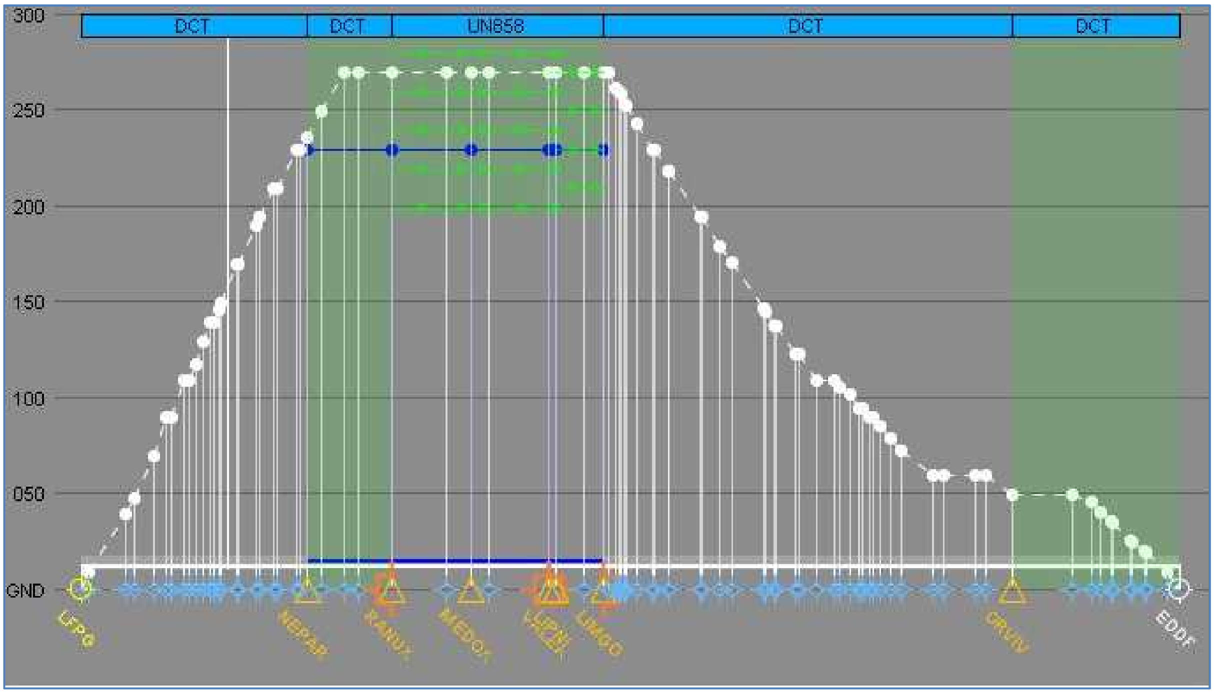



*Figure 61: CDG-FRA FL 270, TOC: FL 270 and CDA*

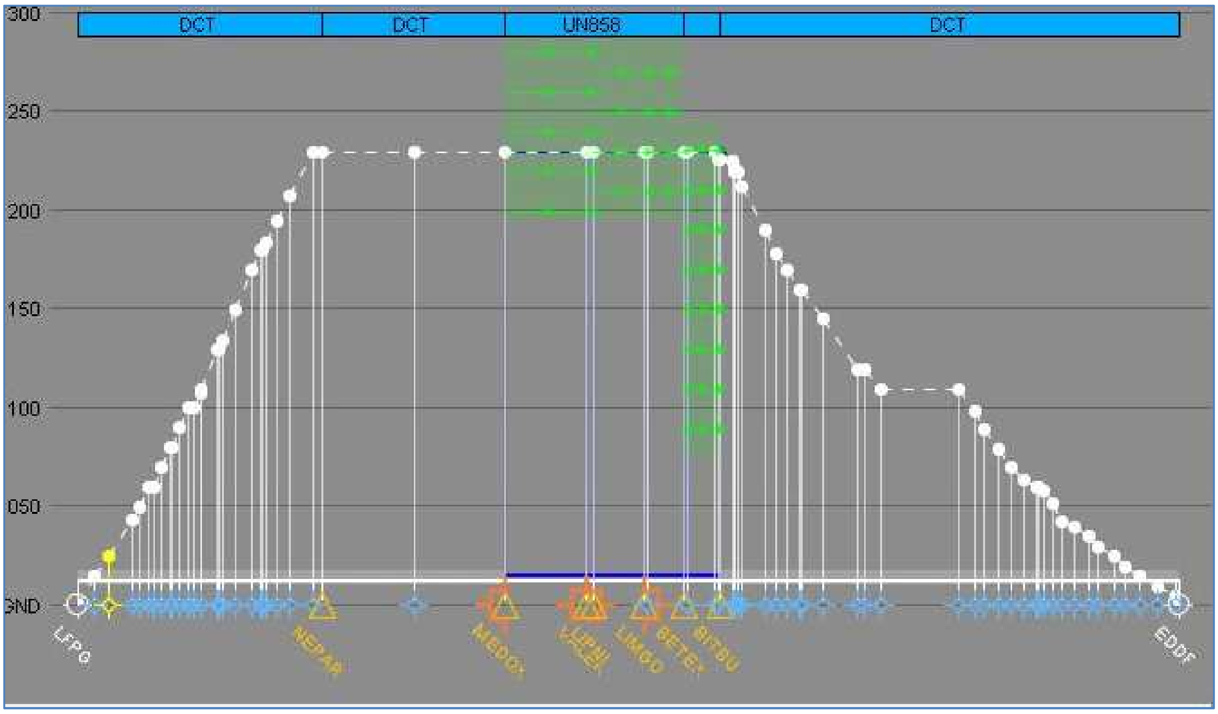



*Figure 62: Classical CDG-FRA FL 230*

The following table shows the average results for the Aircraft type EMBRAER EJET:

| Measure | Ejet Flights | 2016 | City -Pair | FL | Fuel Burn kg Average/flight | CO2 in kg | TBB[10] |
|---|---|---|---|---|---|---|---|
| ODP trial | 38 | From 16/01/2016 To 31/03/2016 | CDG- FRA | FL > 245 | 2.088 | 6.577,2 | 78 |
| Baseline | 30 | From 16/01/2016 To 31/03/2016 | CDG- FRA | FL 230 | 2.187 | 6.889,05 | 80 |

Considered parameters were
Aircraft weight: 39000 kg,
Temperature: ISA
MSC 320 KIAS

The first result shows a significant drop in fuel consumption equal to: 99kg per flight.
But this is a comprehensive income including both (horizontal and vertical profile), but also very important here the Flight level.

It is interesting to know what it is the part of the gain to the optimized descent on the CDG-FRA flight (excluding the horizontal savings).
Total Fuel savings (horizontal + vertical): AVERAGE 99kg / flight

[10] total block time

A cruise at FL Upper than FL 245 iso FL 230 is equal to 83 Kg saving by flight in average
The additional fuel necessary for the descent (with this new CFL) is:
1 minute FL100 = 2.7kg
1 minute FL70 = 4kg
1 minute FL50 = 4.7kg

AVERAGE ON CDG-FRA CRZ 230 ODP Saving to 5000 ft:

| Savings ODP Average CDG-FRA | |
|---|---|
| CRZ FL 230 | 12 kg / flight |

AVERAGE ON CDG-FRA CRZ > 245 ODP Saving to 5000 ft:

| Savings ODP Average CDG-FRA | |
|---|---|
| CRZ FL > 245 | 11 Kg /flight |

The following example illustrates a representative flight for the calculation results above.
On Saturday 13th February 2016, AFR221W operated by HOP! with the following flight plan N0435F230 RANUX1A RANUX UN858 BETEX Z110 RASVO T180 UNOKO UNOKO1L.
The following figure shows in blue color the flight plan and in white color the ODP trial execution.

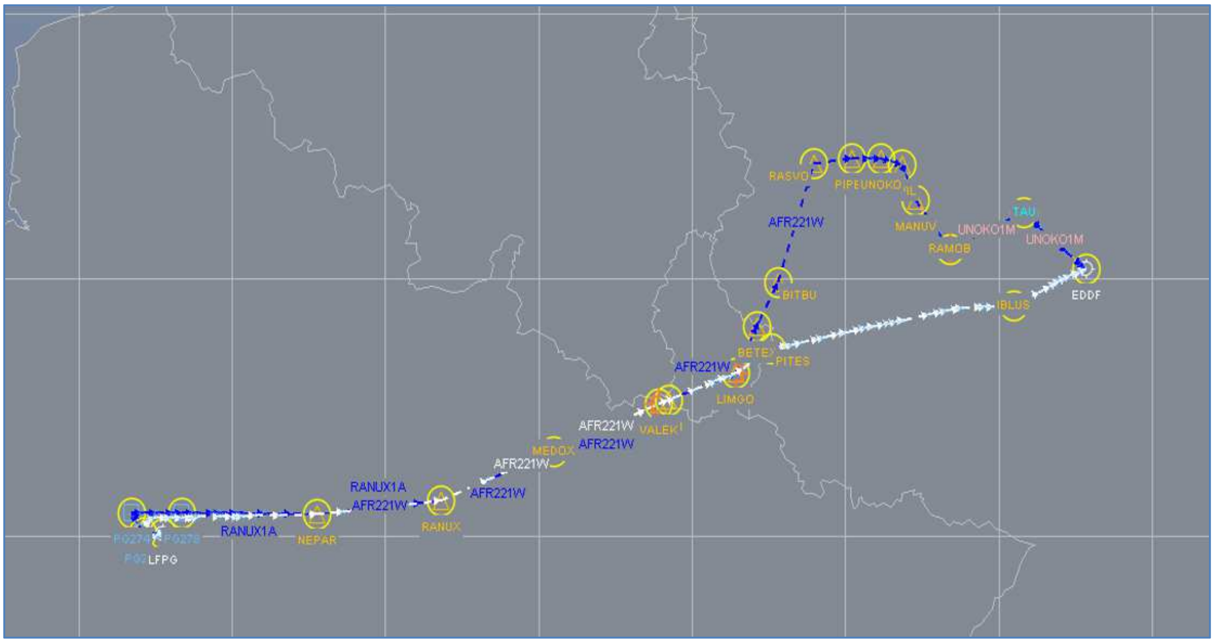



*Figure 63: FLP vs ODP trial, FL 270 After LIMGO PITES DCT IBLUS*

DLH: Lufthansa analysed with the help of AVIASO around 2000 flights (A320 aircraft) between January 2015 and September 2015, of which 260 climbed above FL230 and found that indeed every flight which is climbing above FL230 can expect a longer flight distance by around 8NM. Despite the longer flight distance, these flights saved in average 25kg of fuel, due to the vertical optimization.
This is a measured value: total fuel used as a function of altitude (<FL235 and >FL235). As the fuel consumption depends additionally on other factors (AC type, WX, etc. …) a difference to the AF numbers had to be expected and is due to additional influences (level cap induced or independent).

###### 6.2.12.1.1.2.2 Operational subjective Feedback

Any type of improvable change, such as optimised levels, tactical interventions and clearances are benefits for the airline operators.
However, compared to HFE gains, FL optimisation, VFE gains requires bigger efforts for preparation, design and implementation.

#### 6.2.12.1.2 Results impacting regulation and standardisation initiatives

No specific needs on this Exercise.

#### 6.2.12.1.3 Unexpected Behaviours/Results

The concept of operations for this trial stated that aircrew would request climb above FL245 when in contact with Paris ACC.

However, whether this request took place was not always recorded by the airlines concerned, therefore it is difficult to draw conclusions as to why a potential candidate aircraft did not climb above FL245.

#### 6.2.12.1.4 Quality of Demonstration Results

There was no specific issue concerning the quality of the results achieved in this exercise (see 6.2.12.1.3 above).

#### 6.2.12.1.5 Significance of Demonstration Results

For this trial, HOP! studied 68 flights. Results are considered as significant.

### 6.2.12.2 Conclusions and recommendations

### 6.2.12.3 Conclusions

HOP: In total 68 HOP! flights were studied on this flow CDG-FRA. We observed on that city-pair CDG-FRA, the trajectory optimization brings gains both vertically and horizontally and a continuous descent brings an average gain of 0,58 % of fuel savings. Further findings were:

- No negative impact on safety
- No crew training
- No additional OCC work load
- No AU invest

| | |
|---|---|
| FL OPTIMISED | savings of 4 % for fuel by flight |
| Descent OPTIMISED | saving 0,58 % for fuel by flight |
| $CO_2$ ODP Saving | savings of 0,58 % for fuel by flight |

EUROCONTROL Maastricht UAC: As stated in 6.2.12.1.1.1.2, the option to tactically accept subject traffic in Maastricht airspace presented no operational issues for the MUAC ATCOs. However, our experience was that we did not encounter more flights climbing above FL245 during the trial, than during normal operations.

#### 6.2.12.4 Recommendations

Every tactical optimization of a vertical profile creates even on certain times gains for fuel, CO2, sometimes time. This trial has showed an increase of flights climbing above FL245 on this city pair against to today's weekend operations.

At Maastricht UAC, Controllers had the impression that no more flights were climbing above FL245 during the trial, than during normal operations, we recommend that a change from current operations is not necessary.

Therefore, the HOP! project team recommends that this trail is further investigated and on short term a better awareness of Pilots requesting higher levels pro-actively.

Lufthansa is in line with the HOP! Project team and recommends to remove the level capping. DSNA Controllers and pilots should be sensitized to enable tactical climbs on this routing.

### 6.2.13 Exercise Results for DEM-002-08

#### 6.2.13.1 Summary of Exercise Results

##### 6.2.13.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

###### 6.2.13.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.2.13.1.1.1.1 Performance Analysis

No data was collected by EUROCONTROL Maastricht UAC. The aircraft were given the amended level restriction, ‘to be FL260 level by LIPMI’, but as the cleared level remained the same and transfer to the next frequency occurred in the same geographical area as prior to the trial, from a MUAC perspective there was no measurable change from pre-trial operations.

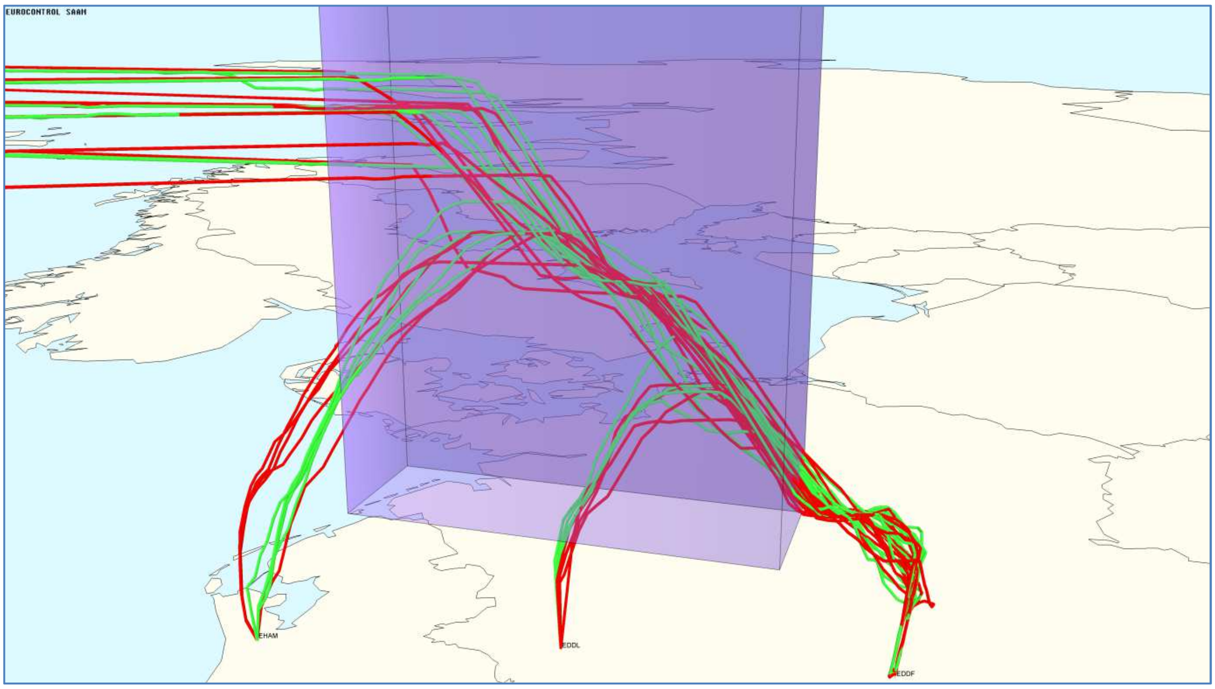



*Figure 64: Reference (red) and ODP (green) radar data recordings to Frankfurt (EDDF) via LIPMI*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-002-08 from SAAM perspective are summarized in Figure 44*Figure 44*. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

##### 6.2.13.1.1.1.2 Operational subjective Feedback

EDGG: The results of the demonstration showed that the later handover could be implemented permanently.

EUROCONTROL Maastricht UAC: We agree with the statement by EDGG – moving the level restriction to be level by LIPMI presented no operational issues.

### 6.2.13.1.1.2 Assessment Results by Airline Operator

#### 6.2.13.1.1.2.1 Performance Analysis

The ARR via LIPMI were actually improved by around a third of the foreseen altitude rise (see following graphic). An improvement beyond LIPMI was not realised.

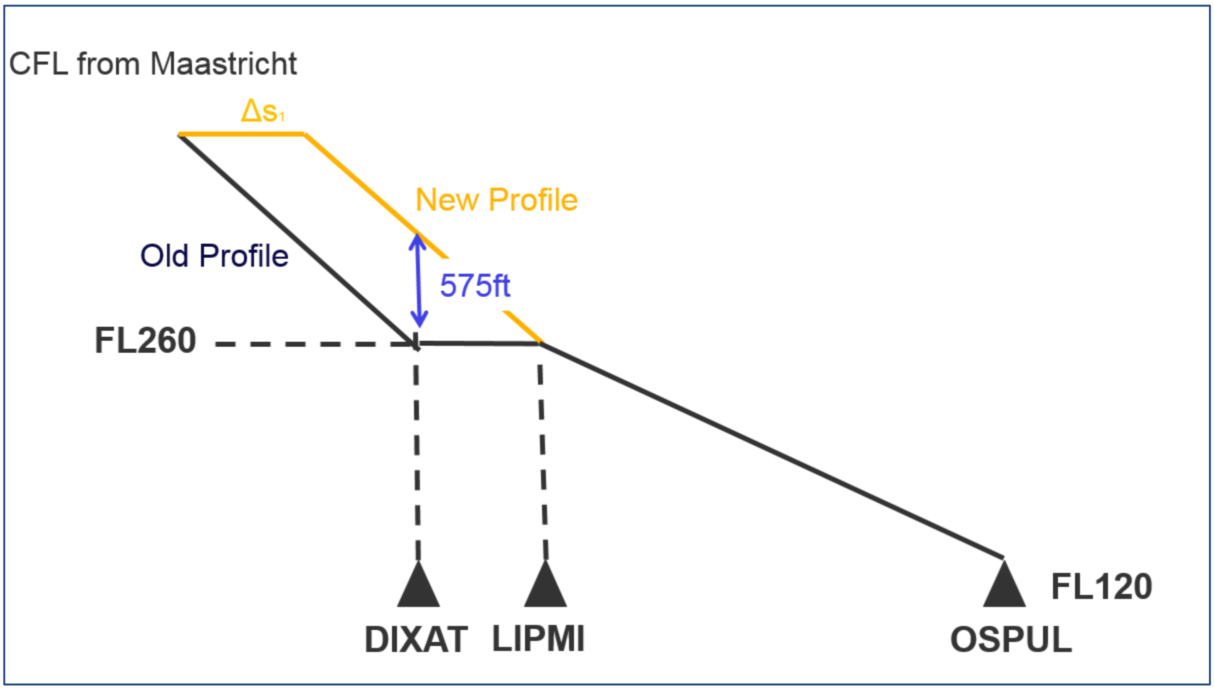



*Figure 65: The average altitude overhead DIXAT was raised during the project from 26334ft (November 2014 until February 2016) to 26909ft (April 2016 until July 2016*

##### 6.2.13.1.1.2.2 Operational subjective Feedback

The amendment of the LoA level restriction for aircraft to be FL260 at LIPMI, instead of FL260 level at DIXAT, resulted in an improvement in the aircraft's profile. As LIPMI lies approximately 12NM beyond DIXAT, it was expected that the average increase in the level that traffic crossed DIXAT would be higher than the actual measured improvement of 575ft. This measured increase equates to a shift in the level restriction by only 2NM beyond DIXAT, far below the theoretical 12NM. Reasons for this less than expected improvement could be because of tactical improvements already in place, as well as descent habits of the operational staff (controllers, pilots), or due to subsequent descent clearances which alter the established descent. The second improvement of this flow, implementation of a "descent at own discretion" clearance towards OSPUL was not measurable.

#### 6.2.13.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.2.13.1.3 Unexpected Behaviours/Results

None.

#### 6.2.13.1.4 Quality of Demonstration Results

*This section describes all issues concerning the quality of the results achieved in the Demonstration Exercise. In that regard quality could refer to both the accuracy of results and the confidence in the results, which might be influenced by decisions, constraints, and assumptions made at exercise level.*

None.

#### 6.2.13.1.5 Significance of Demonstration Results

None.

#### 6.2.13.2 Conclusions and recommendations

#### 6.2.13.3 Conclusions

EUROCONTROL Maastricht UAC: The procedure in the trial presented no operational issues for the MUAC ATCOs as there was no significant change from normal operations.

#### 6.2.13.4 Recommendations

The procedure has already been adopted within permanent operations - implemented 03/03/2016.

### 6.2.14 Exercise Results for DEM-002-09 (FTS only)

#### 6.2.14.1 Summary of Exercise Results

This Demonstration Exercise was a Fast Time Simulation, for details please refer to reference [13].

##### 6.2.14.1.1 Results per KPA

This Demonstration Exercise was a Fast Time Simulation, for details please refer to reference [13].

###### 6.2.14.1.1.1 Assessment Results by ANSP and Eurocontrol

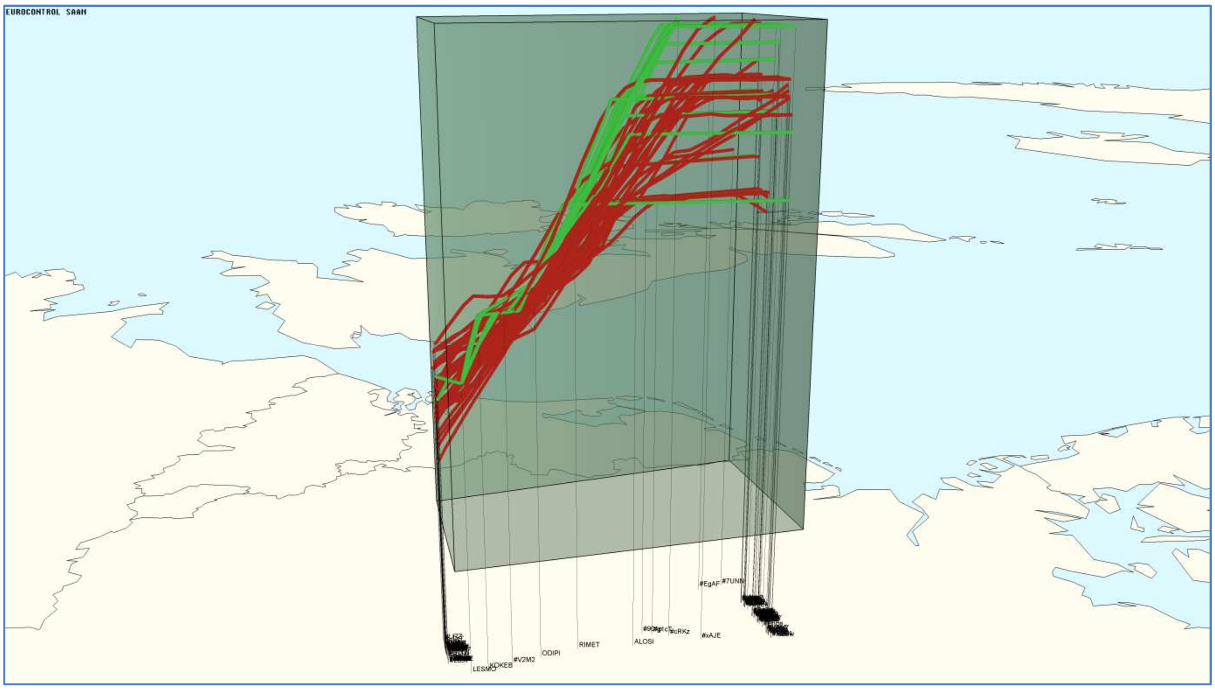



*Figure 66: Reference (red) and ODP (green) radar data recordings to Frankfurt (EDDF) via RIMET*

###### 6.2.14.1.1.1.1 Performance Analysis

This Demonstration Exercise was a Fast Time Simulation, for details please refer to reference [13].

###### 6.2.14.1.1.1.2 Operational subjective Feedback

n/a – not an operational trial, FTS only.

##### 6.2.14.1.1.2 Assessment Results by Airline Operator

###### 6.2.14.1.1.2.1 Performance Analysis

n/a – not an operational trial, FTS only.

###### 6.2.14.1.1.2.2 Operational subjective Feedback

n/a – not an operational trial, FTS only.

#### 6.2.14.1.2 Results impacting regulation and standardisation initiatives

n/a

#### 6.2.14.1.3 Unexpected Behaviours/Results

n/a

#### 6.2.14.1.4 Quality of Demonstration Results

n/a

#### 6.2.14.1.5 Significance of Demonstration Results

n/a

### 6.2.14.2 Conclusions and recommendations

### 6.2.14.3 Conclusions

EUROCONTROL Maastricht UAC supports the conclusions as stated in reference [13].

### 6.2.14.4 Recommendations

EUROCONTROL Maastricht UAC supports the recommendations as stated in reference [13].

## 6.2.15 Exercise Results for DEM-002-10

### 6.2.15.1 Summary of Exercise Results

The trial was suspended after 1 day. The reason for the suspension is that the procedure increases complexity. The traffic has a higher profile, therefore, most of the ODIPI flights cannot be given a tactical direct routing which is normally offered to the majority of the flights via RIMET. In addition, this complicates the sequencing of EDDF Inbounds which enter sector GED from 5 different sectors and have to be handed over with 8NM via a single point of transfer to Frankfurt APP. During the trial, sector HEF was responsible for separation between EDDF Inbounds via RIMET (which are not known to HEF) and Frankfurt departures. With the present airspace structure, this requires additional coordination for each Frankfurt departure and decreases capacity in the sector concerned.

Without an airspace re-design a trial in the RIMET area is difficult or impossible to handle.

### 6.2.15.1.1 Results per KPA

A summary is provided in section 5 "Exercises Results" and 6 "Demonstration Exercises reports".

#### 6.2.15.1.1.1 Assessment Results by ANSP and Eurocontrol

Data collection by EUROCONTROL NMD only.

##### 6.2.15.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-002-10 from SAAM perspective are summarized in Figure 45. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

##### 6.2.15.1.1.1.2 Operational subjective Feedback

EDGG:
The flights that were performed according to the agreed level restrictions showed an impact on other arrival flows, which had to be restricted additionally (lower handoff level from EDMM ACC).

Karlsruhe UAC:
No issue with the procedure. No airspace infringement reported. The flight profiles seem not to differ much during the trial. The actual trial period (one day) was too short for a clear statement, whether the procedure is feasible in regard to additional workload, complexity and safety or not.

EUROCONTROL Maastricht UAC: The trial procedure resulted in additional RT workload to pass the extra profile restrictions, as these were not published in the AIP.

#### 6.2.15.1.1.2 Assessment Results by Airline Operator

##### 6.2.15.1.1.2.1 Performance Analysis

The following figure shows the designed changes for the ARR via new published waypoint ODIPI.

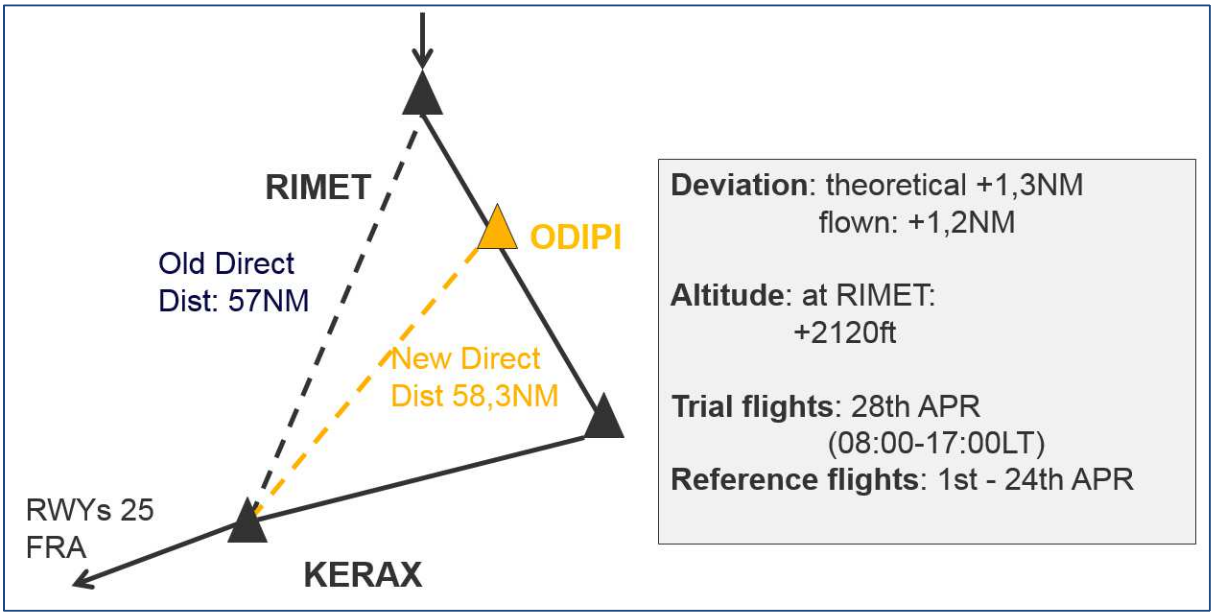



*Figure 67: simplified map on ARR via RIMET / ODIPI and the deviation*

Due to the complex structure of the RIMET trial (horizontal and vertical flow changes, other flows affected) DLH was happy to compare two different analysis methods on this flow, however the sample of 22 flights is very limited and the result of 15kg is arguable. (15 kg are within one standard deviation of 40kg of the average fuel used value on this route portion (due to large variance in input variables as weight, flown distance etc.).

➔ To be able to use real fuel numbers and get valuable statistics a bigger difference on the benefit overhead RIMET plus a greater sample would have been needed.

Nevertheless the methods and results are presented here:
Calculation with actual measured fuel values from the on board fuel flow detectors:
Measured Zone between 150 NM (shortly prior DLE VOR) and 30,0 NM (shortly after Gedern VOR) from EDDF

| | ODP Trial | Reference |
|---|---|---|
| Expected route | RIMET DCT KERAX | RIMET-ODIPI DCT KERAX |
| Exp. route length (GND corrected to match) | 57NM | 58,3NM (extra curve radius can be neglected <10°)) |
| Number of measured flights | 22 (1 B737, 21 A320family) | 432 (14 B737, 418 A320family) |
| Time frame | 28.4.2016 (06:00-15:00 Arrival time UTC) | 1.-24.4.2016 (24h) |
| Avg. altitude over RIMET | 26800ft | 24680ft |
| Extra Air Distance in Zone (due to Wind) | 3,1km | 5,7km |
| Delta(Air Distance) | 2,6km=1,4NM | |
| Fuel used in Zone | 561kg/flight | 583kg/flight |
| Delta Fuel | 22kg/flight | |
| Cost Index | 36 | 35 |
| Time in Zone | - | 0,338h |

| | | |
|---|---|---|
| Fuel Flow in Zone | - | 1692,5kg/h |
| Wind correction in Zone | | -6kg |
| Resulting delta fuel | 16kg/flight | |

*Table 29: calculation results for RIMET*

Alternative calculation (Actual altitude difference with theoretical fuel values):
Assumption: the actual altitude difference is used to fly a respective distance at cruise flight level instead at Transition Flight Level

| | |
|---|---|
| Altitude difference: | 2120ft. |
| A320 family average Descent angle: | 2,94° |
| Deltas= 2120ft/tan(2,94°): | 6,66NM |
| Fuel (6,66NM) at FL340 (CFL): | 33kg |
| Fuel (6,66NM) at FL110 (KERAX): | 50,4kg |
| Delta fuel: | 17,4kg |
| Fuel for 1,3NM (CFL): | ~6,4kg |
| Resulting Fuel Benefit: | 11kg |

The RIMET improvement brings around 10kg of fuel per short range flight.

##### 6.2.15.1.1.2.2 Operational subjective Feedback

Considering the potential savings on the RIMET flow, DLH recommends further investigations on how to optimise this flow without the negative impact on safety as experienced in DEM-002-10. As the demonstration lasted only one day, impact on capacity could not be assessed. The FTS in DEM-002-09 showed clearly, that an optimisation at this interface between four centres (Bremen ACC, Langen ACC, Karlsruhe UAC and Maastricht UAC) is very complex and the analysis should not be limited to one flow without considering effects on other flows.
From Airline Operator point of view: Due to the improvement of the RIMET flow arrivals via GAPLA had to be tactically 2000ft lower which was requested from the previous Munich sector.
AVIASO analysis showed 22 aircraft (almost the same amount) in the trial period being in average 429ft lower than aircraft in the reference period. In a worst case scenario these aircraft had to leave CFL earlier as well, than the calculation is 429/2120ft*17,4kg =4kg, which has to be deducted from the RIMET gain.
Assuming that Munich has given them a higher descent rate and initial descent within Karlsruhe UIR remained the same only 1 or 2kg per flight has to be deducted.

### 6.2.15.1.2 Results impacting regulation and standardisation initiatives

None.

### 6.2.15.1.3 Unexpected Behaviours/Results

The trial was suspended after 1 day

### 6.2.15.1.4 Quality of Demonstration Results

See 6.2.15.1.3 above.

##### 6.2.15.1.5 Significance of Demonstration Results

See 6.2.15.1.3 above.

### 6.2.15.2 Conclusions and recommendations

### 6.2.15.3 Conclusions

As the trial was suspended after 1 day, no conclusions can be drawn.

### 6.2.15.4 Recommendations

Considering the potential savings on the RIMET flow, DLH recommends further investigations on how to optimise this flow without the negative impact on safety as experienced in DEM-002-10. As the demonstration lasted only one day, impact on capacity could not be assessed. The FTS in DEM-002-09 showed clearly, that an optimisation at this interface between four centres (Bremen ACC, Langen ACC, Karlsruhe UAC and Maastricht UAC) is very complex and the analysis should not be limited to one flow without considering effects on other flows.

## 6.3 Demonstration Exercise SCN-0103-003 / Geneva (LSGG/GVA) Report

### 6.3.1 Exercise Scope

Development of Cross-Border CDO solutions for Geneva airport. The Initial proposals are referring to arrival flows involving – apart from Geneva ACC – Reims ACC, Karlsruhe UAC and Zurich ACC.

Procedures for Continuous Descent Arrivals into Geneva will be elaborated. The procedures will comprise a lateral routing and a vertical profile. The vertical profile will allow for Flight Level ranges at specific waypoints along the lateral routing.

| Initial CDO proposals via Routing | Details of change / ODP improvement | ANSPs involved |
|---|---|---|
| NATOR - LUTIX/BENOT | • Handover from Karlsruhe UAC to Zurich at FL350<br>• Descend when ready within Zurich airspace Note: Handover from Zurich to Geneva in descending depending on runway in use will not be followed up because of Safety Assessment results. | Geneva ACC, Zurich ACC, Karlsruhe UAC |

The current letter of agreement between DFS and Skyguide requires traffic inbound to LSGG via NATOR to be pre-descended to FL310 by Rhein Radar before being handed over to Swiss Radar.

During this ODP-trial the handover level was temporarily lifted to FL350. The trial took place on the weekend of February 13th and 14th.

The GD (ground distance) from NATOR to threshold RWY23 at LSGG along the published route is approximately 150nm. From a flight crew's point of view NATOR is clearly part of the cruise phase of the flight and not of the descent phase. It is only due to instruction based on ATC-requirements that a pilot will leave the flight's final cruising altitude before NATOR.

Routing & profile for a straight-in approach to RWY23:

NATOR to RWY23: NATOR – OLBEN – BENOT – NEMOS – VADAR – SPR – ILS (glide path intercept)
GD (ground distance): 132nm

Handover conditions (regardless of RWY in use):
Rhein Radar to Swiss Radar: NATOR FL310
Swiss Radar UAC ZRH to Swiss Radar ACC GVA: BENOT FL250 (released for descent)

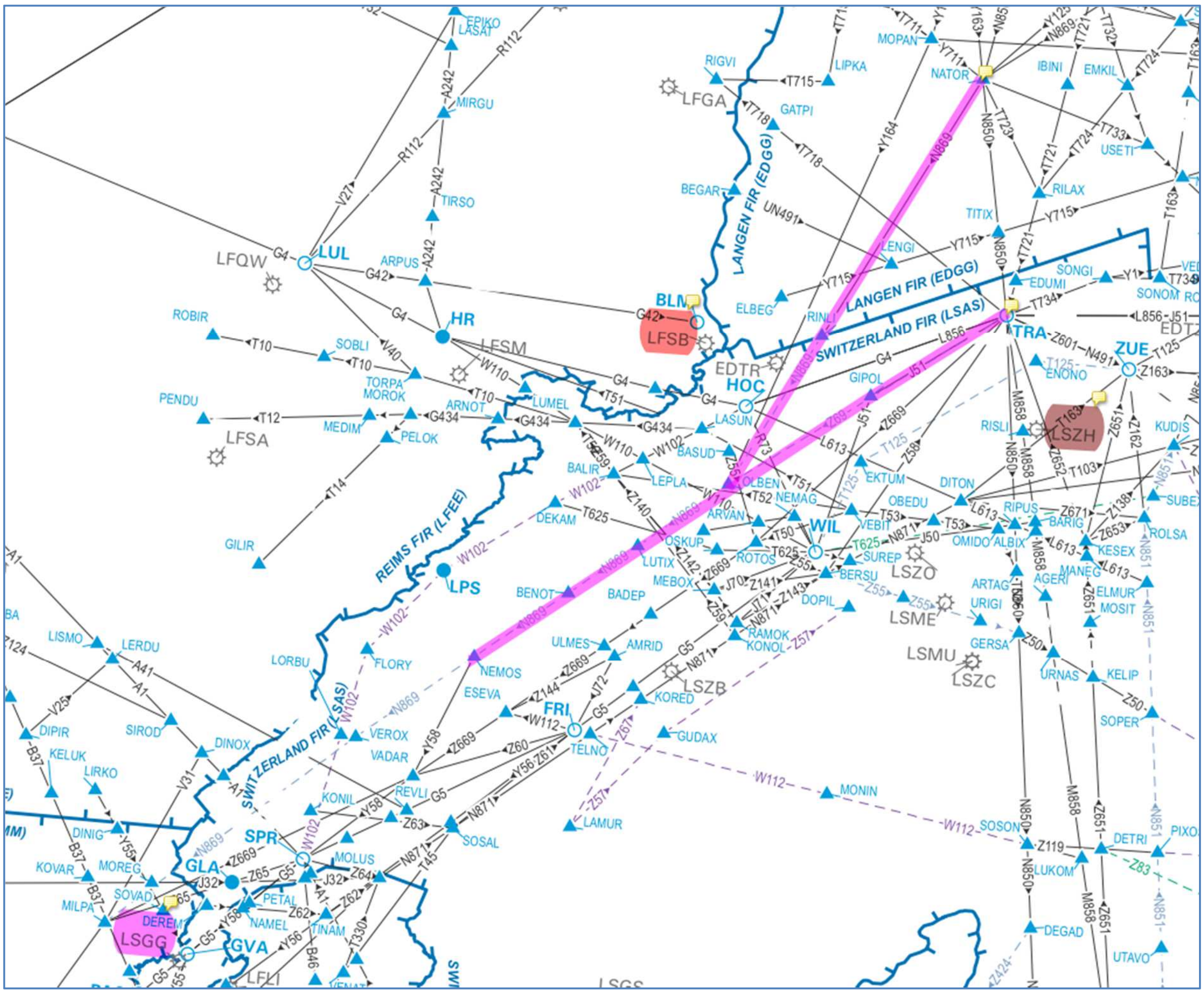



*Figure 68: Trial overview NATOR to Geneva (LSGG) SCN-0103-003/ EXE-0103-003/ DEM-003-01 (chart based on [21])*

Overall SAAM calculation results for EXE-0103-03 are as follows:

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 18 | 0,378 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 19 | -0,020 | 1 | -0,004 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 0 | 0,000 | 19 | -72,510 | 19 | -229,060 | 19 | -1,408 |
| **Total** | 19 | -0,020 | 19 | 0,374 | 19 | -72,510 | 19 | -229,060 | 19 | -1,408 |

*Figure 69: Summary of potential gains for ARR to Geneva via NATOR for EXE-0103-003*

## 6.3.2 Conduct of Demonstration Exercise EXE-0103-003 and DEM-003-01

Since there is just one Demonstration Exercise the Exercise and the appropriate Demonstration number are in a 1:1 relationship, meaning that EXE-0103-003 equals DEM-003-01.

### 6.3.2.1 Exercise Preparation

*Provide here with the configuration of the V&V Platform/systems/tools/simulators used for this exercise.*

The analysis of the descent profile includes 3 aspects:

1. Descent profile validation
2. Impact of FL-limitations on flight profile calculation

3. Flight data analysis

## Flight data analysis

For flight data analysis, data of all flights operated with Airbus A320-family aircraft via BENOT between January 1st and March 28th were analysed. The Trial phase took place on the weekend of February 13th and 14th has been compared with the pre-trial and post-trial phase (see Table 16).

The following flights were not considered in order to ensure the comparability of data:

- Approaches to RWY05
  The pilots' descent technique changes when the landing runway lies more than 50nm further away than the straight-in option
- Flights with a head- or tailwind component in excess of 60kt during descent
  This filters out flights that were subject to extreme weather conditions
- Flights operated with A321 aircraft
  In order to compare flights with similar engine performance factors. Flights during the trial period providing valid data were operated with A319 and A320 aircraft only
- Flights without recorded data at either OLBEN or BENOT, mainly caused due to major fly-bys (e.g. due weather)

In order not to obtain false and incomparable results for fuel consumptions, only the flight segment between NATOR and BENOT is considered for fuel-comparison.

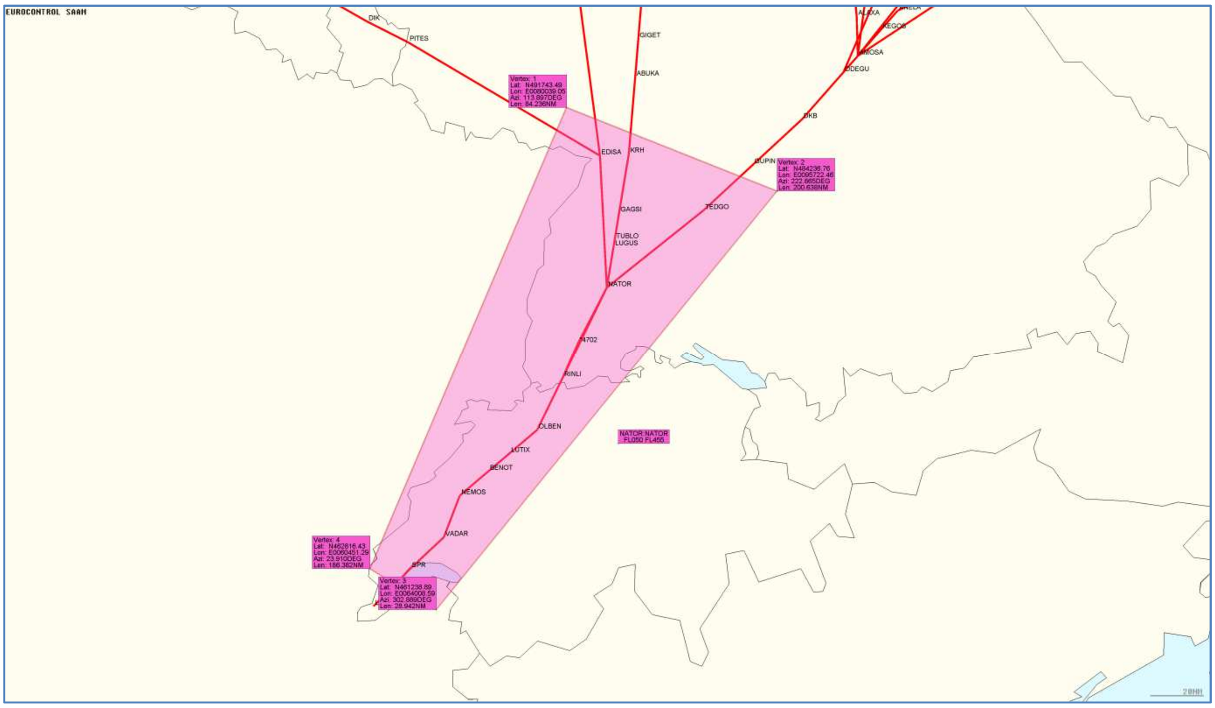



*Figure 70: Trial overview and the measurement window to Geneva (LSGG) via NATOR*

### 6.3.2.2 Exercise execution

To validate the handover level at BENOT, an optimum descent profile was calculated from FL390.
Statistically, BENOT is mainly crossed at around FL227.
Based on the following assumptions, the TOD can be calculated using Airbus' LPC NG (Less Paper Cockpit Next Generation) software.

- AIRBUS 320-214
- In-flight performance module of EFB (electronic flight bag) version V5210029/20160531
- Gross weight at TOD 60'000kg
- ISA-conditions
- Descent speed M.778 / 262kt
- TOD FL390
- Position BENOT between FL220 and FL250
- Glide path intercept (18nm long final RWY23) at 7'000ft and 210kt

**From FL390 to 7'000ft (glide path intercept), a track distance of 97nm is required under the conditions specified above.**

Modern FPM (Flight Planning Manager) software calculates the aircraft's most economical profile from lift-off from the expected departure runway to touchdown on the expected arrival runway. It takes all known constraints, such as RAD restrictions, into account. It can also be tailored by the user and fed with statistical data.

On 13th/14th February 2016, a total of 11 flights (3 A319 and 8 A320) operated by SWISS International Air Lines participated in the trial. All flights were calculated 3 times using the same weights and atmospheric model. On all profiles, the only reason for different trip fuel calculation could be allocated to the restricting altitude at NATOR.

Examples of flight profiles calculated by SABRE FPM (all input data, except the FL restriction at NATOR, are the same):

| | NO **FL-restriction NATOR** | FL350 **at NATOR** | FL310 **at NATOR** |
|---|---|---|---|
| **UUDD-LSGG23** | F360 WAR/F380<br>TEDGO/F390 | F360 WAR/F380<br>TEDGO/F370<br>NATOR/F350 | F360 WAR/F380<br>TEDGO/F370<br>NATOR/F310 |
| **ESSA-LSGG23** | F380 BAGOS/F390 | F380 BAGOS/F390<br>NATOR/F350 | F380 BAGOS/F390<br>NATOR/F310 |
| **LKPR-LSGG23** | F380 TEDGO/F390 | F380 TEDGO/F370<br>NATOR/F350 | F380 TEDGO/F370<br>NATOR/F310 |

#### 6.3.2.3 Deviation from the planned activities

No deviations from the planned trial activities.

### 6.3.3 Exercise Results

#### 6.3.3.1 Summary of Exercise Results

The desirable TOD from FL390 for a moderately heavy A320 (60'000KG, ISA, CAS 262KT) is ~35nm after NATOR. Any descent before NATOR must be considered as step descent impacting the cruise of the flight.

Limiting early pre-descents out of cruise phase as much and as often as possible is one of the best means to reduce the overall fuel consumption generally allocated to descents.

##### 6.3.3.1.1 Results per KPA

###### 6.3.3.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.3.3.1.1.1.1 Performance Analysis

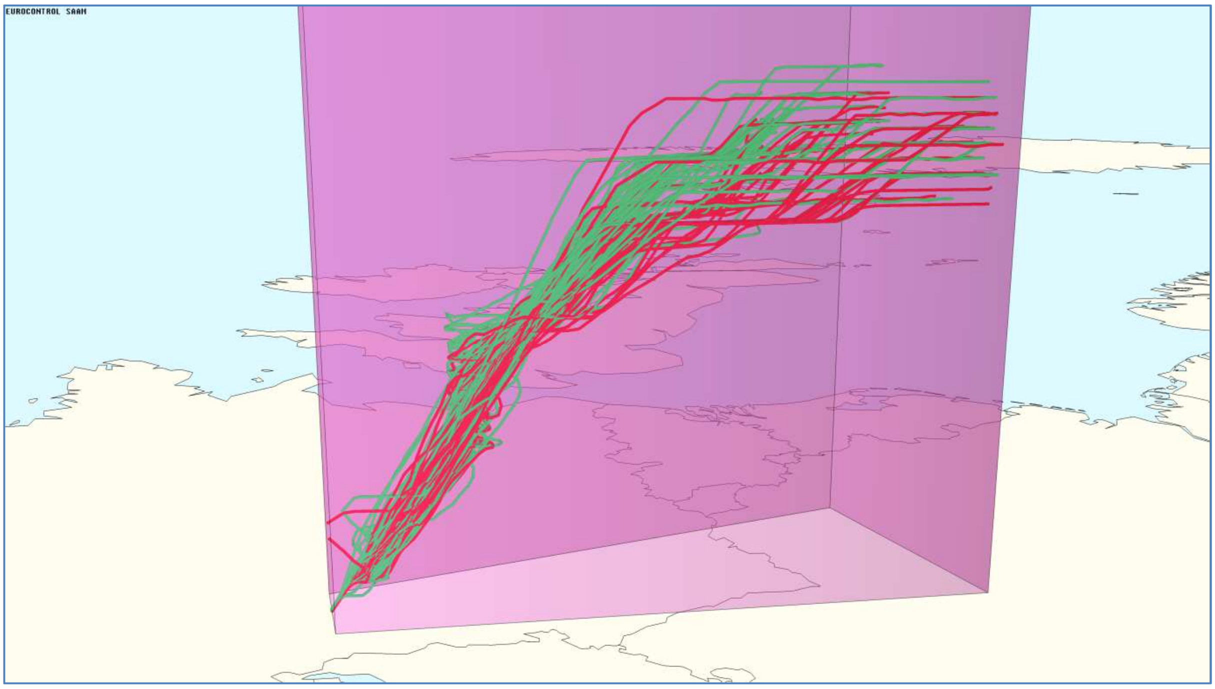



*Figure 71: Reference (red) and ODP (green) radar data recordings to Geneva (LSGG) via NATOR*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-003-01 from SAAM perspective are summarized in Figure 61. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.3.3.1.1.1.1.1 Skyguide

There had been a total number of 29 planned ODP Trials participants. 6 (21%) of them didn't file via LSAZ during the trial dates. 17 (58%) performed a CDO while 6 (21%) could not perform a continuous descent. 12 flights (41%) were not able to start their procedure out of CFL but out of FL330-. Reasons for that had been traffic situation or missing coordination.

Since a real CDO starting at CFL was rejected during CDO-development phase (safety recommendation) only an ODP procedure out of EFL350 had been designed. During low to medium traffic periods a handling was possible without major problems. Nevertheless situations occurred repeatedly in which ZRH ACC had to interrupt or cancel CDOs due to traffic in the vicinity of BEGAR and/or in the region of LUTIX/BENOT.
Because GVA ACC had not been able to contribute to this flow the procedure ended at FL250 overhead LUTIX (LoA). At the present time GVA INI is not able to offer a reasonable CDO procedure from the North.

###### 6.3.3.1.1.1.2 Operational subjective Feedback

Feedback Karlsruhe UAC:

Raised transfer level (NATOR FL350 instead of NATOR FL310) is operational feasible for Karlsruhe UAC.

#### 6.3.3.1.1.2 Assessment Results by Airline Operator

##### 6.3.3.1.1.2.1 Performance Analysis

###### 6.3.3.1.1.2.1.1 SWISS

For flight data analysis, data of all flights operated with Airbus A320-family aircraft via BENOT between January 1st and March 28th were analysed.

The following flights were not considered in order to ensure the comparability of data:

- Approaches to RWY05 (The pilots' descent technique changes when the landing runway lies more than 50nm further away than the straight-in option)
- Flights with a head- or tailwind component in excess of 60kt during descent (This filters out flights that were subject to extreme weather conditions)
- Flights operated with A321 aircraft (Flights during the trial period providing valid data were operated with A319 and A320 aircraft only)
- Flights without recorded data at either OLBEN or BENOT, mainly caused due to major fly-bys (e.g. due weather)

| | Pre-Trial (01JAN – 12FEB) 43 days | **Trial (13/14FEB) 2 days** | Post-Trial (15FEB – 28MAR) 43 days |
|---|---|---|---|
| **Total of flights analysed** | **63** | **8** | **45** |
| A319 | 4 | 1 | 10 |
| A320 | 59 | 7 | 35 |

a) Flight Level analysis

| | GTD 200* | NATOR | OLBEN | BENOT |
|---|---|---|---|---|
| Average FL before Trial | FL361 | FL340 | FL275 | FL227 |
| **Average FL during Trial** | **FL359** | **FL350** | **FL279** | **FL226** |
| Average FL after Trial | FL364 | FL346 | FL277 | FL229 |

*GTD = Ground Track Distance to Touchdown (here: 200NM)

This table shows that the average descent profile has not changed but that the handover FL at NATOR was slightly higher than normal during flight trials.

Although the current LoA between DFS and Skyguide specifies the handover to take place at FL310, it can be observed by looking at the average FL at NATOR that ATCOs probably often coordinate adjusted handover conditions tactically. This helps to accommodate the flight crews' request to stay at a high FL as long as possible and might result in a transfer at a higher FL than FL310 or at least a transfer in a "descending…"-state.

b) Atmosphere (True Altitude, Wind and Calibrated Airspeed)

GPS-Altitude versus FL:

| | NATOR | | | OLBEN | | | BENOT | | |
|---|---|---|---|---|---|---|---|---|---|
| | GPS | FL | Δ | GPS | FL | Δ | GPS | FL | Δ |
| Pre-Trial | 33'453ft | 340 | -1.61% | 27'222ft | 275 | -1.01% | 22'516ft | 227 | -0.81% |
| **Trial** | **33'995ft** | **350** | **-2.87%** | **26'956ft** | **279** | **-3.38%** | **21'817ft** | **226** | **-3.46%** |
| Post-Trial | 34'093ft | 346 | -1.47% | 27'383ft | 277 | -1.14% | 22'656ft | 229 | -1.07% |

The atmosphere was colder during the trial weekend than the average atmosphere before and after.

Based on "True Altitude" measurements by GPS, the average flights' descent between NATOR and BENOT encompassed

- 10'937ft before trial
- **12'178ft during trial**
- 11'437ft after trial

Wind and CAS:

| | GTD200 | | NATOR | | OLBEN | | BENOT | |
|---|---|---|---|---|---|---|---|---|
| | Ø wind | Ø CAS | Ø wind | Ø CAS | Ø wind | Ø CAS | Ø wind | Ø CAS |
| Before | 23kt | 254kt | 23kt | 263kt | 21kt | 277kt | 19kt | 276kt |
| **Trial** | **23kt** | **247kt** | **31kt** | **258kt** | **37kt** | **265kt** | **29kt** | **239kt** |
| After | 21kt | 252kt | 22kt | 261kt | 19kt | 278kt | 18kt | 274kt |

The average wind and speed remain the same before and after the trial weekend. The sample size of 8 trial flights is quite small and due to the fact that several flights had to join the holding pattern at VADAR during the trial, an early reduction to holding speed is reflected in the low average CAS at BENOT. For intermediate descent, headwind was up to 15kt stronger during the trial weekend. Considering that ATCOs normally insist on a given profile by assigning descent rates or by imposing level restrictions, this has a negative impact on fuel consumption during descent when compared to figures with less strong headwind (e.g. position BENOT always has to be crossed at or below FL250 although the optimum profile with the impact of strong headwind would require a higher crossing level, thus the flight has to dive below the ideal profile).

c) Fuel-consumption

In order not to obtain false and incomparable results, only the flight segment between NATOR and BENOT is considered for fuel-comparison. The average weight of analysed flights differs by a maximum of 700kg only. This minor difference in gross weight only has a small influence on the fuel consumption during descent since both engines are at or close to idle power during an optimised descent regardless of aircraft gross weight.

| | Ø Fuel consumption NATOR - BENOT | Ø Ground Track Distance NATOR - BENOT |
|---|---|---|
| 01 January – 12 February | 419kg | 94.4nm |
| **13 & 14 February** | **379kg** | **93.5nm** |
| 15 February – 28 March | 401kg | 93.9nm |

The average ground track distance (GTD) is within 1nm and mean headwinds were stronger during the trial weekend.
Although at first glance it seems that the levels at NATOR are also within 1'000ft (see table above) the difference between trial and sample flights (before and after the trial) might be that most of these sample flights were already in a descent to a lower FL at NATOR (e.g. subject to active coordination allowing the pilot to reach FL310 at some point after NATOR). Thus they eventually had to level off at FL310 whereas trial flights were able to continue their cruise at FL350 for a short while before starting the descent towards LSGG.
Performance calculations show that an average fuel saving of up to 35kg can be achieved by relaxing the level constraint at NATOR. This finding can be confirmed with the above fuel figures derived from flight data. Thus, the average fuel saving during intermediate descent ranges from 5.5% to 9.5% of the fuel burned on that route segment.

The average SWISS trial flight operated with A320-family equipment on an inbound route via BENOT to LSGG RWY 23 burned between 22kt and 40kg less fuel than comparable flights before and after the trial. This result could be achieved thanks to the possibility to extend the cruise phase at FL350 instead of FL310. As shown in the tables above, average deviations in atmospheric conditions (true altitude, wind) as well as aircraft parameters (CAS, weight) were only minor and support the reliability of these figures.

###### 6.3.3.1.1.2.2 Operational subjective Feedback

No pilot feedback was collected on this flow.

Any level-change before the TOD is perceived as a simple ATCO-instruction. The "Country Rules and Regulations" of Switzerland orders pilots to descend with a ROD of 1000-2500 FPM. The early descent in combination with this regulation doesn't leave room for further optimisation by pilots regarding early descent.

#### 6.3.3.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.3.3.1.3 Unexpected Behaviours/Results

None.

#### 6.3.3.1.4 Quality of Demonstration Results

The quality of the above figures could be confirmed with help of a calculation crosscheck performed by flight planning software. Modern FPM (Flight Planning Manager) software calculates the aircraft's most economical profile from lift-off from the expected departure runway to touchdown on the expected arrival runway. It takes all known constraints, such as RAD restrictions, into account. It can also be tailored by the user and fed with statistical data.

On 13th/14th February 2016, a total of 11 flights (3 A319 and 8 A320) operated by SWISS International Air Lines participated in the trial. All flights were calculated 3 times using the same weights and atmospheric model. On all profiles, the only reason for different trip fuel calculation could be allocated to the restricting altitude at NATOR.

Examples of flight profiles calculated by FPM (all input data, except the FL at NATOR, are the same):

| | **NO** FL-restriction NATOR | **FL350** at NATOR | **FL310** at NATOR |
|---|---|---|---|
| UUDD-LSGG23 | F360 WAR/F380 TEDGO/F390 | F360 WAR/F380 TEDGO/F370 NATOR/F350 | F360 WAR/F380 TEDGO/F370 NATOR/F310 |
| ESSA-LSGG23 | F380 BAGOS/F390 | F380 BAGOS/F390 NATOR/F350 | F380 BAGOS/F390 NATOR/F310 |
| LKPR-LSGG23 | F380 TEDGO/F390 | F380 TEDGO/F370 NATOR/F350 | F380 TEDGO/F370 NATOR/F310 |

**It is evident that the potential fuel saving indicated in the table below can be attributed to a change in handover conditions at NATOR.**

The following fuel and time data are taken from flight plan calculation (11flights merged):

| | Total airborne time | Total trip fuel required | Δ fuel to next scenario |
|---|---|---|---|
| NATOR at FL310 | 28H20' (Ø2h35) | 66'656kg (Ø6'060kg) | - |
| **NATOR at FL350** | **28h17' (Ø2h34')** | **66'398kg (Ø6'036kg)** | **-258kg (Ø23.4kg/flight)** |
| NATOR at CRZ FL | 28h16' (Ø2h34') | 66'272kg (Ø6'025kg) | -126kg (Ø11.5kg/flight) |
| **Total saving without restriction at NATOR** | | | **-384kg (Ø34.9kg/flight)** |

#### 6.3.3.1.5 Significance of Demonstration Results

None.

## 6.3.4 Conclusions and recommendations

### 6.3.4.1 Conclusions

The desirable TOD from FL390 is ~35nm after NATOR. Any descent before NATOR must be considered as step descent impacting the cruise of the flight.

It is evident that the potential fuel saving indicated in the table below can be attributed to a change in handover conditions at NATOR.

It is clearly shown that the omission of pre-descents has a positive impact on the overall trip fuel consumption.
The average SWISS trial flight operated with A320-family equipment on an inbound route via BENOT to LSGG RWY 23 burned between 22kt and 40kg less fuel than comparable flights before and after the trial. This result could be achieved thanks to the possibility to extend the cruise phase at FL350 instead of FL310. As shown in the tables above, average deviations in atmospheric conditions (true altitude, wind) as well as aircraft parameters (CAS, weight) were only minor and support the reliability of these figures.

Limiting early pre-descents as much and as often as possible is one of the best means to reduce the overall fuel consumption generally allocated to descents.

### 6.3.4.2 Recommendations

The opinion of SWISS is that limiting early pre-descents as much and as often as possible is one of the best means to reduce the overall fuel consumption generally allocated to descents.

Skyguide recommends:

- At the present time there is no solution for a possible CDO arrival from the north.
- An optimisation (ODP) according EFL from RHINE is desirable (flexible EFL according traffic demand?) and should be subject to future agreements with adjacent units.

## 6.4 Demonstration Exercise SCN-0103-004 / Munich (EDDM/MUC) Report

### 6.4.1 Exercise Scope

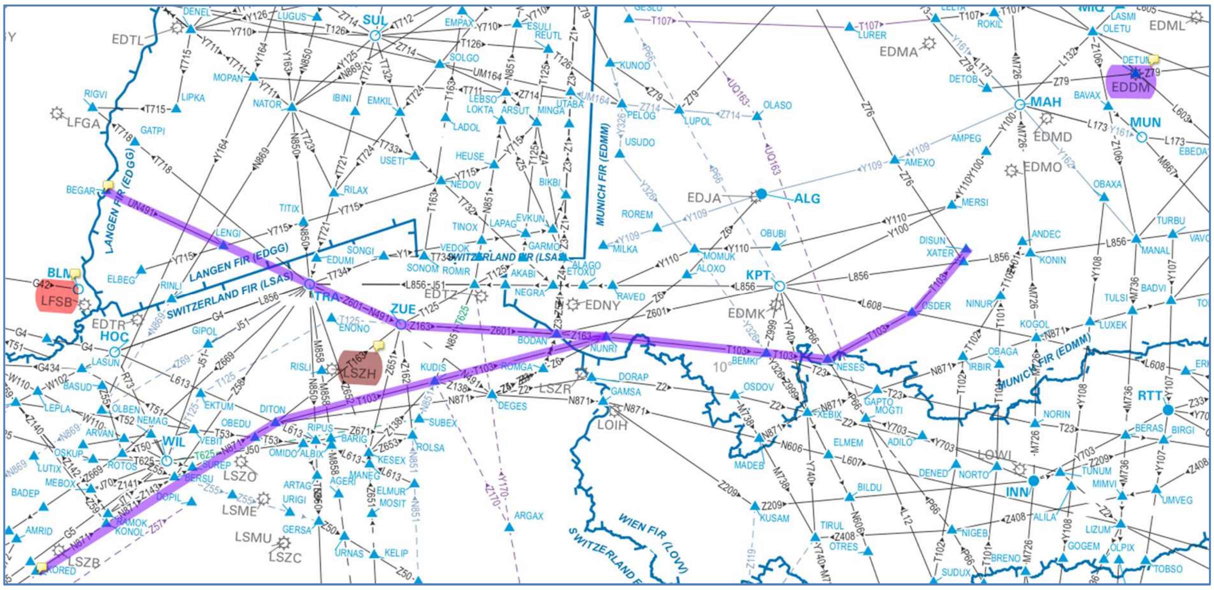



*Figure 72: Trial overview BEGAR/ KORED-NUNRI to Munich (EDDM) SCN-0103-004/ EXE-0103-004/ DEM-004-01 and DEM-004-03 (chart based on [21])*

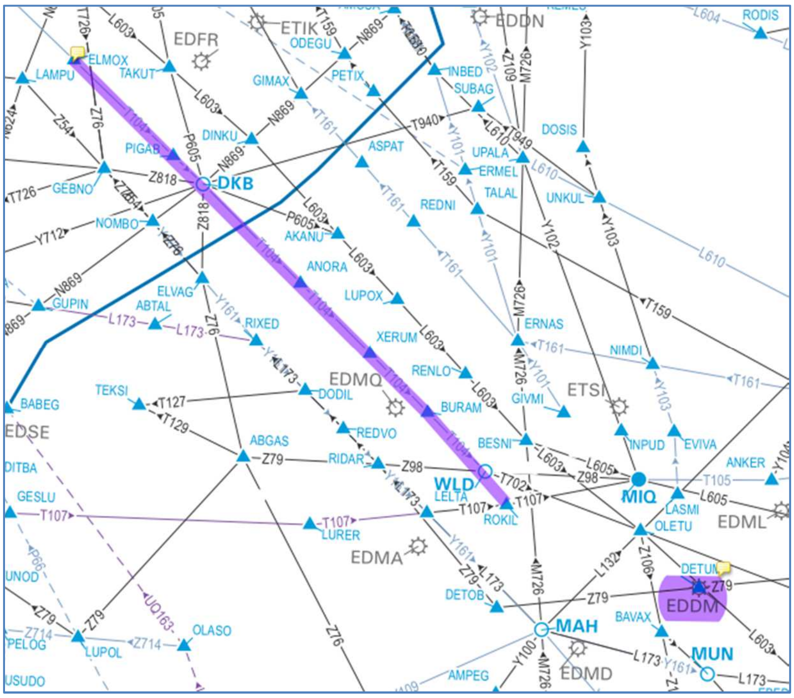


*Figure 73: Trial overview ELMOX-DKB to Munich (EDDM) SCN-0103-004/ EXE-0103-004/ DEM-004-02 (chart based on [21])*

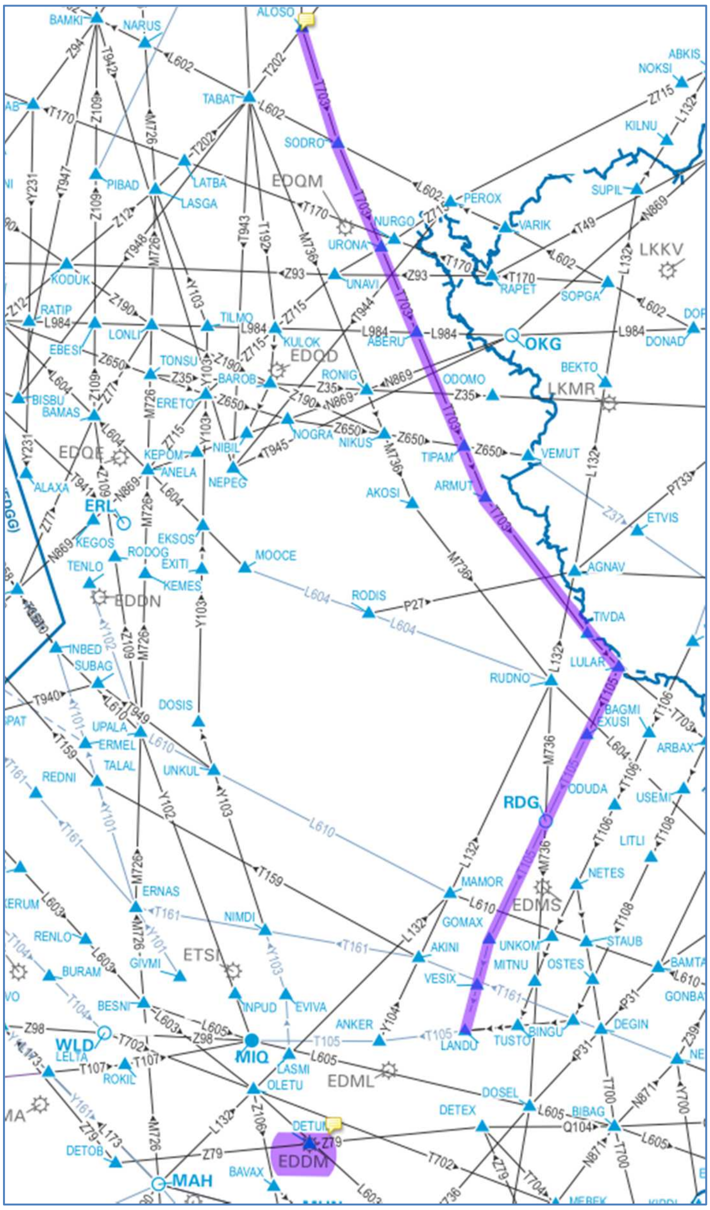



*Figure 74: Trial overview ALOSO/ SODRO to Munich (EDDM) SCN-0103-004/ EXE-0103-004/ DEM-004-04 and DEM-004-06 (chart based on[21])*

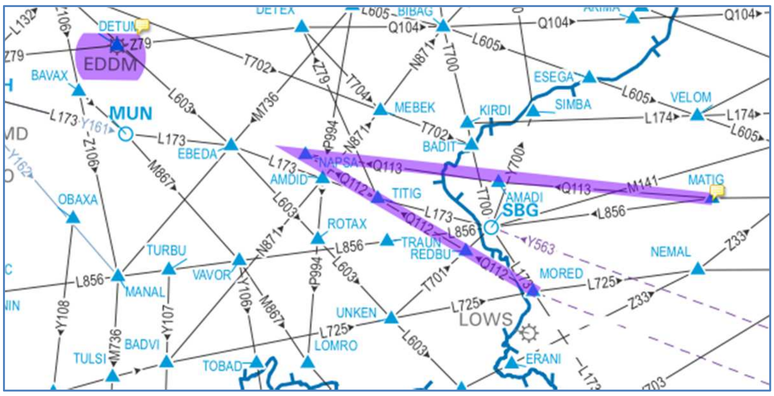



*Figure 75: Trial overview NAPSA to Munich (EDDM) SCN-0103-004/ EXE-0103-004/ DEM-004-05 (chart based on [21])*

Overall SAAM calculation results for EXE-0103-04 are as follows:

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 4 | 0,105 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 16 | -0,030 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 12 | -2,475 | 16 | -272,899 | 16 | -862,190 | 16 | -5,847 |
| Total | 16 | -0,030 | 16 | -2,371 | 16 | -272,899 | 16 | -862,190 | 16 | -5,847 |

*Figure 76: Summary of potential gains for ARR to MUNICH via BEGAR for DEM-004-01*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 4 | 0,140 | 4 | 2,099 | 4 | 6,620 | 4 | 0,019 |
| Equal | 4 | -0,030 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Total | 4 | -0,030 | 4 | 0,140 | 4 | 2,099 | 4 | 6,620 | 4 | 0,019 |

*Figure 77: Summary of potential gains for ARR to MUNICH via ELMOX for DEM-004-02*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 28 | 3,721 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 43 | 0,040 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 15 | -2,890 | 43 | -2306,273 | 43 | -7287,530 | 43 | -48,384 |
| Total | 43 | 0,040 | 43 | 0,831 | 43 | -2306,273 | 43 | -7287,530 | 43 | -48,384 |

*Figure 78: Summary of potential gains for ARR to MUNICH via KORED for DEM-004-03*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 32 | 0,810 | 0 | 0,000 | 0 | 0,000 | 2 | 0,064 |
| Equal | 39 | 0,040 | 3 | 0,008 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 4 | -0,065 | 39 | -223,350 | 39 | -705,600 | 37 | -3,693 |
| Total | 39 | 0,040 | 39 | 0,753 | 39 | -223,350 | 39 | -705,600 | 39 | -3,629 |

*Figure 79: Summary of potential gains for ARR to MUNICH via SODRO for DEM-004-04 and DEM-004-06*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 7 | 1,816 |
| Equal | 120 | -0,760 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 120 | -75,179 | 120 | -3106,253 | 120 | -9815,687 | 113 | -33,038 |
| Total | 120 | -0,760 | 120 | -75,179 | 120 | -3106,253 | 120 | -9815,687 | 120 | -31,222 |

*Figure 80: Summary of potential gains for ARR to MUNICH via NAPSA for DEM-004-05*

## 6.4.2 Conduct of Demonstration Exercise EXE-0103-004

### 6.4.2.1 Exercise Preparation

1. Procedure design:

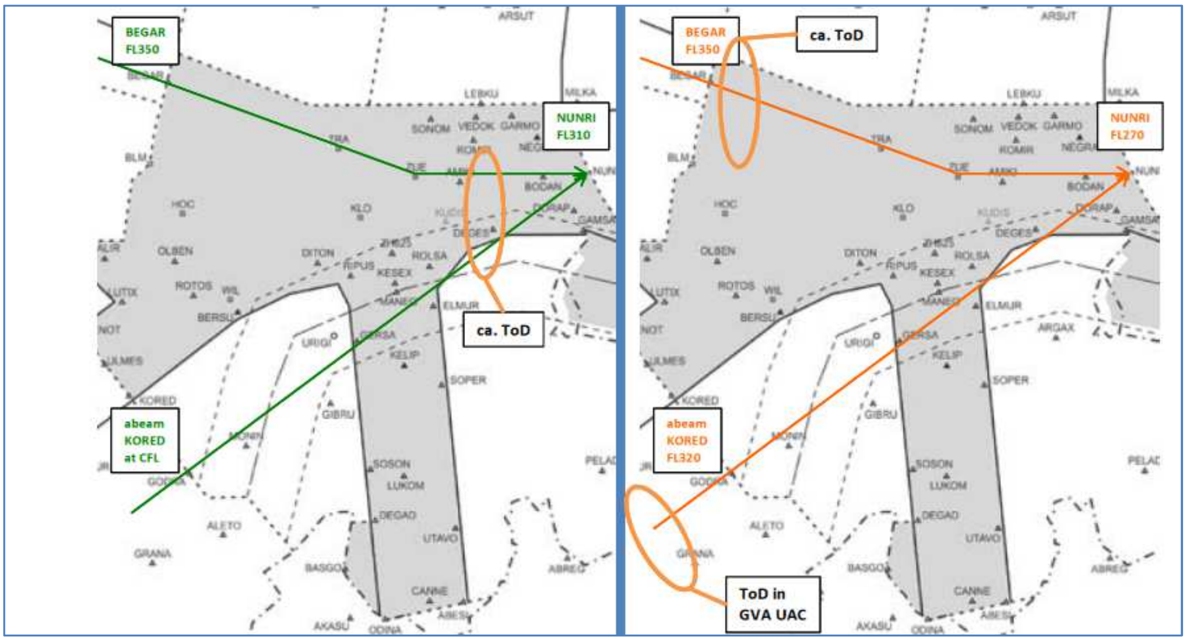



*Table 30: changes of NUNRI trial simplified*

| Before ODP | After ODP |
|---|---|
| LoA Reims to Zurich at BEGAR: FL350<br>LoA Zurich to Munich at BEGAR:<br>FL270 by default; FL310 in case of runway change | LoA Reims to Zurich at BEGAR: **FL350**<br>LoA Zurich to Munich at BEGAR:<br>**FL310 by default; FL270 in case of runway change** |

2. Airline Safety Assessment

No safety assessment was necessary on this flow.

3. Pilot training

No training was necessary for ODP trial

4. Pilot Questionnaires

Pilot report was available for participating Pilots to express themselves about ODP changes.

### 6.4.2.2 Exercise execution

For AF, 885 flights were flown between LFPG and EDDM from November 2015 to April 2016. They were 146 flights via the south routing. LoA changed concerns all flights flying via BEGAR and NUNRI therefore, all those flights were concerned by the ODP changes.

The general approach followed for the results analysis depends on the operational impact of the ODP improvement. This is described below:
On that flow, ODP was a LoA update allowing the flight to stay some Nautical Mile more on authorized cruising flight level. From a cockpit point of view, there were no changes from daily operation. Therefore, concept of operations for Pilots was: “business as usual”.

#### 6.4.2.3 Deviation from the planned activities

No deviation from planned demonstration activities.

### 6.4.3 Exercise Results for DEM-004-01

#### 6.4.3.1 Summary of Exercise Results

Refer to paragraph section 5.

##### 6.4.3.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

###### 6.4.3.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.4.3.1.1.1.1 Performance Analysis

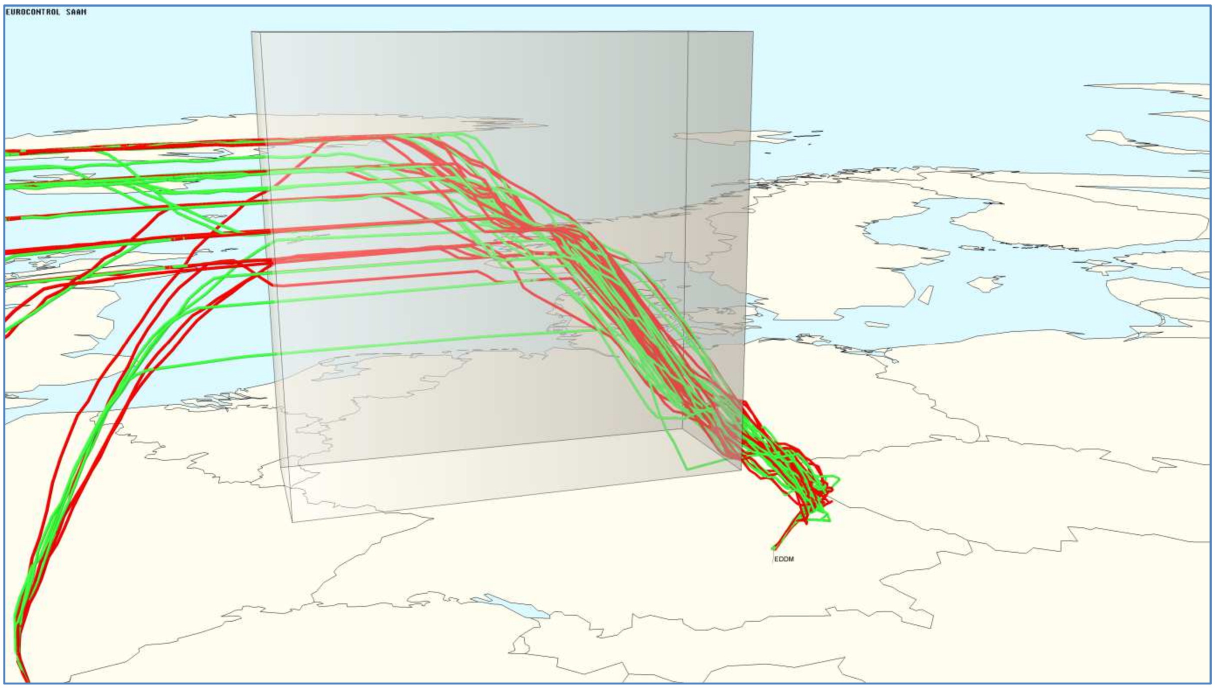



*Figure 81: Reference (red) and ODP (green) radar data recordings to Munich (EDDM) via BEGAR*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-004-01 from SAAM perspective are summarized in Figure 69. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.4.3.1.1.1.2 Operational subjective Feedback

###### 6.4.3.1.1.1.3 Capacity

Details on capacity can be found in 6.4.3.1.1.1.2. From ACC Munich point of view there was no impact on the capacity in the involved sector FUE.

##### 6.4.3.1.1.2 Assessment Results by Airline Operator

###### 6.4.3.1.1.2.1 Performance Analysis

###### 6.4.3.1.1.2.1.1 Air France

Study of vertical profile evolution

Baseline Definition and analysis:

To analyse ODP profile influence, we studied actual flight data before the introduction of ODP change. Chosen baseline sample is September 2015.

In September 2015, 73 AF flights were filed via NUNRI routing (South routing). 12 flights were excluded as the realized routing was not via the expected routings (rerouting via EPL; weather avoidance). Baseline was finally of 61 flights .The number of flights is considered enough for the baseline definition.

Altitude distribution around BEGAR and NUNRI are displayed on the following graphic:

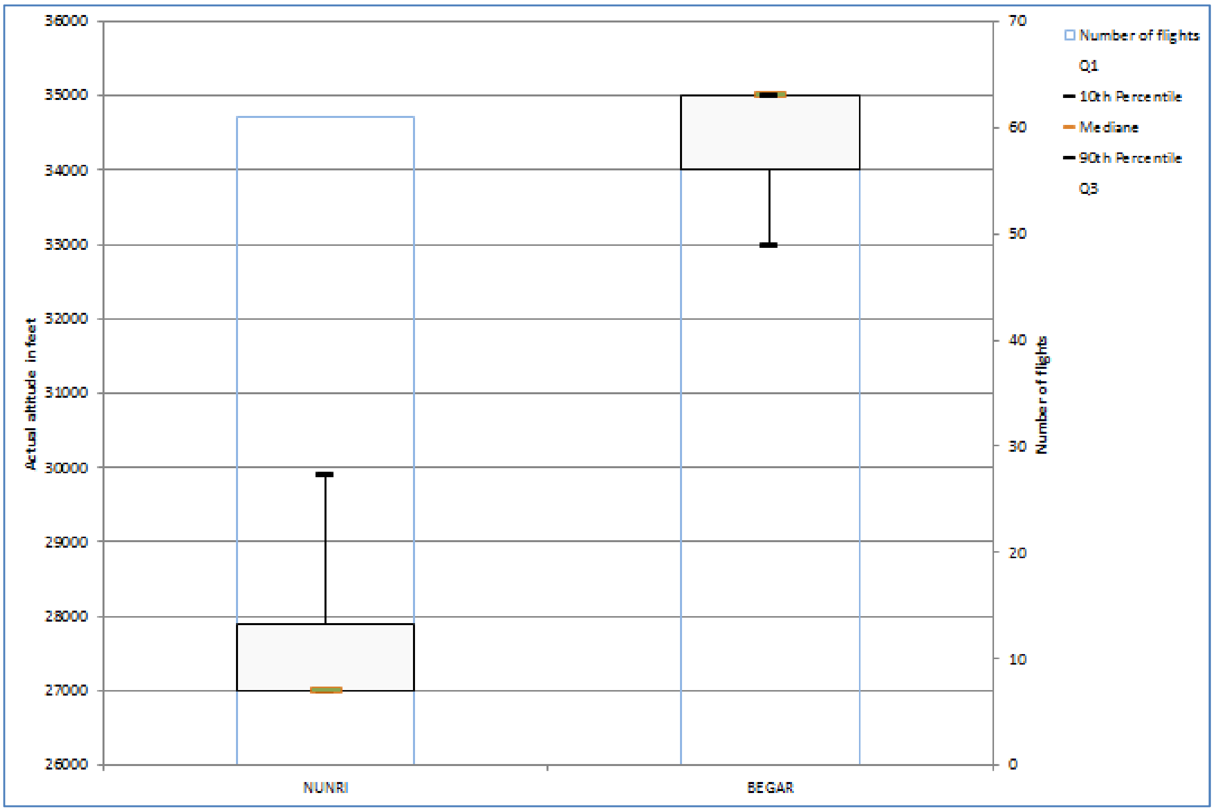



*Figure 82: altitude distribution for BEGAR and NUNRI*

Dispersion is limited to 1000ft in the baseline. Median value is FL270 for NUNRI (average value 27600) and FL350 for BEGAR.

Adherence to expected FL has been defined with a tolerance of +/- 200 ft.

Actual FL repartition at respectively BEGAR and NUNRI are as follows:

| | "Before ODP" situation | |
|---|---|---|
| BEGAR | 77 % at FL350 | 5% at FL370 |
| NUNRI | 55 % at FL270 | 7% at FL310 |

ODP profile is defined as a combination of NUNRI FL310 (or higher) and BEGAR FL350 (or higher). In September 2015, there were around **10% -- 6 flights**—with ODP profile.

Trial data analysis:

Impact of ODP trial has been studied on flights from November 2015 to April 2016: in total, 146 flights were studied.

Flight distribution evolution has been sum up on the following figures.

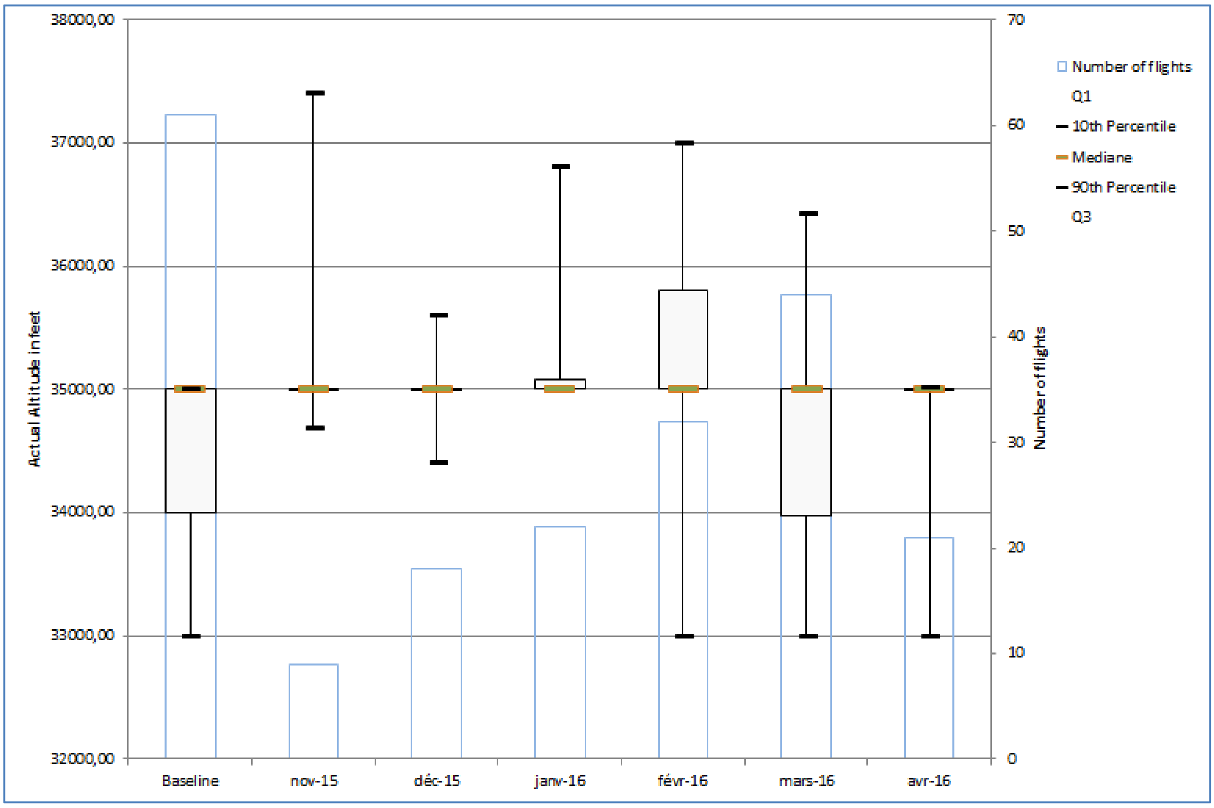



*Figure 83:BEGAR Altitude evolution from November 2015 to April 2016 (compared to Baseline)*

BEGAR Altitude is pretty steady. No change is shown which is consistent with the framework of the project (change is on NUNRI waypoint).

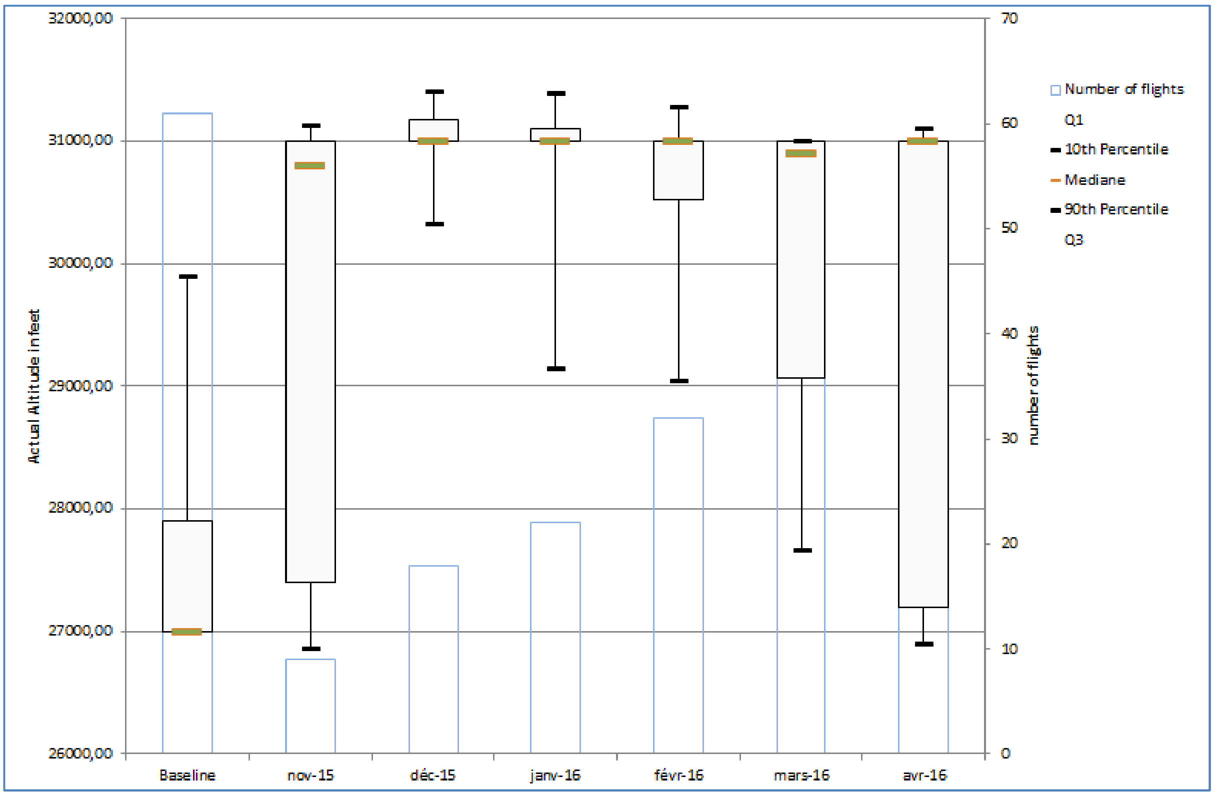



*Figure 84:NUNRI Altitude evolution from November to April 2016 (compared to baseline)*

Altitude at NUNRI clearly increased. We can see that median value rises up of 4000ft to around FL310 and average value of FL300.

Number of flown ODP profiles is shown on the following figure per trial month.

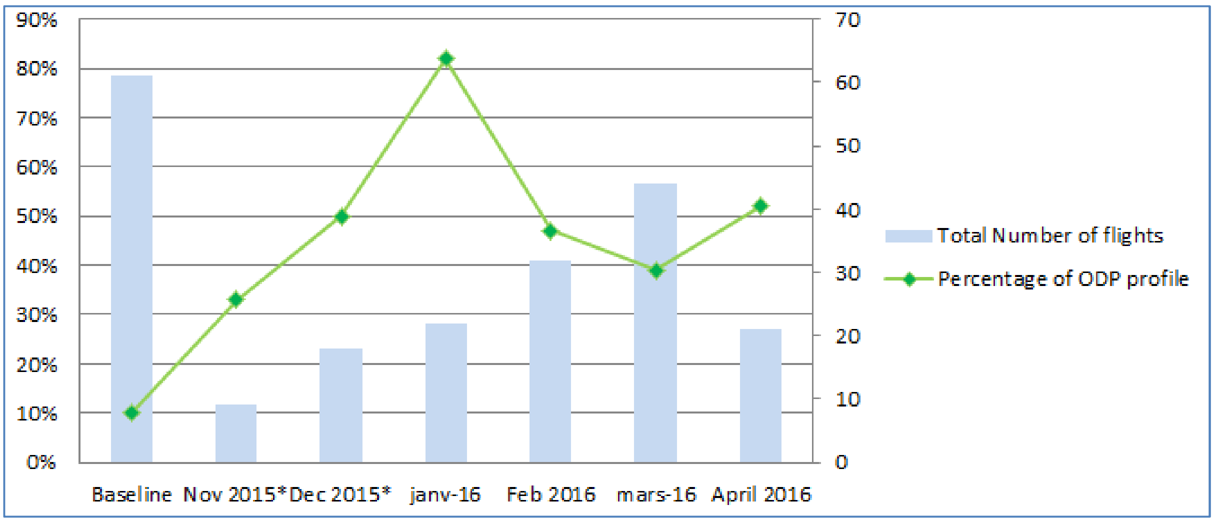



*Figure 85: number of ODP flown flights via NUNRI by month*

*Note:* Number of flights going through NUNRI was impacted by the BILINI project. Sample of flights for November and December is small (9 flights in November, 18 flights in December) and might not be representative.*

We can see that, after a raise up to 82% of flights, number of ODP profiles seems to stay around 40% to 50% . From November 2015 to April 2016, ODP profile was flown in average by 48% of AF flights (70 out of 146 flights).

Further analysis has been done in order to understand the evolution of ODP profile. We studied in particular the linked with the runway configuration.

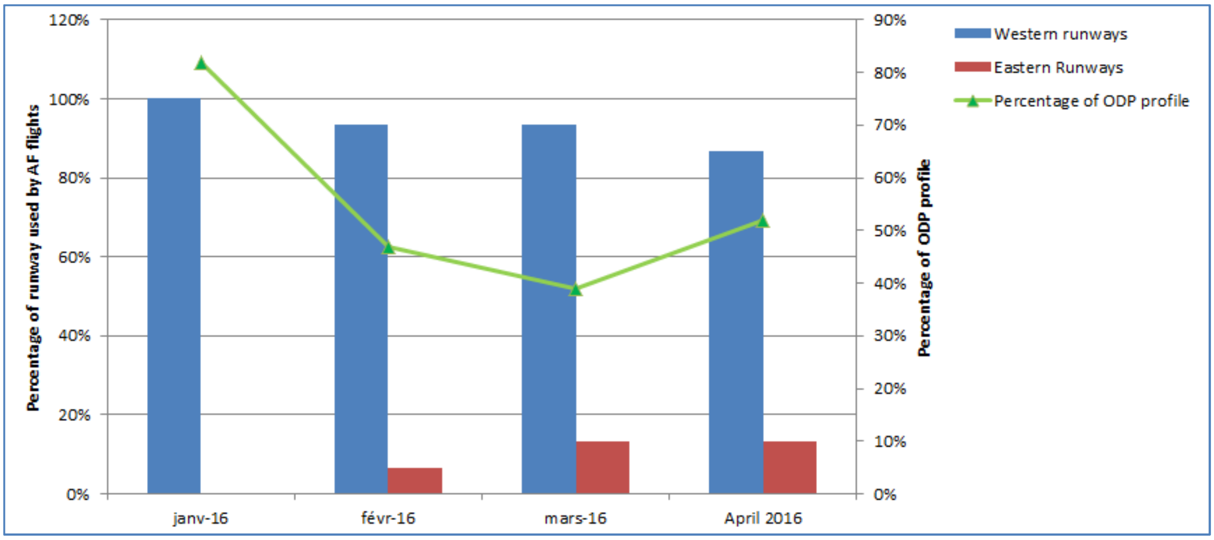


Figure 86: Runway configuration in MUC per month (left is the percentage of runway configuration, right is percentage of ODP profile)

As you can see, runway was in western configuration for 90% of landing AF flights (For the flow of traffic coming from LFPG, this is the runway configuration leading to the longer horizontal flight path). This figure highlights the fact that there is no linked between the flown FL at NUNRI and the runway configuration. This is confirmed by the aircraft performance data. Indeed, for A320, NUNRI could be flown at cruising flight Level. For short haul, the aircraft could stay more than 40 NM at cruising FL if no constraint in TMA and could start the descent at NURNI from FL370 to meet the constraint at FL160.
Therefore, being at FL 310 at NUNRI gives the crew around 20 additional NM to manage to be levelled at FL160 at DISUN. This is way enough NM to manage properly the energy. Thus, from a cockpit point of view, there is no reason to anticipate more the descent and therefore, it seems that the reduction of flown ODP profile is not coming from cockpit performance constraint. It could be interesting to work further with ATC to try and understand the complexity on their side.

<u>Fuel figures</u>

Study with LIDO:

Common hypothesis for the calculation for the baseline and ODP profile are: A320 – Aircraft Performance; Mean Payload on this routing; same horizontal Routing; Aircraft reference speed; Yearly statistical weather

Result of vertical profile comparison:

| Baseline | | ODP Profile | |
|---|---|---|---|
| BEGAR | NUNRI | BEGAR | NUNRI |
| 350 | 270 | 350 | 310 |
| Delta Fuel = 10kg | | | |

Some limitations are linked to this assessment method. As discussed in 5.3.3, to be levelled on a waypoint in LIDO, descent must be anticipated to previous waypoint.

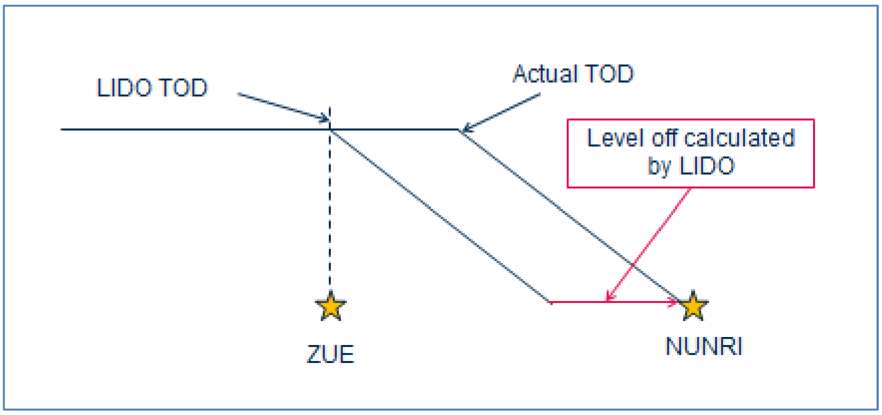



*Figure 87: overview of level off calculated by LIDO for the NUNRI flow*

To be levelled at NUNRI, descent should start between 26 to 33 NM before NUNRI (if respectively coming from FL350 or FL370). Used waypoints are either ZUE or TRA. This might be too anticipated compared to the real behaviour of the aircraft – or could be assimilated to a descent where the ATCO put the aircraft in descent right away.

In order to refine and confirm the fuel assessment, we used airbus aircraft performance table. To do the evaluation, we calculate the extra NM that flight spent on cruising FL.

From our actual data, we know that AF flights were FL300 in average at NUNRI. Total gain per flight is of around 10kg. LIDO number is confirmed.

Thus:

| | |
|---|---|
| **Total Fuel savings for the trial period** | **700kg of Fuel** |
| **Total Fuel savings per year**<br><br>**(100% of ODP profile)** | **3, 2 tons of Fuel** |

| | |
|---|---|
| **Total Fuel savings per year**<br><br>**(50% of ODP profile)** | **1,6 tons of Fuel** |

#### 6.4.3.1.1.2.1.2 Lufthansa

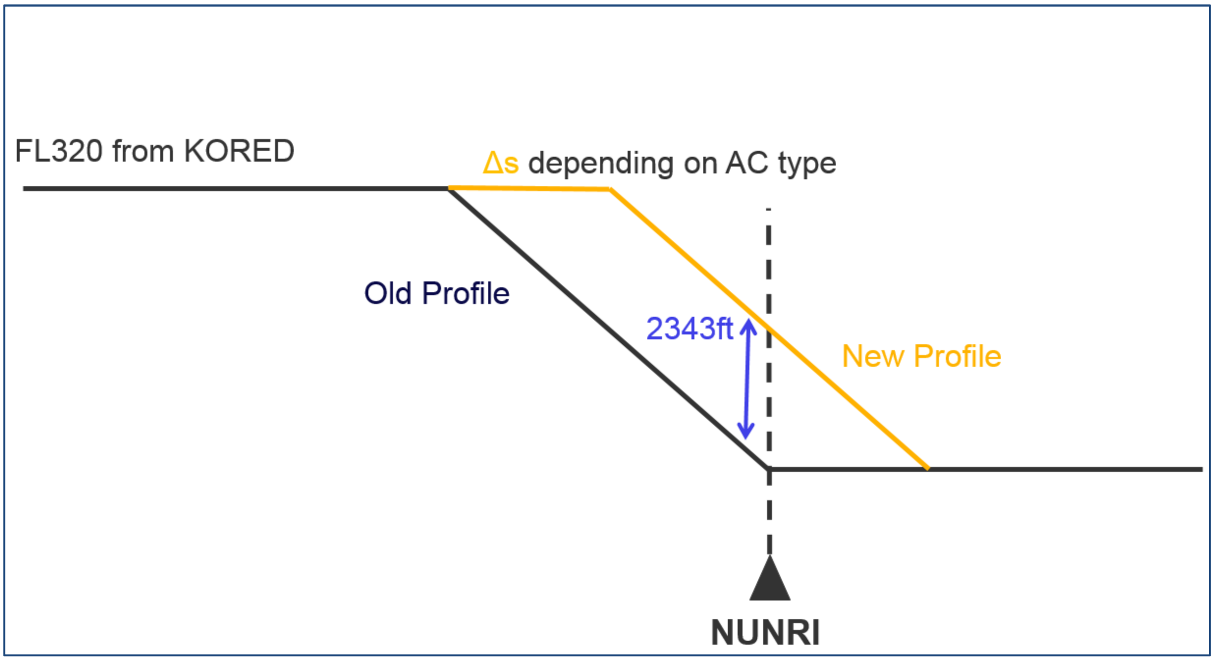



*Figure 88: profile improvement through ODP project at ARR via NUNRI*

In total, 2578 DLH flights inbound Munich (without flights departed from Zurich) were in the analysis between Nov 2014 and May 2016. After implementation of the new NUNRI handover procedure the average altitude overhead NUNRI according to flight recorder data was raised by 2343 ft. Based on the WP1 findings the following fuel calculation was made:
It was assumed, that a corresponding distance calculated by the aircrafts average descent angle (taken from WP1) was flown at FL320 instead of FL270 NUNRI.

| | |
|---|---|
| Altitude difference | 2343ft |
| Average theoretical distance Δs<br>Flown at FL320 iso. FL270 | A330: Δs : 8,81NM<br>A340: Δs : 8,67NM<br>A319: Δs : 7,26NM<br>A320: Δs : 7,73NM<br>A321: Δs : 7,73NM<br>E95: Δs : 6,61NM<br>CR900: Δs : 6,94NM |
| Average fuel saved at 90%MLAW | A330: 8,27kg<br>A340: 11,70kg<br>A321: 3,33kg<br>A320: 3,96kg<br>A319: 3,33kg<br>E95: 2,0kg |

| | |
|---|---|
| | CRJ900:4,2kg |
| **Aircraft numbers (1.11.2015-26.5.2016)** | A330: 59 = 487,93kg<br>A340: 86 = 1006,2kg<br>A319: 412 = 1371,96kg<br>A320: 548 = 2170,08kg<br>A321: 685 = 2281,05kg<br>E95: 1894 = 3788kg<br>CRJ900: 874 = 3670,8kg |
| **Fuel total in period** | **= 14776kg** |
| **Fuel per year (estimate 14776/208*365)** | **~26t** |

##### 6.4.3.1.1.2.2 Operational subjective Feedback

DLH Switching the NUNRI logic was a large improvement on this flow.
Combined with the NUNRI CDO and a possible KORED at CFL one of the most penalized flows with regards to vertical efficiency would catch up to European average.

##### 6.4.3.1.1.2.3 Safety

###### 6.4.3.1.1.2.3.1 Air France

No Air Safety report following this change. Therefore, for AF point of view, there were no safety impacts.

#### 6.4.3.1.2 Results impacting regulation and standardisation initiatives

No specific needs on this exercise. Please see general feedback from ODP on that topic in section 5.

#### 6.4.3.1.3 Unexpected Behaviours/Results

There were no unexpected behaviour/results

#### 6.4.3.1.4 Quality of Demonstration Results

There was no specific issue concerning the quality of the results achieved in this Exercise.

Fuel assessment limits are described in 5.5.1.

#### 6.4.3.1.5 Significance of Demonstration Results

<u>Air France:</u>

For this trial, AF studied 207 flights. Results are considered significant.

### 6.4.4 Conclusions and recommendations

#### 6.4.4.1 Conclusions

Air France

207 AF flights were studied. Results per KPA are:

Safety: no impact

Flight Efficiency:

| | |
|---|---|
| Total Fuel savings for the trial period | 700kg of Fuel |
| Total Fuel savings per year<br>(100% of ODP profile) | 3, 2 tons of Fuel |
| Total Fuel savings per year<br>(50% of ODP profile) | 1,6 tons of Fuel |

#### 6.4.4.2 Recommendations

Flight efficiency savings on that flow are pretty tight. TOP still remains anticipated of 70 NM before the optimum TOP.

Other leads have been identified to improve Flight Efficiency but their studies couldn't be managed in the timeline of ODP. In particular:

- FL at NUNRI could be cruising FL; further simulation could be done on that topic. Especially, influence of runway on NUNRI FL should be further investigated as for a cockpit prospective, it should not be an issue (see section 6.4.3.1.1.2.2)
- Constraints between the ACC and Approach could be also investigated. Those constraints were excluded from ODP scope because of their complexity although they impact directly the TOP position and induce level off on the trajectories. This topic is particularly difficult as it impacts the feeding of MUC airport. Innovative solutions with potential airspace redesign may be necessary to move forward with flight efficiency improvement without degradation of capacity.

### 6.4.5 Exercise Results for DEM-004-02

#### 6.4.5.1 Summary of Exercise Results

##### 6.4.5.1.1 Results per KPA

A summary is provided in section 5 "Exercises Results" and 6 "Demonstration Exercises reports".

###### 6.4.5.1.1.1 Assessment Results by ANSP and Eurocontrol

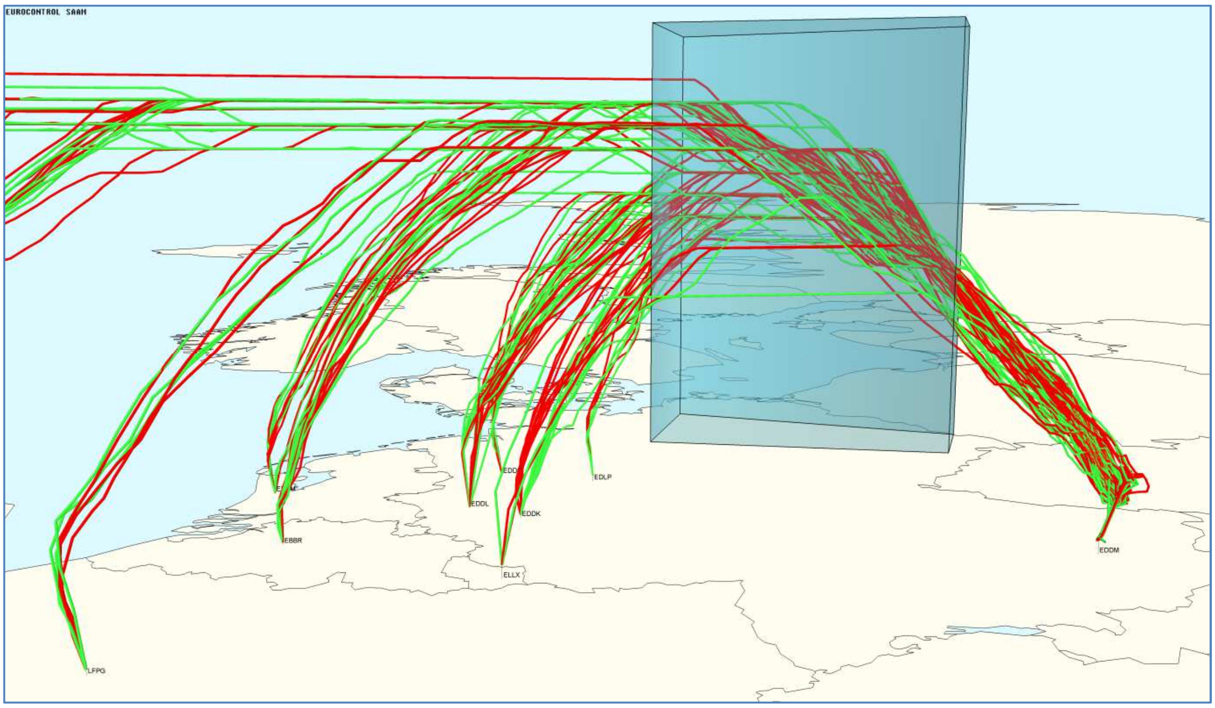



*Figure 89: Reference (red) and ODP (green) radar data recordings to Munich (EDDM) via ELMOX*

###### 6.4.5.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-004-02 from SAAM perspective are summarized in Figure 77. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.4.5.1.1.1.2 Operational subjective Feedback

Feedback Karlsruhe UAC:

As the publication of the CDO via ELMOX DKB was delayed, no demonstration flights took place so far and no experiences and results can be reported.

It was a gain of ODP to make a publication for ELMOX and LEVBU possible and to prepare everything needed (Safety, NSA process) in order to publish this CDO on 2nd of February 2017. Unfortunately, the publication date is after ODP but potential gain results from BADA are available in Figure 70.

In order to ensure a smooth publication, Munich ACC is still in the trial phase with some airlines. Figures from June 2016 have shown a CDO clearance rate within Munich ACC of 24,4% when RWY 26 was in use (403 CDOs out of 1.653 total flights).

##### 6.4.5.1.1.2 Assessment Results by Airline Operator

###### 6.4.5.1.1.2.1 Performance Analysis

No results available as implementation was postponed

###### 6.4.5.1.1.2.2 Operational subjective Feedback

DLH regrets that the implementation of the EMPAX CDO was postponed as other important airspace changes were prioritised. The EMPAX CDO (extension of the existing ANORA CDO) will combine two different centres (Karlsruhe and Munich) and will prevent early descents towards ANORA.

Instead it will bring more flexibility for the pilot in the upper airspace' descent.

#### 6.4.5.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.4.5.1.3 Unexpected Behaviours/Results

None.

#### 6.4.5.1.4 Quality of Demonstration Results

n/a

#### 6.4.5.1.5 Significance of Demonstration Results

n/a

## 6.4.6 Conclusions and recommendations

### 6.4.6.1 Conclusions

None.

### 6.4.6.2 Recommendations

None.

## 6.4.7 Exercise Results for DEM-004-03

### 6.4.7.1 Summary of Exercise Results

#### 6.4.7.1.1 Results per KPA

A summary is provided in section 5 "Exercises Results" and 6 "Demonstration Exercises reports".

##### 6.4.7.1.1.1 Assessment Results by ANSP and Eurocontrol

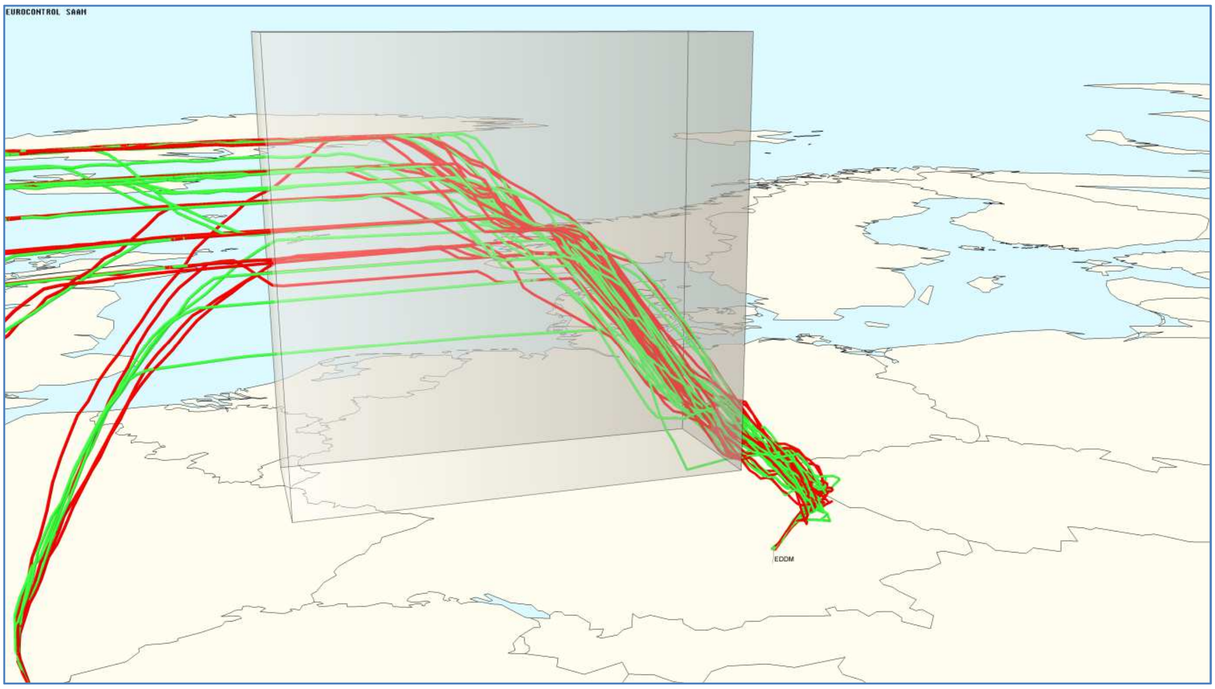



*Figure 90: Reference (red) and ODP (green) radar data recordings to Munich (EDDM) via KORED-NUNRI*

#### 6.4.7.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-004-03 from SAAM perspective are summarized in Figure 71. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

##### 6.4.7.1.1.1.1.1 Skyguide

There had been a total number of 76 planned ODP Trials participants. Unfortunately 42 of them filed outside LSAZ. 28 of the remaining 34 flights were able to perform a CDO. The remaining 6 did not perform a CDO due to various reasons such as: lack of information (poor briefing?), technical problem, traffic (2x), emergency, early descent due to LoA (EFL too low/ MILANO).

In low to medium traffic situations during MIL OFF, a higher EFL (Cruising FL via KORED) is manageable. In order to enable the procedure up to 4 ACC sectors are involved (compared to only one nowadays) which can increase workload and complexity. The already implemented change (LoA) of standard XFL310 to MUNICH brings us closer to a ODP profile than the former XFL270 and can be considered a major improvement. Due to airspace structure a higher XFL than FL310 is not possible (RHINE ALPS) so that this procedure won't lead to a real CDO but is an optimisation (ODP).

Munich ACC suspended the CDO trial via NUNRI, but will restart this trial with AIRAC 15SEP16 (outside of ODP timeframe).

No issues were encounter in handling inbounds EDDS according to the trial procedure during low traffic periods. The XFL120-140 ARSUT (accord. LoA) proved well.

###### 6.4.7.1.1.1.2 Operational subjective Feedback

For ARR EDDM via NUNRI FL310 is the maximum possible FL. For RWY 08 this is already the optimum. For RWY 26 the restricting factors are the airspace structure at one hand and the complexity of the sectors involved on the other hand. There is a conflict of aims between capacity and VFE.

From ATC side it doesn´t make sense to involve additionally Karlsruhe UAC for flights with destination Munich via NUNRI. The involved sector would be ALP (ALPEN) which is very complex with a lot of vertical movements. Because this profile with FL310 overhead NUNRI is close to the optimum, the flying time within Karlsruhe UAC airspace would be very short. The receiving sector in Munich ACC is the sector FUE (FÜSSEN) which has also a complex structure with a lot of vertical movements. When aircraft would be transferred later, there would be less time to descend the aircraft through this complex airspace structure.

##### 6.4.7.1.1.2 Assessment Results by Airline Operator

###### 6.4.7.1.1.2.1 Performance Analysis

The distance KORED (FL320) – DITON- NUNRI (FL310/270) is 103NM resulting in around 85NM longer at CFL if the KORED restriction is removed and NUNRI to be crossed at FL270.

Fuel calculation for the removal of the KORED restriction for an Airbus A320 and A340-600 with 90%MLAW

| | Fuel (85NM at FL390) | Fuel (85NM at FL320) | Delta |
|---|---|---|---|
| A340-600 | 1274,4kg | 1398kg | 123,6kg |
| A320 | 411,4kg | 458kg | 46,6kg |

*Table 31: Fuel calculation for the removal of the KORED restriction for an Airbus A320 and A340-600 with 90%MLAW*

###### 6.4.7.1.1.2.2 Operational subjective Feedback

The Feedback for NUNRI is given at DEM-004-001

The KORED restriction inbound Munich is one of most restrictive and fuel costly early descent. Considering the above theoretical fuel potential DLH recommends to further investigate the possibility to pass the Geneva Zurich FIR boundary at CFL for Munich arrivals.

#### 6.4.7.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.4.7.1.3 Unexpected Behaviours/Results

None.

#### 6.4.7.1.4 Quality of Demonstration Results

n/a

#### 6.4.7.1.5 Significance of Demonstration Results

None.

### 6.4.8 Conclusions and recommendations

#### 6.4.8.1 Conclusions

None.

#### 6.4.8.2 Recommendations

The following has been recommended by Skyguide:

- Since a complete CDO for EDDM inbounds is not possible at present time and Skyguide has no influence on tfc planning in MUNICH ACC a flexible handling (EFL) is preferable. Depending on RWY in use (XFL270 or 310) the EFL via KORED should be adjusted accordingly.
- A flexible handling of EFL for inbounds EDDS could be used. However, if tfc and complexity increases lower EFL (acc. LoA) are preferable.
- As MILANO did not take part the EFL320 for EDDS inbounds had been judged as "too low". A process as stated above could be used.

### 6.4.9 Exercise Results for DEM-004-04

#### 6.4.9.1 Summary of Exercise Results

##### 6.4.9.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

###### 6.4.9.1.1.1 Assessment Results by ANSP and Eurocontrol

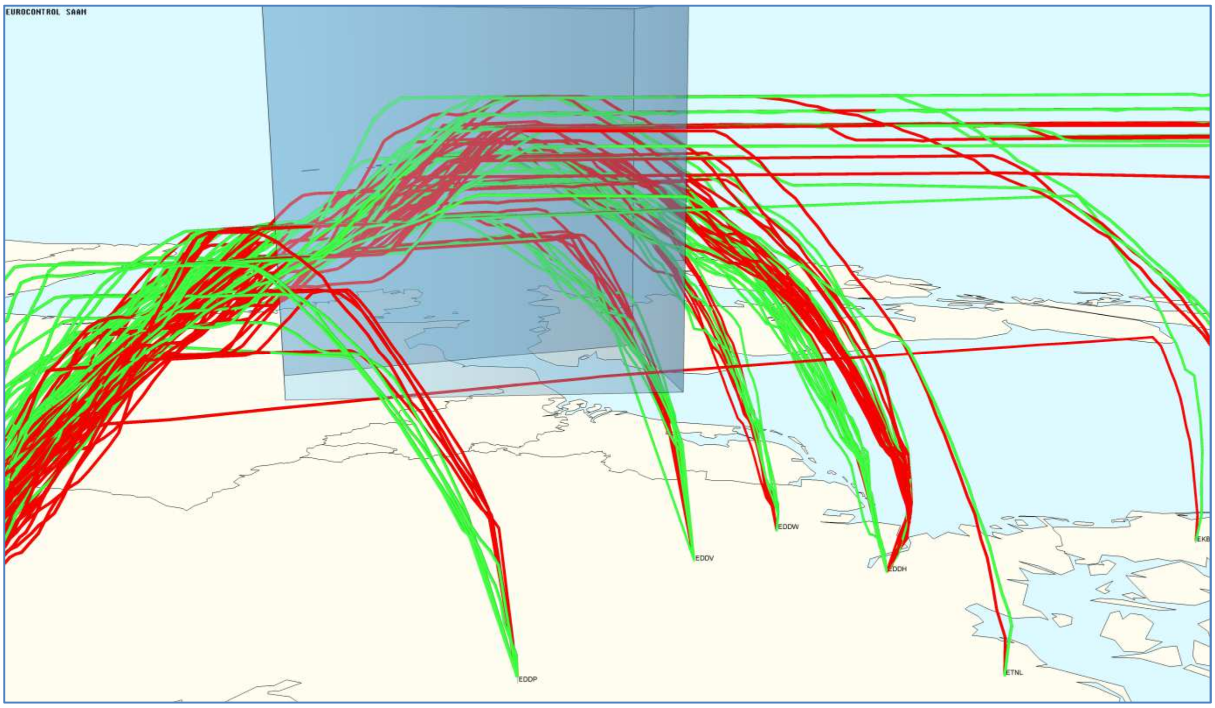



*Figure 91: Reference (red) and ODP (green) radar data recordings to Munich (EDDM) via SODRO*

###### 6.4.9.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-004-04 from SAAM perspective are summarized in Figure 79. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.4.9.1.1.1.2 Operational subjective Feedback

The complex airspace structure including many vertical movements within the involved Munich ACC sectors FRK (FRANKEN) and RDG (RODING) limiting the further optimization of this flow.

During the ODP project, to transfer conditions have been improved by two steps. First step was the later transfer of 10NM from Karlsruhe UAC to Munich ACC at the point SODRO. Second step was the raised transfer level by 2000ft for the transfer between the Munich ACC sectors FRK and RDG.

In case other transfer conditions in the sector FRK could be improved (for example ARR EDDF via T170 VAGAB) there could be a chance to provide further improvement for the arrivals to EDDM via SODRO-ARMUT.

##### 6.4.9.1.1.2 Assessment Results by Airline Operator

###### 6.4.9.1.1.2.1 Performance Analysis

The following graphic shows the average altitude improvement at ARMUT. After implementation, the overflow altitude rose by 1166ft from 24066ft to 25232 feet. As aircraft are already down to FL290/310 before SODRO and continue on a shallow descent instead of an idle descent, fuel improvements are not measurable and well below 10kg.

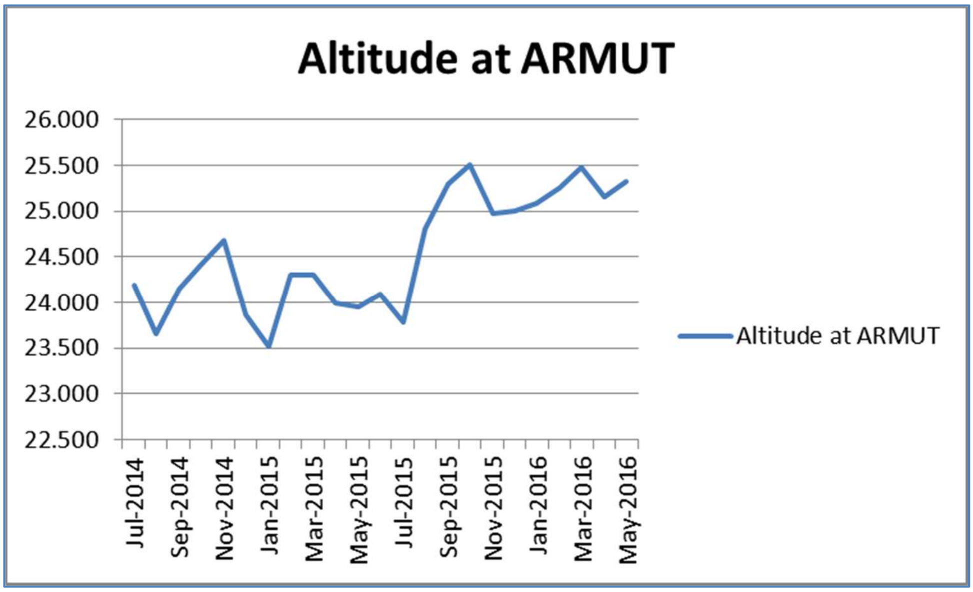



*Figure 92: altitude improvement over time after ODP changes at ARMUT*

The following figure shows the total improvement on this routing in a simplified way.

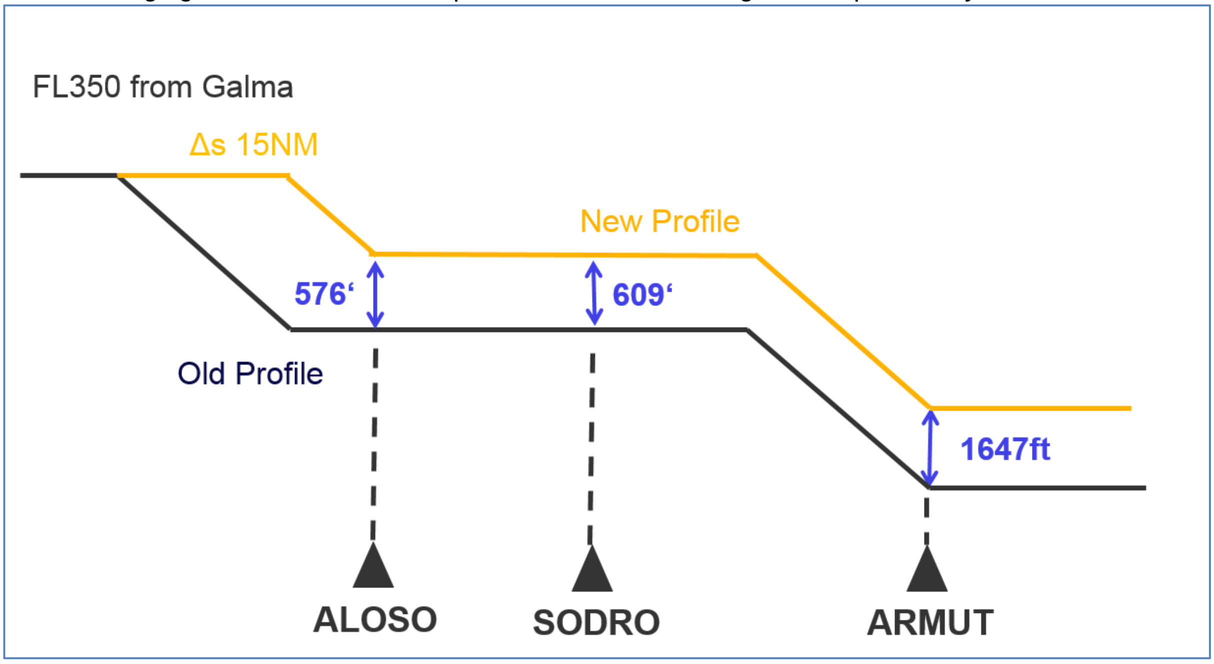



*Figure 93: ODP improvement on the overall routing for ARR via SODRO*

#### 6.4.9.1.1.2.2 Operational subjective Feedback

None.

### 6.4.9.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.4.9.1.3 Unexpected Behaviours/Results

None.

#### 6.4.9.1.4 Quality of Demonstration Results

n/a

#### 6.4.9.1.5 Significance of Demonstration Results

None.

### 6.4.9.2 Conclusions and recommendations

### 6.4.9.3 Conclusions

None.

### 6.4.9.4 Recommendations

None.

## 6.4.10 Exercise Results for DEM-004-05

### 6.4.10.1 Summary of Exercise Results

#### 6.4.10.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

##### 6.4.10.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.4.10.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-004-05 from SAAM perspective are summarized in Figure 73. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.4.10.1.1.1.2 Operational subjective Feedback

During the trial it turned out that the necessity to (re)clear ARRs EDDM for ODP procedures due to missing fileable STARs suitable for ODP was not acceptable by involved personnel, ATCOs and pilots, as it caused additional workload for both of them. Consequently and due to the fact that STARs to EDDM out ACC Wien sectors could not be made available for ODP, the trial was stopped by Austro Control. Next opportunity to implement procedures for EDDM out of ACC Wien sectors will be after implementation of cross-border free route airspace initiative between Slovenia Control and Austro Control WEF AIRAC 10 NOV 2016. Negotiations between DFS and Austro Control

###### 6.4.10.1.1.2 Assessment Results by Airline Operator

###### 6.4.10.1.1.2.1 Performance Analysis

No performance analysis available.

###### 6.4.10.1.1.2.2 Operational subjective Feedback

See 6.4.10.1.1.2.2, no other feedback from Airline Operator.

##### 6.4.10.1.2 Results impacting regulation and standardisation initiatives

None.

##### 6.4.10.1.3 Unexpected Behaviours/Results

None.

##### 6.4.10.1.4 Quality of Demonstration Results

n/a

##### 6.4.10.1.5 Significance of Demonstration Results

None.

#### 6.4.10.2 Conclusions and recommendations

#### 6.4.10.3 Conclusions

None.

#### 6.4.10.4 Recommendations

None.

### 6.4.11 Exercise Results for DEM-004-06

#### 6.4.11.1 Summary of Exercise Results

##### 6.4.11.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

###### 6.4.11.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.4.11.1.1.1.1 Performance Analysis

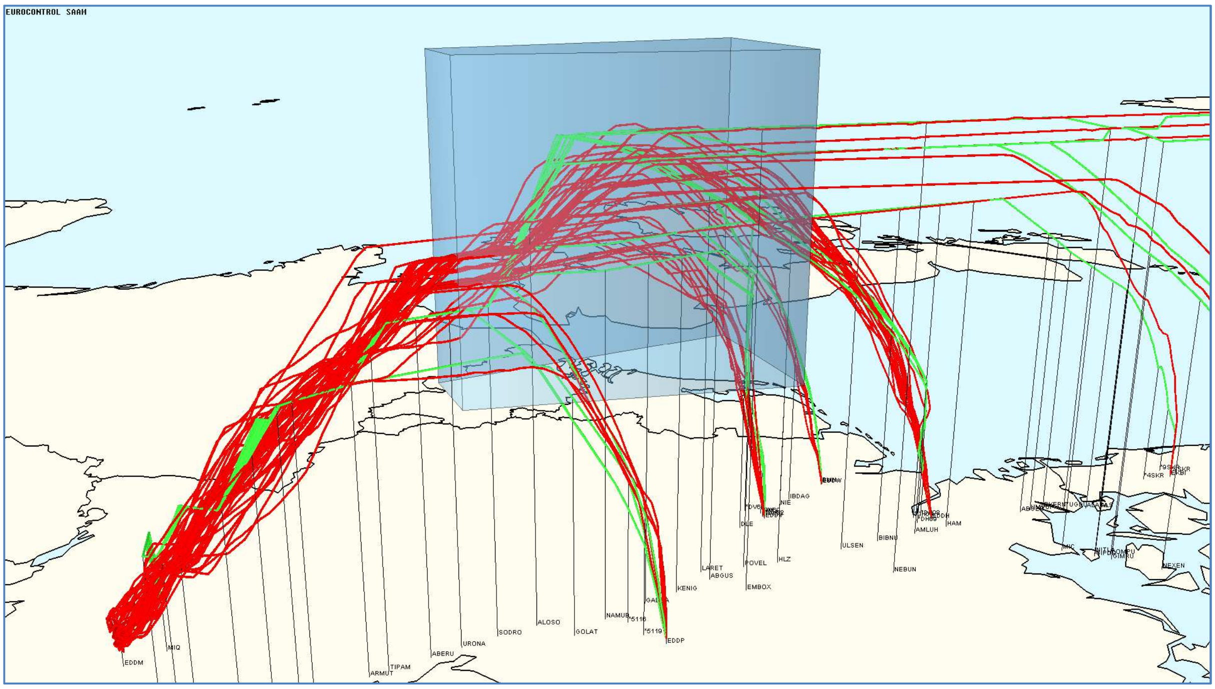



*Figure 94: Reference (red) and ODP (green) radar data recordings to Munich (EDDM) via SODRO*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-004-06 from SAAM perspective are summarized in Figure 72. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.4.11.1.1.1.2 Operational subjective Feedback

For Munich ACC, please check feedback in chapter 6.4.9.1.1.1.2.

Feedback Karlsruhe UAC:

Later transfer from Karlsruhe UAC to Munich ACC (15NM prior to SODRO FL320 instead of 25 prior SODRO) is operational possible and was implemented WEF 17SEP15 as permanent procedure.

##### 6.4.11.1.1.2 Assessment Results by Airline Operator

###### 6.4.11.1.1.2.1 Performance Analysis

The improvements showed only limited success. As SODRO was already overflown at FL310 on a tactical basis the average altitude rise was limited to 576ft.

With the already above used method this results in the following fuel figures:

Only A320 DLH aircraft are operating regularly on the SODRO routing and 5800 flights were considered for the analysis:

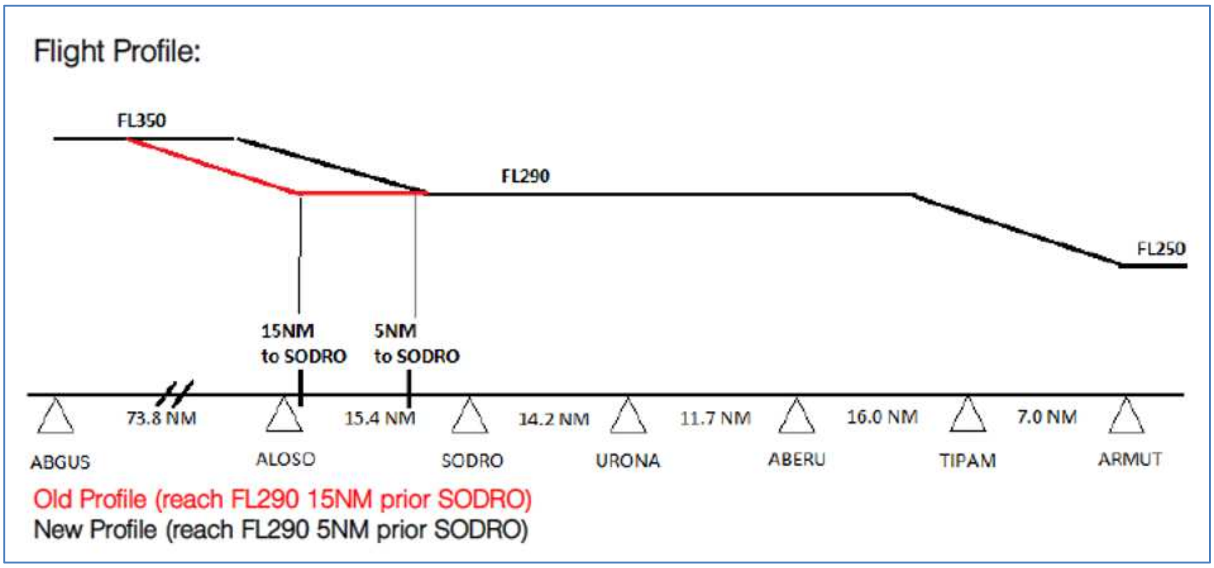



*Figure 95: visualization of profile improvement at SODRO between Karlsruhe UAC and Munich ACC*

Calculation results are summarised as follows:

| Enlarged CFL distance: | | | | Fuel Used FL350, Speed 450kts | | | Fuel Used FL290, Speed 462kts | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A/C Type | descent angle: | weight | Δs | Time [min] | Fuel Burn [kg/h] | Fuel Used [kg] | Time [min] | Fuel Burn [kg/h] | Fuel Used [kg] | Fuel Saved [kg] |
| A321 | 2,94° | 70t | 2,02 | 0,27 | 2544 | 11,4 | 0,26 | 2958 | 12,9 | 1,5 |
| A320 | 2,89° | 60t | 2,06 | 0,28 | 2270 | 10,4 | 0,28 | 2712 | 12,1 | 1,7 |
| A319 | 2,98° | 55t | 2,00 | 0,26 | 2176 | 9,7 | 0,26 | 2614 | 11,3 | 1,6 |

*Table 32: results of 5.800 flights for routings via SODRO*

Finally, fuel figures were evaluated for the whole ODP period between July 2014 and September 2016 to investigate if an improvement could be seen. Average fuel in the zone between 150,0NM (25NM prior SODRO) and 30,0NM (5NM prior LANDU) from EDDM. Average fuel consumption for the A320 family was 539kg and the expected fuel benefits of DEM-004-04 and DEM-004-06 were well within the variance of the flights and therefore couldn't be measured.

#### 6.4.11.1.1.2.2 Operational subjective Feedback

During the ODP project many aspects of the SODRO flow were under discussion, and DLH likes to thank the DFS procedure designer staff for its efforts on this vertically extremely penalized flow.

The most promising alternative seemed to be an adaptation of the strict RAD rule, which forbids traffic on the citypairs HAJ-MUC, BRE-MUC and HAM-MUC to fly the horizontally shorter and vertically more efficient western routing via DLE-DKB due to capacity issues in the western German sectors.

This adaption which would have allowed traffic on off-peak hours was stopped on short notice during the project due to future traffic forecasting, DLH recommends to resume discussion on this routing.

##### 6.4.11.1.2 Results impacting regulation and standardisation initiatives

None.

##### 6.4.11.1.3 Unexpected Behaviours/Results

None.

##### 6.4.11.1.4 Quality of Demonstration Results

n/a

##### 6.4.11.1.5 Significance of Demonstration Results

None.

#### 6.4.11.2 Conclusions and recommendations

#### 6.4.11.3 Conclusions

Later transfer from Karlsruhe UAC to Munich ACC was implemented WEF 17SEP15 as permanent procedure.

#### 6.4.11.4 Recommendations

None.

## 6.5 Demonstration Exercise SCN-0103-005 / Strasbourg (LFST/SXB) Report

*Provide Demonstration Exercise Report for Exercise #1, according to the Demonstration Exercise Report Template provided hereunder.*

### 6.5.1 Exercise Scope

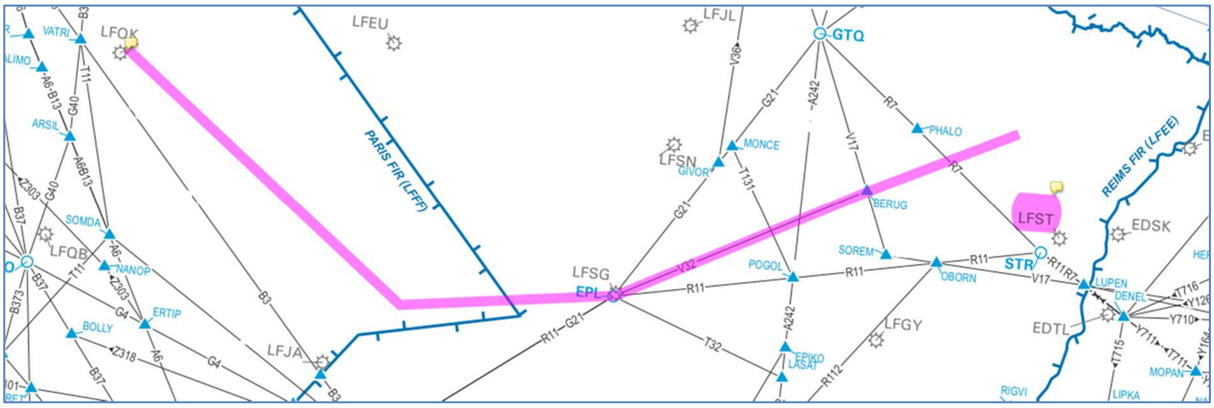



*Figure 96: Trial overview EPL to Strasbourg (LFST) SCN-0103-005/ EXE-0103-005/ DEM-005-02 (chart based on [21])*

Overall SAAM calculation results for EXE-0103-05 are as follows (the flow with city pair EHAM-LFST was not trialed, details see Table 12):

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 3 | 2,221 |
| Equal | 3 | 0,000 | 0 | 0,000 | 2 | -0,538 | 2 | -1,700 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 3 | -2,863 | 1 | -35,410 | 1 | -111,890 | 0 | 0,000 |
| Total | 3 | 0,000 | 3 | -2,863 | 3 | -35,948 | 3 | -113,590 | 3 | 2,221 |

*Figure 97: Summary of potential gains for ARR to Strasbourg via EPL (City pair LFPO-LFST)*

### 6.5.2 Conduct of Demonstration Exercise EXE-0103-005

#### 6.5.2.1 Exercise Preparation

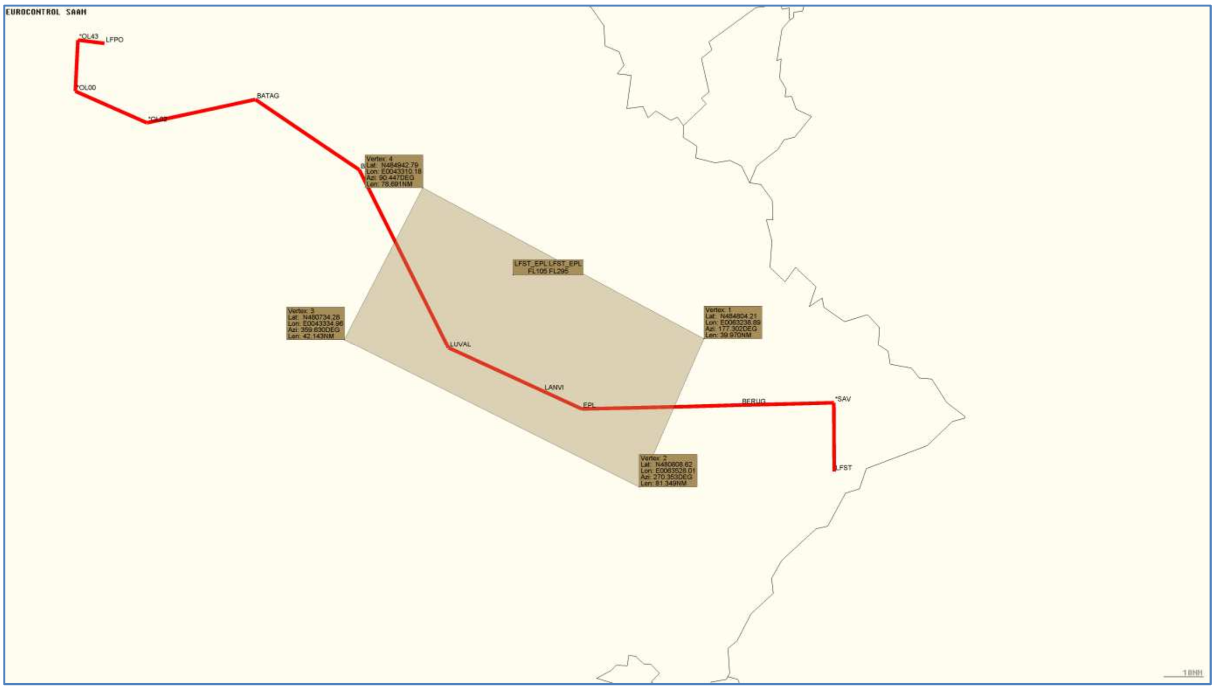



*Figure 98: Trial overview and the measurement window for Strasbourg (LFST)*

#### 6.5.2.2 Exercise execution

Not applicable since the demonstration has been cancelled, details see Table 12.

#### 6.5.2.3 Deviation from the planned activities

Yes, see 4.3.

### 6.5.3 Exercise Results for DEM-005-01

#### 6.5.3.1 Summary of Exercise Results

Not applicable since the demonstration has been cancelled, details see Table 12.

##### 6.5.3.1.1 Results per KPA

Not applicable since the demonstration has been cancelled, details see Table 12.

##### 6.5.3.1.2 Results impacting regulation and standardisation initiatives

Not applicable since the demonstration has been cancelled, details see Table 12.

##### 6.5.3.1.3 Unexpected Behaviours/Results

Not applicable since the demonstration has been cancelled, details see Table 12.

##### 6.5.3.1.4 Quality of Demonstration Results

Not applicable since the demonstration has been cancelled, details see Table 12.

##### 6.5.3.1.5 Significance of Demonstration Results

Not applicable since the demonstration has been cancelled, details see Table 12.

### 6.5.4 Conclusions and recommendations for DEM-005-01

#### 6.5.4.1 Conclusions

Details can be found in Table 12.

#### 6.5.4.2 Recommendations

### 6.5.5 Exercise Results for DEM-005-02

#### 6.5.5.1 Summary of Exercise Results

##### 6.5.5.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

###### 6.5.5.1.1.1 Assessment Results by ANSP and Eurocontrol

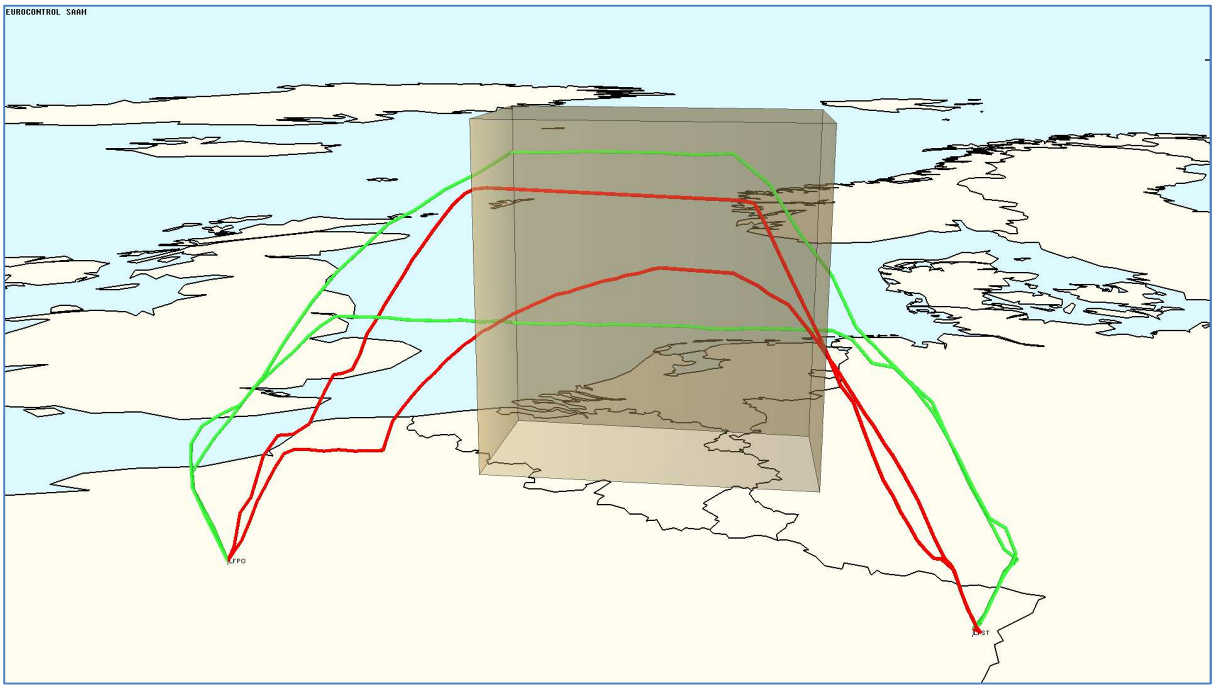


*Figure 99: Reference (red) and ODP (green) radar data recordings for Strasbourg (LFST)*

###### 6.5.5.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-005-02 from SAAM perspective are summarized in Figure 83. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.5.5.1.1.1.2 Operational subjective Feedback

None.

##### 6.5.5.1.1.2 Assessment Results by Airline Operator

###### 6.5.5.1.1.2.1 Performance Analysis

HOP! had no flights via EPL, all 18 weekly flights are planned via GTQ.

###### 6.5.5.1.1.2.2 Operational subjective Feedback

HOP! had no flights via EPL, all 18 weekly flights are planned via GTQ.

#### 6.5.5.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.5.5.1.3 Unexpected Behaviours/Results

None.

##### 6.5.5.1.4 Quality of Demonstration Results

None.

##### 6.5.5.1.5 Significance of Demonstration Results

None.

### 6.5.6 Conclusions and recommendations

#### 6.5.6.1 Conclusions

None.

#### 6.5.6.2 Recommendations

None.

## 6.6 Demonstration Exercise SCN-0103-006 / Stuttgart (EDDS/STR) Report

### 6.6.1 Exercise Scope

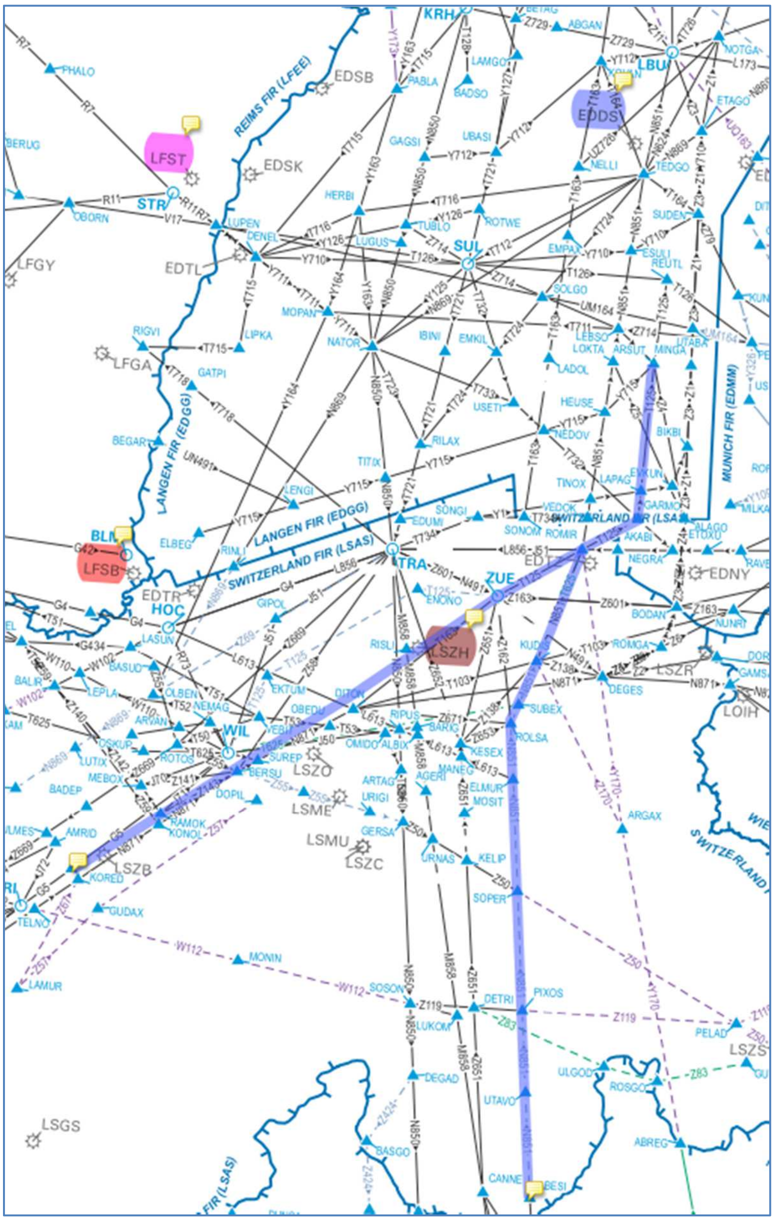



*Figure 100: Trial overview ABESI/ KORED to Stuttgart (EDDS) SCN-0103-006/ EXE-0103-006/ DEM-006-01 and DEM-006-02 (chart based on [21])*

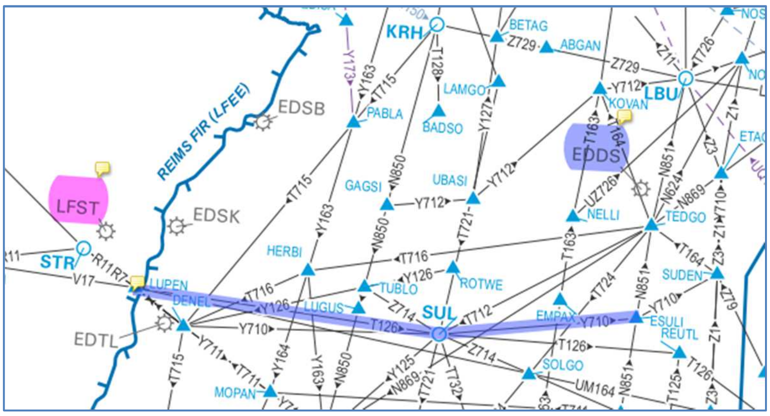



*Figure 101: Trial overview LUPEN to Stuttgart (EDDS) SCN-0103-006/ EXE-0103-006/ DEM-006-03 (chart based on [21])*

Overall SAAM calculation results for EXE-0103-06 are as follows:

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 1 | 0,159 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 1 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 0 | 0,000 | 1 | -37,060 | 1 | -117,100 | 1 | -0,757 |
| Total | 1 | 0,000 | 1 | 0,159 | 1 | -37,060 | 1 | -117,100 | 1 | -0,757 |

*Figure 102: Summary of potential gains for ARR to Stuttgart via ABESI, DEM-006-01*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 23 | 2,921 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 26 | 0,030 | 2 | 0,000 | 0 | 0,000 | 0 | 0,000 | 1 | -0,002 |
| Decrease | 0 | 0,000 | 1 | -0,054 | 26 | -807,457 | 26 | -2550,879 | 25 | -17,909 |
| Total | 26 | 0,030 | 26 | 2,867 | 26 | -807,457 | 26 | -2550,879 | 26 | -17,910 |

*Figure 103: Summary of potential gains for ARR to Stuttgart via KORED, DEM-006-01*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 1 | 0,032 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 5 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 4 | -0,759 | 5 | -25,521 | 5 | -80,620 | 5 | -0,274 |
| Total | 5 | 0,000 | 5 | -0,727 | 5 | -25,521 | 5 | -80,620 | 5 | -0,274 |

*Figure 104: Summary of potential gains for ARR to Stuttgart via LUPEN, DEM-006-03*

## 6.6.2 Conduct of Demonstration Exercise EXE-0103-006

### 6.6.2.1 Exercise Preparation

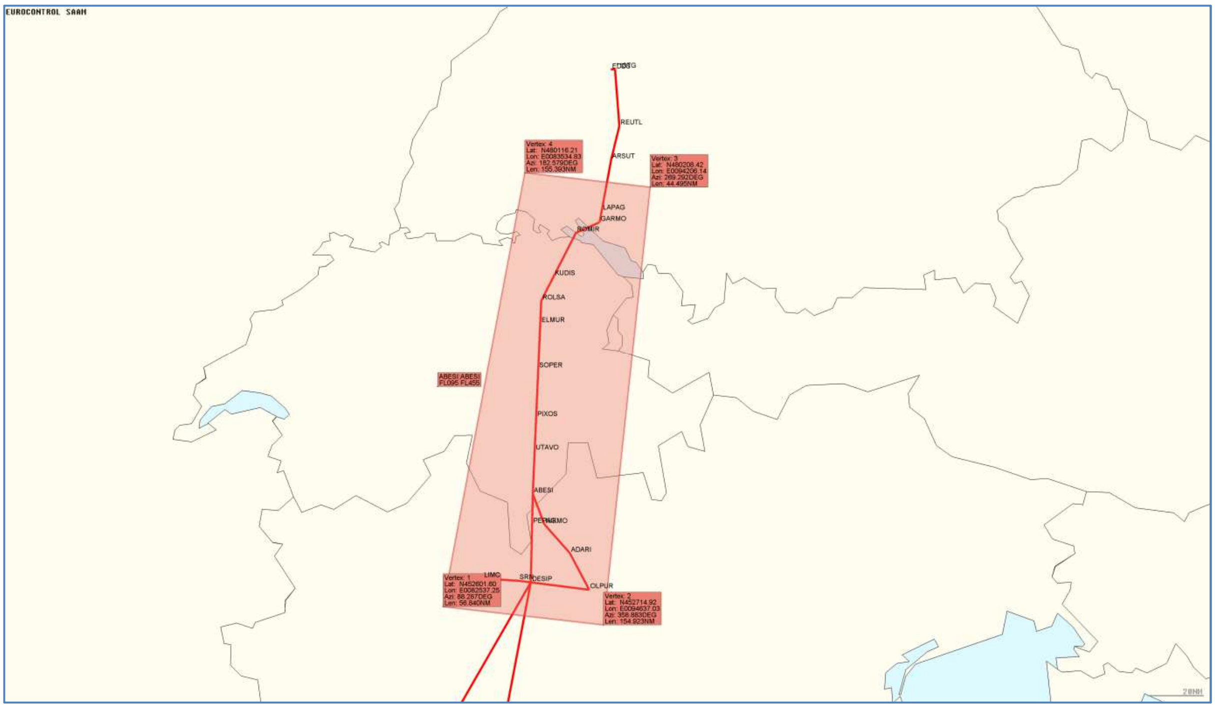



*Figure 105: Trial overview and the measurement window for Stuttgart (EDDS) via ABESI*

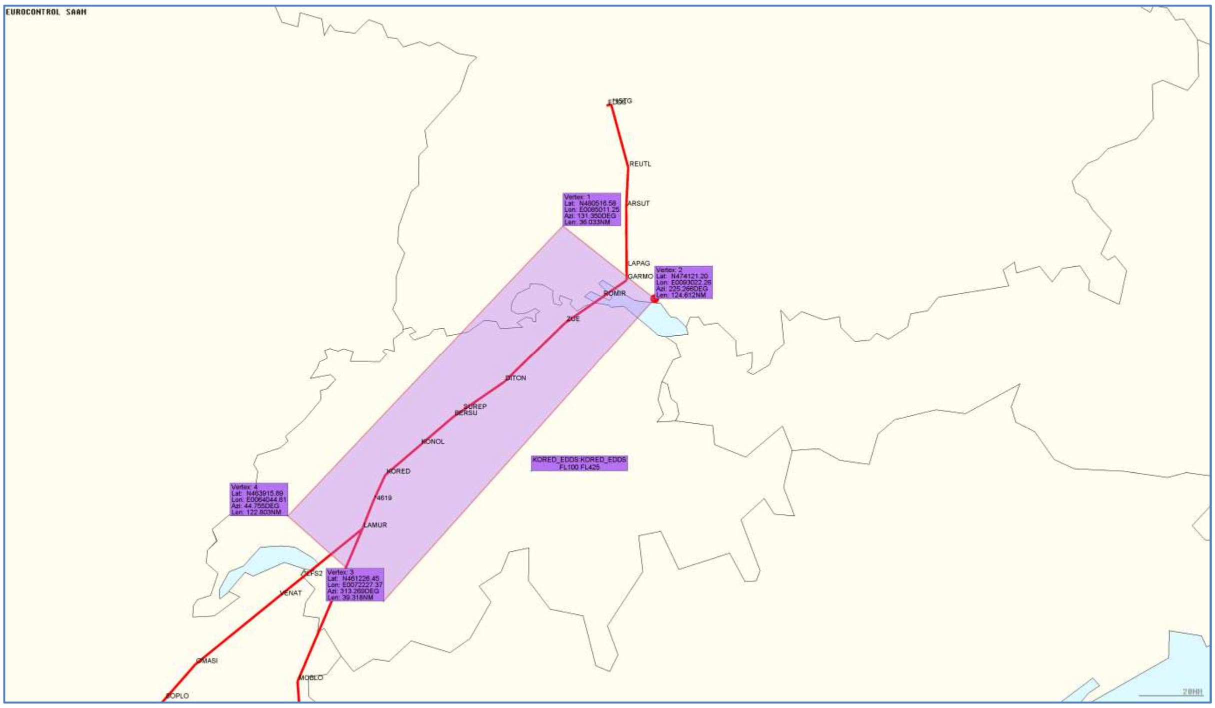


*Figure 106: Trial overview and the measurement window for Stuttgart (EDDS) via KORED*

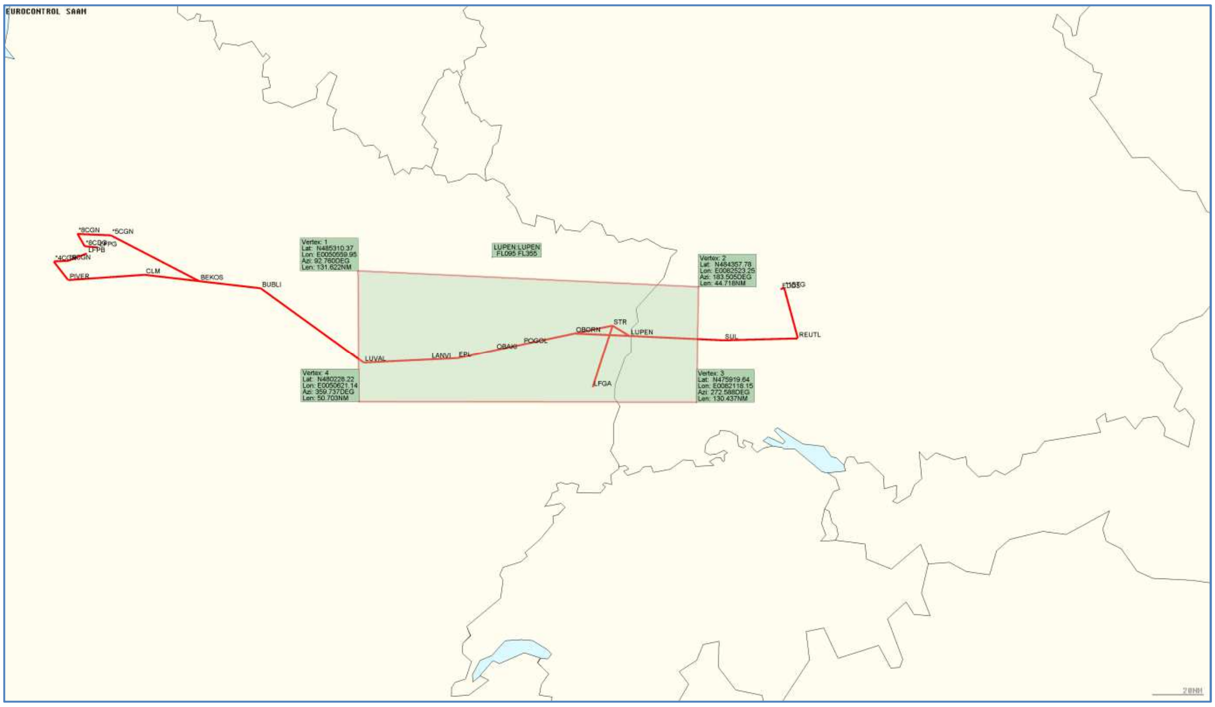


*Figure 107: Trial overview and the measurement window for Stuttgart (EDDS) via LUPEN*

### 6.6.2.2 Exercise execution

### 6.6.2.3 Deviation from the planned activities

None.

### 6.6.3 Exercise Results for DEM-006-01

#### 6.6.3.1 Summary of Exercise Results

##### 6.6.3.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

##### 6.6.3.1.2

###### 6.6.3.1.2.1 Assessment Results by ANSP and Eurocontrol

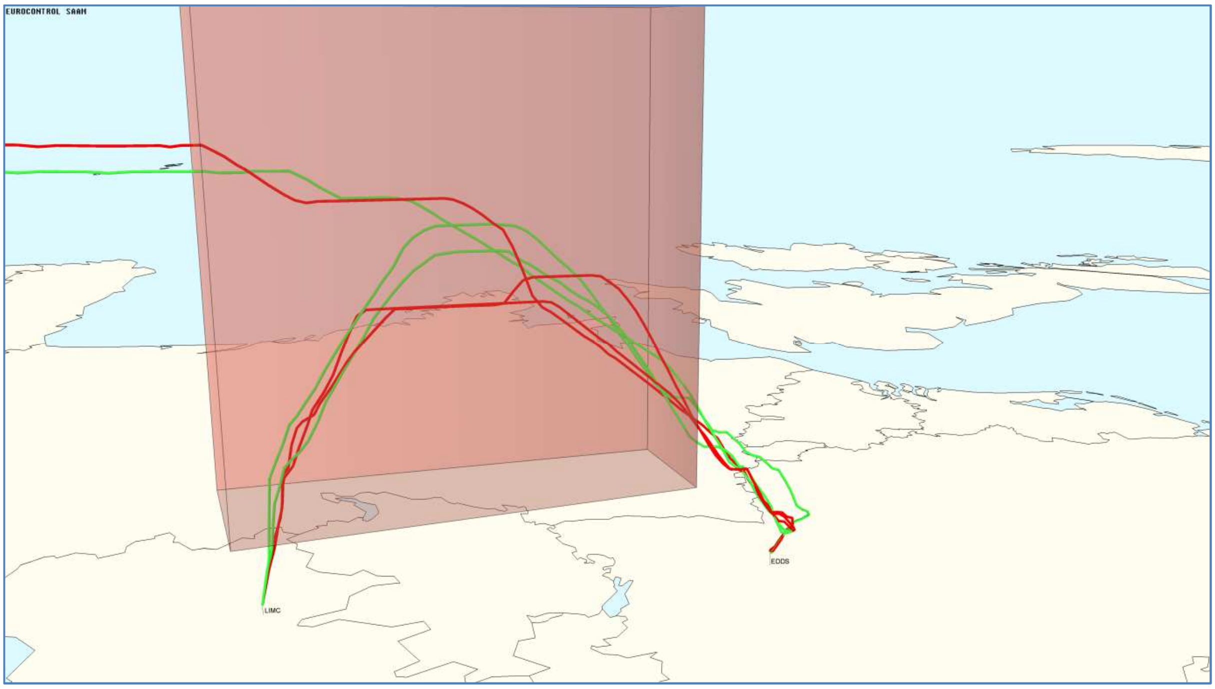



*Figure 108: Reference (red) and ODP (green) radar data recordings for Stuttgart (EDDS) via ABESI*

###### 6.6.3.1.2.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-006-01 from SAAM perspective are summarized in Figure 88. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.6.3.1.2.1.2 Operational subjective Feedback

None.

###### 6.6.3.1.2.2 Assessment Results by Airline Operator

###### 6.6.3.1.2.2.1 Performance Analysis

No Airline data available. DLH had no flights on this routing.

###### 6.6.3.1.2.2.2 Operational subjective Feedback

No Airline data available. DLH had no flights on this routing.

#### 6.6.3.1.3 Results impacting regulation and standardisation initiatives

None.

#### 6.6.3.1.4 Unexpected Behaviours/Results

None.

#### 6.6.3.1.5 Quality of Demonstration Results

None.

#### 6.6.3.1.6 Significance of Demonstration Results

None.

## 6.6.4 Conclusions and recommendations

### 6.6.4.1 Conclusions

None.

### 6.6.4.2 Recommendations

None.

## 6.6.5 Exercise Results for DEM-006-02

### 6.6.5.1 Summary of Exercise Results

#### 6.6.5.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

##### 6.6.5.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.6.5.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-006-02 from SAAM perspective are summarized in Figure 89. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.6.5.1.1.1.1.1 Skyguide

There had been a total number of 76 planned ODP Trials participants. Unfortunately 42 of them filed outside LSAZ. 28 of the remaining 34 flights were able to perform a CDO. The remaining 6 did not perform a CDO due to various reasons such as: lack of information (poor briefing?), technical problem, traffic (2x), emergency, early descent due to LoA (EFL too low/ MILANO).

In low to medium traffic situations during MIL OFF, a higher EFL (Cruising FL via KORED) is manageable. In order to enable the procedure up to 4 ACC sectors are involved (compared to only one nowadays) which can increase workload and complexity. The already implemented change (LoA) of standard XFL310 to MUNICH brings us closer to a ODP profile than the former XFL270 and can be considered a major improvement. Due to airspace structure a higher XFL than FL310 is not possible (RHINE ALPS) so that this procedure won't lead to a real CDO but is an optimisation (ODP).

No issues were encounter in handling inbounds EDDS according to the trial procedure during low traffic periods. The XFL120-140 ARSUT (accord. LoA) proved well.

###### 6.6.5.1.1.1.2 Operational subjective Feedback

##### 6.6.5.1.1.2 Assessment Results by Airline Operator

###### 6.6.5.1.1.2.1 Performance Analysis

No Airline data available. DLH had no flights on this routing.

###### 6.6.5.1.1.2.2 Operational subjective Feedback

No Airline data available. DLH had no flights on this routing.

#### 6.6.5.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.6.5.1.3 Unexpected Behaviours/Results

None.

#### 6.6.5.1.4 Quality of Demonstration Results

None.

#### 6.6.5.1.5 Significance of Demonstration Results

None.

### 6.6.6 Conclusions and recommendations

#### 6.6.6.1 Conclusions

None.

#### 6.6.6.2 Recommendations

The following has been recommended by Skyguide:

- Since a complete CDO for EDDM inbounds is not possible at present time and Skyguide has no influence on tfc planning in MUNICH ACC a flexible handling (EFL) is preferable. Depending on RWY in use (XFL270 or 310) the EFL via KORED should be adjusted accordingly.
- A flexible handling of EFL for inbounds EDDS could be used. However, if tfc and complexity increases lower EFL (acc. LoA) are preferable.
- As MILANO did not take part the EFL320 for EDDS inbounds had been judged as "too low". A process as stated above could be used.

### 6.6.7 Exercise Results for DEM-006-03

#### 6.6.7.1 Summary of Exercise Results

##### 6.6.7.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

###### 6.6.7.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.6.7.1.1.1.1 Performance Analysis

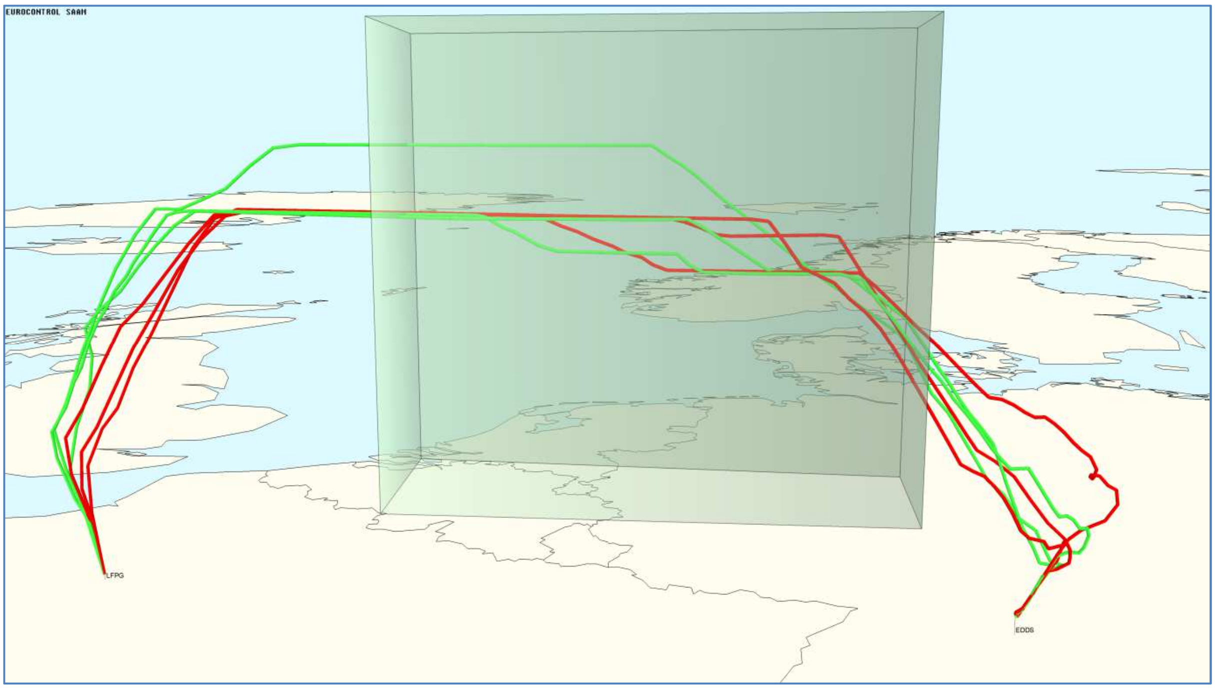



*Figure 109: Reference (red) and ODP (green) radar data recordings for Stuttgart (EDDS) via LUPEN*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-006-03 from SAAM perspective are summarized in Figure 90. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

##### 6.6.7.1.1.1.2 Operational subjective Feedback

EDGG: no comments, since DSNA decided the trial to be outside ODP and in FABEC VFE.

#### 6.6.7.1.1.2 Assessment Results by Airline Operator

##### 6.6.7.1.1.2.1 Performance Analysis

No specific trial evaluated by HOP!, therefore:

*Figure 110: City pair LFPG-EDDS for FL310*

In total 259 HOP! flights were studied on this flow CDG-STR applying CDO from TOD raise up to 5000ft. We observed on that city-pair CDG-STR, the trajectory optimization brings gains brings an average gain of 0,50 % of fuel savings or 12 to 15 kg fuel gain(Embraer 190)
On this analysis except tactical gain due to ATC, no NM gain were observed. Further findings were:

- No negative impact on safety
- No crew training
- No additional OCC , CREW work load
- No AU invest

###### 6.6.7.1.1.2.2 Operational subjective Feedback

Any type of improvable change, such as optimised levels, tactical interventions and clearances are benefits for the airline operators.

However, compared to HFE gains, FL optimisation, VFE gains requires bigger efforts for preparation, design and implementation.

#### 6.6.7.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.6.7.1.3 Unexpected Behaviours/Results

None.

#### 6.6.7.1.4 Quality of Demonstration Results

None.

#### 6.6.7.1.5 Significance of Demonstration Results

None.

## 6.6.8 Conclusions and recommendations

### 6.6.8.1 Conclusions

None.

### 6.6.8.2 Recommendations

None.

# 6.7 Demonstration Exercise SCN-0103-007 / Vienna (LOWW/VIE) Report

## 6.7.1 Exercise Scope

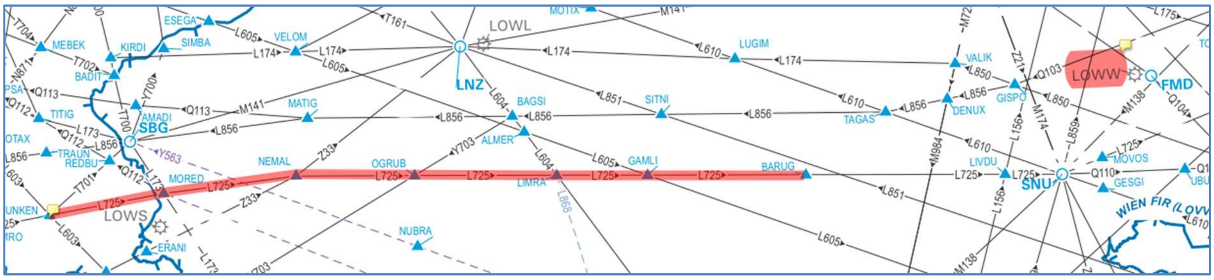



*Figure 111: Trial overview GAMLI to Vienna (LOWW) SCN-0103-007/ EXE-0103-007/ DEM-007-01 (chart based on [21])*

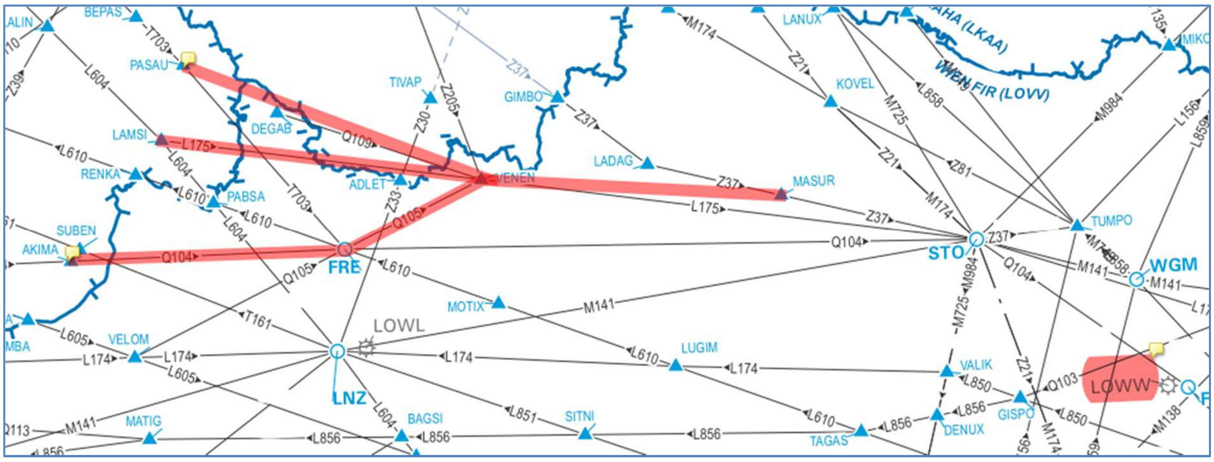



*Figure 112: Trial overview VENEN to Vienna (LOWW) SCN-0103-007/ EXE-0103-007/ DEM-007-02 (chart based on [21])*

Overall SAAM calculation results for EXE-0103-07 are as follows:

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 40 | 1,364 | 0 | 0,000 | 0 | 0,000 | 1 | 0,050 |
| Equal | 40 | -0,060 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 0 | 0,000 | 40 | -353,520 | 40 | -1118,900 | 39 | -7,249 |
| Total | 40 | -0,060 | 40 | 1,364 | 40 | -353,520 | 40 | -1118,900 | 40 | -7,199 |

*Figure 113: Summary of potential gains for ARR to Vienna via VENEN, DEM-007-01*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 29 | 3,230 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 29 | 0,100 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 0 | 0,000 | 29 | -643,839 | 29 | -2034,360 | 29 | -12,496 |
| Total | 29 | 0,100 | 29 | 3,230 | 29 | -643,839 | 29 | -2034,360 | 29 | -12,496 |

*Figure 114: Summary of potential gains for ARR to Vienna via GAMLI, DEM-007-02*

## 6.7.2 Conduct of Demonstration Exercise EXE-0103-007

### 6.7.2.1 Exercise Preparation

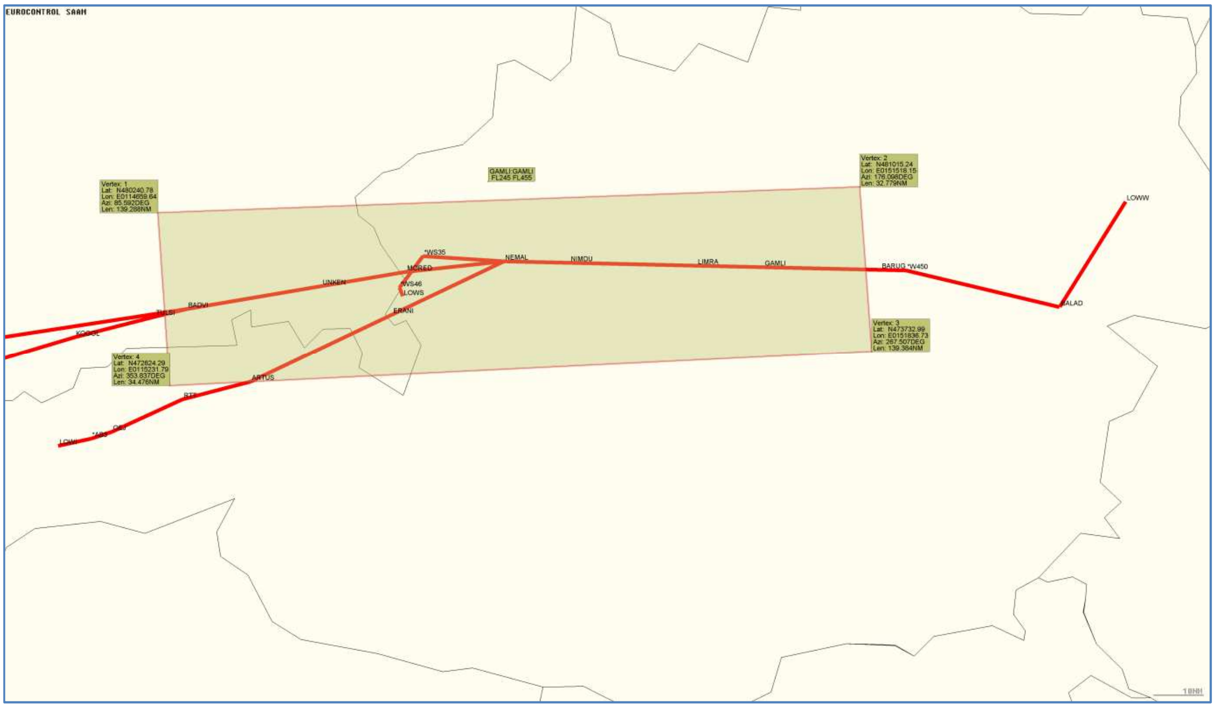



*Figure 115: Trial overview and the measurement window for Vienna (LOWW) via GAMLI*

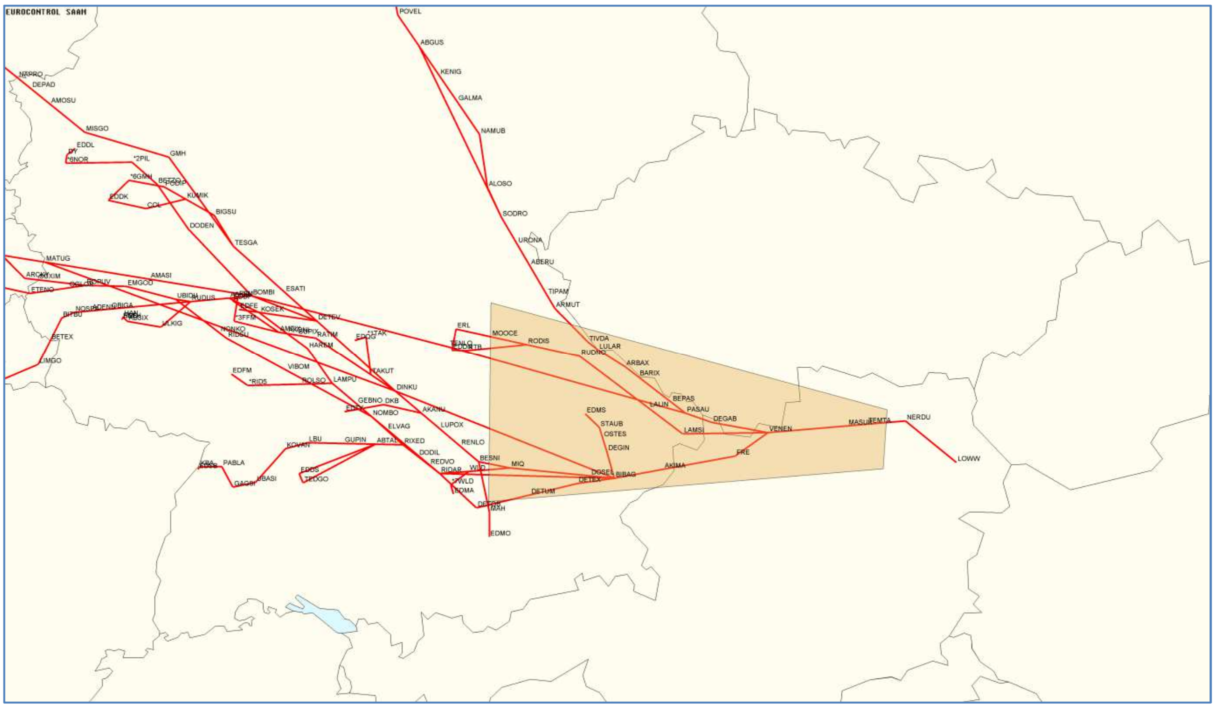



*Figure 116: Trial overview and the measurement window for Vienna (LOWW) via VENEN*

1. Procedure design:

The constraints between ACC and APP sectors were out of scope of the study because of the up-coming cut-over to the new ATM system in APP sectors which meant an excessive demand of resources and the need to eliminate any additional complexity and risk in the transition phase.

Thus the goal was to develop fileable ODP procedures available to all flights enabling continuous descend from cruising level down to the ACC-APP interface.

Austro Control started with basic calculations of optimum descent paths using minimum and maximum descent angles already evaluated in CDO EDDM design process.

These basic calculations were cross-checked with our partner airlines´ descent calculations and the aircraft descent profiles formulated in SJU ODP WP1.

With the following analyses of relevant conflicting traffic flows, traffic counts, sector capacities and sector operating hours the possibilities of offering optimum descent profiles without hampering sector capacities were evaluated. The results showing capacities for improvement of procedures were discussed with ATM system and procedures experts and draft procedures were created taking in mind ATM stripless system logic, MTCD necessities and ACC Vienna´s standard operating procedures as well as human factors and safety aspects.

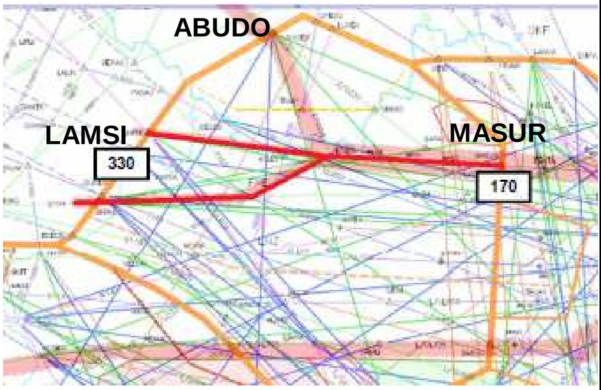
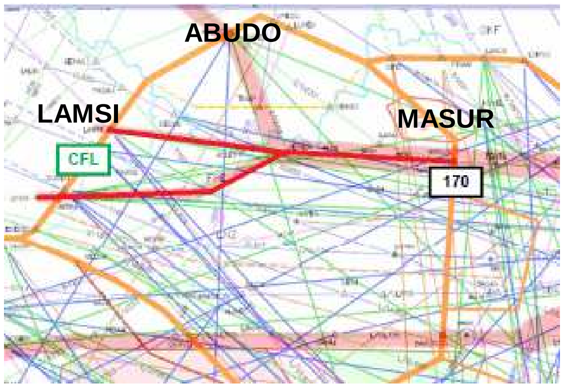
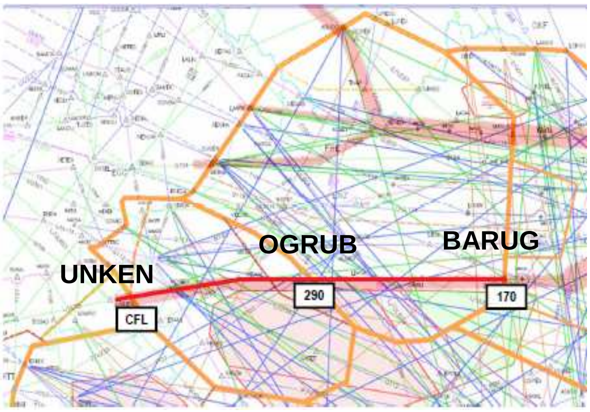
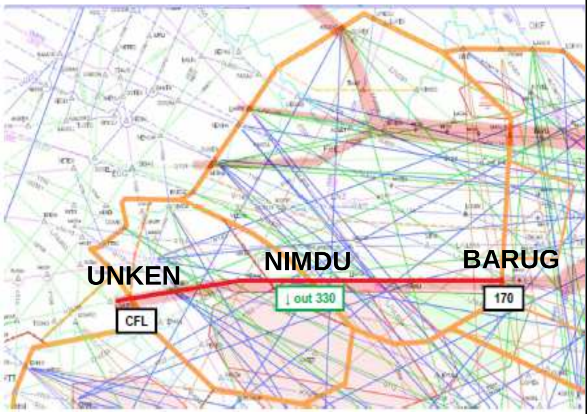
A fast time simulation (CAPAN study by Eurocontrol ref. [14]) finally showed that the intended changes´ effects on workload and sector capacities would be acceptable and manageable within available sector configurations.

The resulting published procedures are available on a 24/7 basis and do offer the chance for continuous descent within the ODP limits by default as far as traffic situation permits. ATM sectors involved can provide continuous descend clearances without the need for prior coordination and downstream sectors can continue ODP as far as practicable.

The ODP procedures are implemented in ATM standard operating procedures and can easily be handled and modified by controllers, thus meeting the needs of high workload periods as well as offering unrestricted descent on tactical basis during low workload periods.

For the northern ODP flow via VENEN entry conditions from KUAC were changed and published via RAD tool.

For the southern ODP flow via GAMLI a two-step approach was necessary with the change of handover level between ACC sectors first and the publication of an appropriate STAR to LOWW, NEMAL 1 W, with the goal to insert vertical profile restrictions not interfering a continuous descent and protecting ATM sector capacities.

<table>
<tr><th>Before ODP</th><th>After ODP</th></tr>
<tr><td>North Arrival<br></td><td></td></tr>
<tr><td>South Arrival<br></td><td></td></tr>
</table>

AF North routes are via ABUDO only. As this flow was excluded from ODP trial, AF did not participate in the North Trial.

South Arrival trial is sum up on the following table:

| Before ODP | After ODP |
|---|---|
| GAMLI (Sud Arrival): OGRUB FL290 | GAMLI: NIMDU **FL330** (via NEMAL1W STAR) |

Note: NIMDU replaced OGRUB – difference of position of 5NM).

ODP changes on this South arrival flow were implemented into two steps:

- Step 1: Tactical change : raise of FL at OGRUB to FL330 from B-sector to N-sector from November 28, 2015
- Step 2: STAR Publication: New STAR including the FL change were published on March 3rd, 2016. This new STAR publication was the opportunity for ATCO and Pilots to practice the new ICAO phraseology and hence execute continuous descents within the given altitude limitations.

2. Airline Safety Assessment

On AF flow, no safety assessment was necessary.

3. Pilot training

No training was necessary for ODP trial

4. Pilot Questionnaires

- Pilot report was available for Pilots to express themselves about ODP changes.

### 6.7.2.2 Exercise execution

**AF inputs:**

For AF, 749 flights were flown between LFPG and LOWW from September 2015 to May 2016. 446 were flights via the south routing. All those flights were concerned by the ODP changes. Definition of reference and target situations is described in next section about Performance Analysis.

- The general approach followed for the results analysis depends on the operational impact of the ODP improvement. This is described below: Step 1 - tactical change of the constraint on NIMDU: This has no impact on the pilot procedure or flight planning. Fuel benefits are on the tactical side (no Fuel transport gain). Complete analysis is detailed in the next section.
- Step 2 – New STAR publication:
    - a change in the STAR nomination ODP : It was include in the flight plan and approach charts.
    - Publication of the FL improvement at NIMDU: Integration of this tactical practice into the publication is an improvement from a pilot awareness point of view. However, even if published, constraint at NIMDU is not taking into account in the flight plan. This is linked to LIDO flight planning calculator algorithm (compliant with ICAO flight plan). The figure below illustrates vertical profile calculation by LIDO. As you can see, the flight starts naturally its descent before NIMDU to meet with the BARUG constraints. Therefore NIMDU constraint is ignored (same situation before and after ODP from a flight planning point of view).

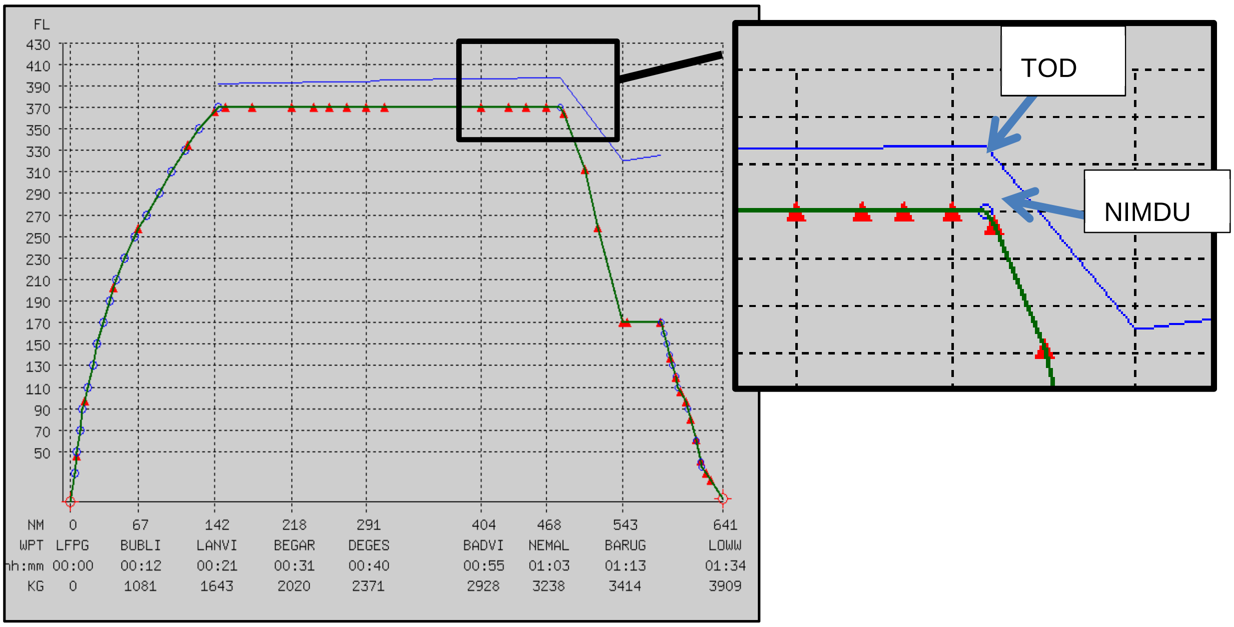



*Figure 117: change in ToD at NIMDU*

Thus, we considered the modification proposed by ODP as a tactical level only as it has no impact of flight planned fuel. A Complete analysis is given in the next sections.

- Modification of phraseology in Vienna: this has been notified in Pilot operational manual. Impact of the introduction of this new phraseology could not be studied by AF.

#### 6.7.2.3 Deviation from the planned activities

No deviations.

### 6.7.3 Exercise Results for DEM-007-01

#### 6.7.3.1 Summary of Exercise Results

1. Flight level constraints that are published in approach procedures based on existing letters of agreements provide predictability for FMS profile calculation and flight planning and allow for better descents.
2. Avoiding pre-descents and pro-active inter-sector coordination combined with a clearance to follow an optimised descent profile leads to the best possible savings in a given environment.
3. Considering the better fuel scores without a published constraint at NIMDU, however, it is questionable if flight level constraints in upper airspace are a good means to improve flight efficiency. They might, on the contrary, lead to a reduction in coordination activities and in turn reduce the possible benefit. If constraints in upper airspace are part of procedures, they should be published exactly on the idle descent path of most aircraft types, thus be defined as altitude windows.

   Here a short snapshot of the above mention discrepancy from chapter 6.7.3.1.1.2.1:

Swiss performance calculation: -33,9kg (-16,95%) between pre ODP to full implementation NEMAL 1W)

Air France performance calculation: -30kg /flight saved between pre ODP and NEMAL1W publication

### 6.7.3.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

#### 6.7.3.1.1.1 Assessment Results by ANSP and Eurocontrol

##### 6.7.3.1.1.1.1 Performance Analysis

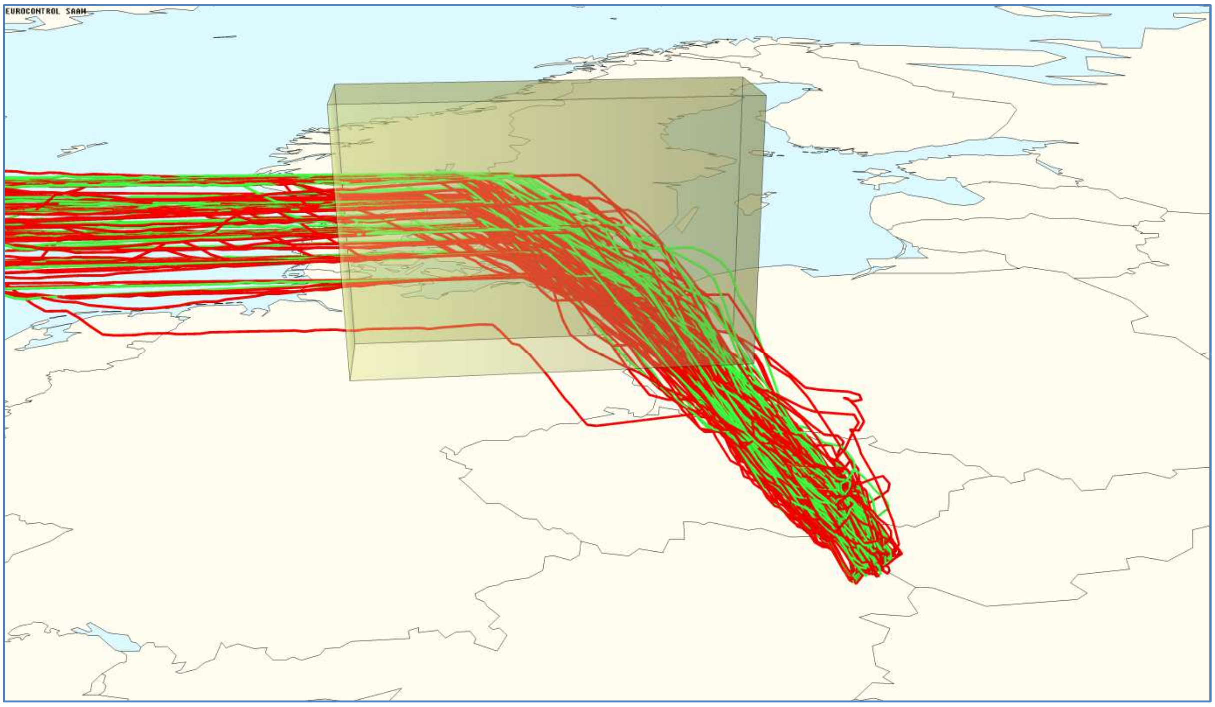



*Figure 118: Reference (red) and ODP (green) radar data recordings for city pair Paris (LFPG) to Vienna (LOWW) via GAMLI*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-007-01 from SAAM perspective are summarized in Figure 99. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

##### 6.7.3.1.1.1.2 Operational subjective Feedback

<u>Feedback Karlsruhe UAC:</u>

No operational change for Karlsruhe UAC. Traffic via UNKEN is transferred in RFL to Vienna ACC before and after the ODP project.

Feedback ACC Wien:

Operational feedback was gained from ATCOs using a questionnaire (ref. Appendix C) referring to aspects of traffic complexity, workload and situational awareness. No negative impact on sector capacities were observed or reported. The results for all Vienna ODP flows did not show any significant change in traffic complexity or workload level in any of the involved ACC Wien working positions:

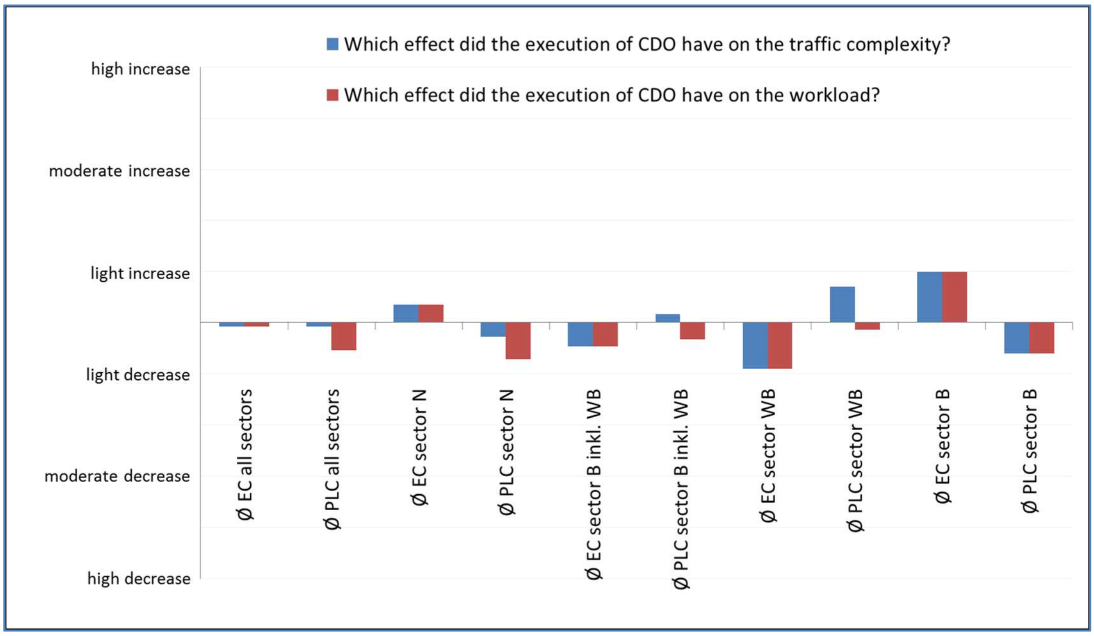



*Figure 119: questionnaire results from Vienna ACC ATCOs*

###### 6.7.3.1.1.2 Assessment Results by Airline Operator

###### 6.7.3.1.1.2.1 Performance Analysis

###### 6.7.3.1.1.2.1.1 SWISS

NEMAL 1W was introduced on 03 March 2016. For flight data analysis, the flight data of all flights operated with Airbus A320-family aircraft from LSZH to LOWW between January 1st and May 3rd were analysed.
Since some of the possible positive effects of the STAR-improvement (introduction of NEMAL 1W WEF 03MAR16) were already anticipated by implementing a higher transfer FL between sectors at Vienna ACC (FL330 from B-sector to N-sector WEF 28NOV15), flight data from spring 2015 were also analysed for reference.

The following flights were not considered in order to increase the comparability of pre- and post-implementation data:

- Flights with a GTD (Ground Track Distance) of more than 115% of the GCD (Great Circle Distance) at a GCD of 200nm from the landing runway (max. permissible GTD of 230nm at a GCD of 200nm); this filter removes flights that were subject to holding and/or long vectoring and/or extensive weather avoidance during descent

- Flights with a head- or tailwind component in excess of 60kt; this filters out flights that were subject to extreme weather conditions

- Flights with a CRZ-FL at or below FL330; they are not affected by a descent clearance before position NIMDU

| | Before ODP (03MAR – 03MAY) 62days | After handover-change (01JAN – 02MAR) 62 days | After Implementation (03MAR – 03MAY) 62 days |
|---|---|---|---|
| **Total of flights considered** | **56*** | **81** | **87** |
| A319 | 19 | 24 | 10 |
| A320 | 23 | 40 | 48 |
| A321 | 14 | 17 | 29 |

*due to the early pre-descents into LOWW, SWISS limited the CRZ-FL of their flights to FL330 on some flights until late spring 2015. This explains the smaller sample size due to the common filters applied.

a) Flight Level analysis

CRZ-FL at waypoint UNKEN:

| | FL340 | FL350 | FL360 | FL370 | FL380 | FL390 | Total |
|---|---|---|---|---|---|---|---|
| 03 Mar – 03 May15 | 3 | 38 | 2 | 9 | - | 4 | 56 |
| 01 Jan – 02 Mar16 | 2 | 22 | 4 | 40 | - | 13 | 81 |
| 03 Mar – 03 May16 | 3 | 39 | 3 | 31 | 1 | 10 | 87 |

| | UNKEN | NEMAL | NIMDU | BARUG |
|---|---|---|---|---|
| **Average FL before ODP** | FL356 | FL331 | FL311 | FL168 |
| Average FL after handover-change | FL366 | FL349 | FL334 | FL164 |
| **Average FL after implementation** | FL362 | FL339 | FL320 | FL167 |
| **Δ before ODP to after full implementation of NEMAL 1W** | +600ft | +800ft | +900ft | -100ft |

Before implementation of the NEMAL 1W arrival, flights were required to cross the waypoint OGRUB (positioned 5nm after NIMDU) at or below FL290. Today, NEMAL 1W requires flights to cross NIMDU at or below FL330.

Based on analysed data, the most optimised profile could be flown after improving the inter-sector handover conditions but before implementing the NEMAL 1W STAR. The fact that the crossing level at position NIMDU is higher before the implementation than after is quite notable. A possible explanation might be that higher levels were actively coordinated for flights via OGRUB before the introduction of the new STAR. This coordination activity between ACC sectors was probably reduced after the implementation of a published procedure.

b) Atmosphere (True Altitude, Wind and Calibrated Airspeed)

GPS-Altitude versus FL:

| | UNKEN | | | NEMAL | | | NIMDU | | | BARUG | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GPS | FL | Δ | GPS | FL | Δ | GPS | FL | Δ | GPS | FL | Δ |
| Pre-ODP | 35’517ft | 356 | -0.23% | 33’041ft | 331 | -0.18% | 31’106ft | 311 | 0.02% | 16’959ft | 168 | 0.9% |
| Post-change | 36’073ft | 366 | -1.44% | 34’332ft | 349 | -1.63% | 32’881ft | 334 | -1.55% | 16’268ft | 164 | -0.8% |
| Post-Impl. | 35’803ft | 362 | -1.10% | 33’538ft | 339 | -1.07% | 31’733ft | 320 | -0.83% | 16’651ft | 167 | -0.29% |

The atmosphere was slightly warmer in the pre-implementation period than in the ODP periods.

Based on “True Altitude” measurements by GPS, the flights’ descent between NIMDU and BARUG encompassed

- 14’147ft before ODP changes
- 16’612ft after improvement of inter-sector handover
- 14’956ft after implementation of NEMAL 1W.

Wind and CAS:

| | UNKEN | | NEMAL | | NIMDU | | BARUG | |
|---|---|---|---|---|---|---|---|---|
| | Ø wind | Ø CAS | Ø wind | Ø CAS | Ø wind | Ø CAS | Ø wind | Ø CAS |
| Pre-ODP | 4kt | 253kt | 1kt | 262kt | -1kt | 267kt | -2kt | 281kt |
| Post-change | -27kt | 248kt | -27kt | 256kt | -26kt | 263kt | -19kt | 284kt |
| Post-implementation | -12kt | 252kt | -13kt | 262kt | -12kt | 269kt | -9kt | 282kt |

- (minus) is a tailwind component

Stronger tailwind during the second analysis period also partially explains the higher average crossing FLs at waypoints during descent observed during this period. Due to the higher ground speed, flights subject to more tailwind cross a waypoint slightly earlier and higher when descending normally.

c) Fuel-consumption

In order not to obtain false and incomparable results, only the flight segment between NIMDU and BARUG is considered for fuel-comparison. The average weight of analysed flights for all 3 phases is within 500kg. This difference in gross weight only causes a minor increase in fuel consumption during descent.

| | Ø Fuel consumption NIMDU - BARUG | Ø Ground Track Distance NIMDU - BARUG |
|---|---|---|
| 03 March – 03 May 15 | 200kg | 62.6NM |
| 01 January – 02 March 16 | 136.7kg | 62.6NM |
| 03 March – 03 May 16 | 166.1kg | 62.4NM |

| | | |
|---|---|---|
| **Δ pre-ODP to phase I (inter-sector handover)** | **-63.3kg (-31.65%)** | **0NM** |
| **Δ pre-ODP to full implementation NEMAL 1W** | **-33.9kg (-16.95%)** | **-0.2NM** |

Ground track distance is nearly the same for all three evaluation phases. Tailwind encountered during the two periods in 2016 increases ground speed and reduces thus the flight time between NIMDU and BARUG. Considering that the crossing FL at all analysed waypoints is within 1'000ft, the impact of wind during descent can be seen here. However, wind alone doesn't explain this result. The fact that pilots were able to benefit from new handover agreements and optimised descent profiles is quite notable.

###### 6.7.3.1.1.2.1.2 Air France

**Step 1: Tactical Change Study:**

**Baseline Definition and analysis:**

Chosen baseline sample is September and October 2015.

In total, 98 AF flights were filed via OGRUB routing (South routing).

ODP profile in Step 1 is defined as FL330 at OGRUB (instead of FL290). This definition has been extended to FL330 and higher at OGRUB. Both numbers are given in this report.

| | *Before ODP improvement* | | |
|---|---|---|---|
| | *FL290* | *FL330* | *FL 330 and higher* |
| *OGRUB* | *26%* | *7%* | *16%* |

*Note: Adherence to expected FL has been defined with a tolerance of +/- 200 ft.*

As you can see, before the ODP step 1 trial, there were only 16% of flights that had the opportunity to fly at FL330 or higher at OGRUB.

For more details, actual altitude distribution at OGRUB is displayed on the following graphics:

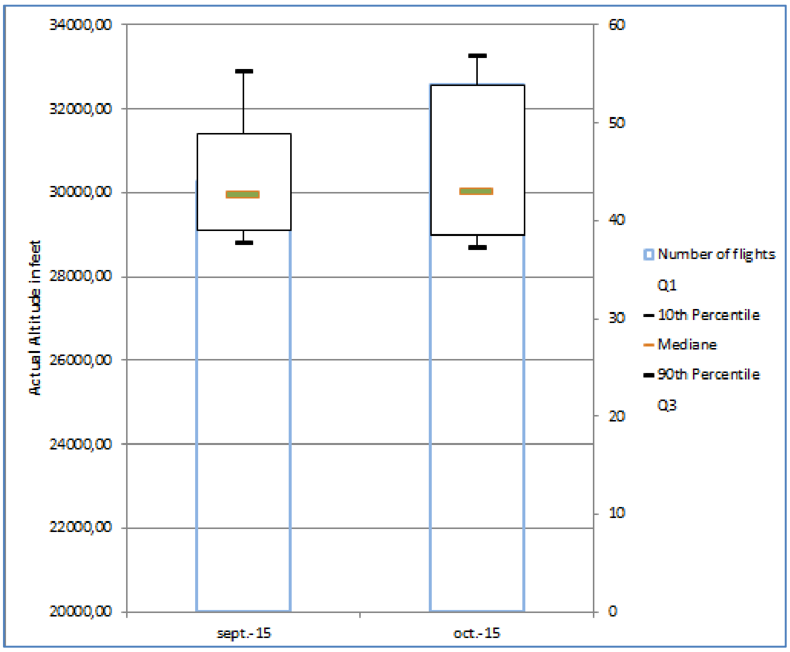



*Figure 120: Actual Altitude distribution at OGRUB*

As you can see, the median value is of 30 000ft with an important FL dispersion around OGRUB.

**Trial data analysis:**

Impact of tactical change has been studied on flights from December 2015 to February 2016: in total, 140 flights were studied.

As for the reference data, we studied the actual ODP profile percentage and the actual FL distribution at OGRUB.

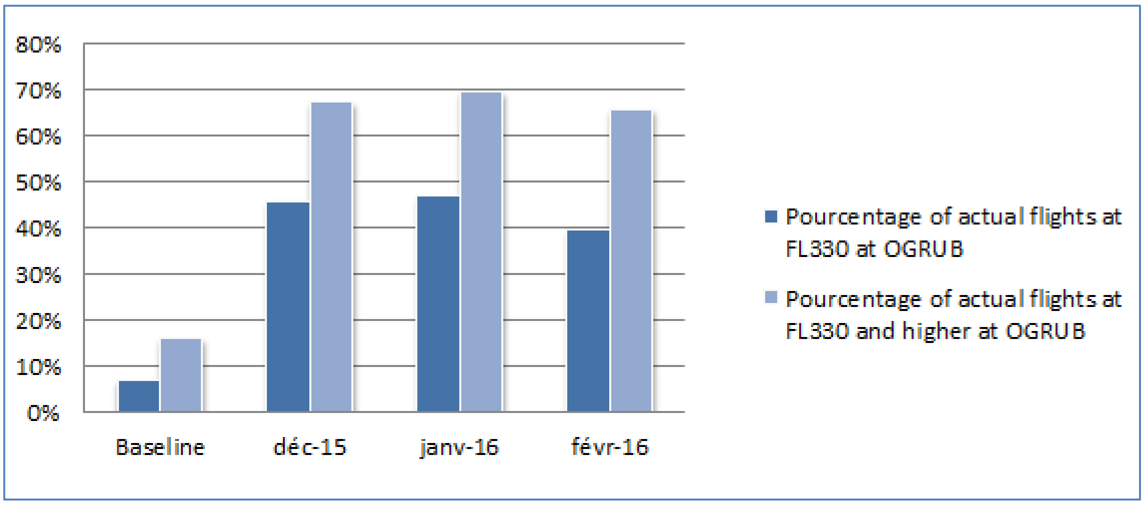



*Figure 121: Evolution of flown ODP profiles before and after ODP step 1 implementation*

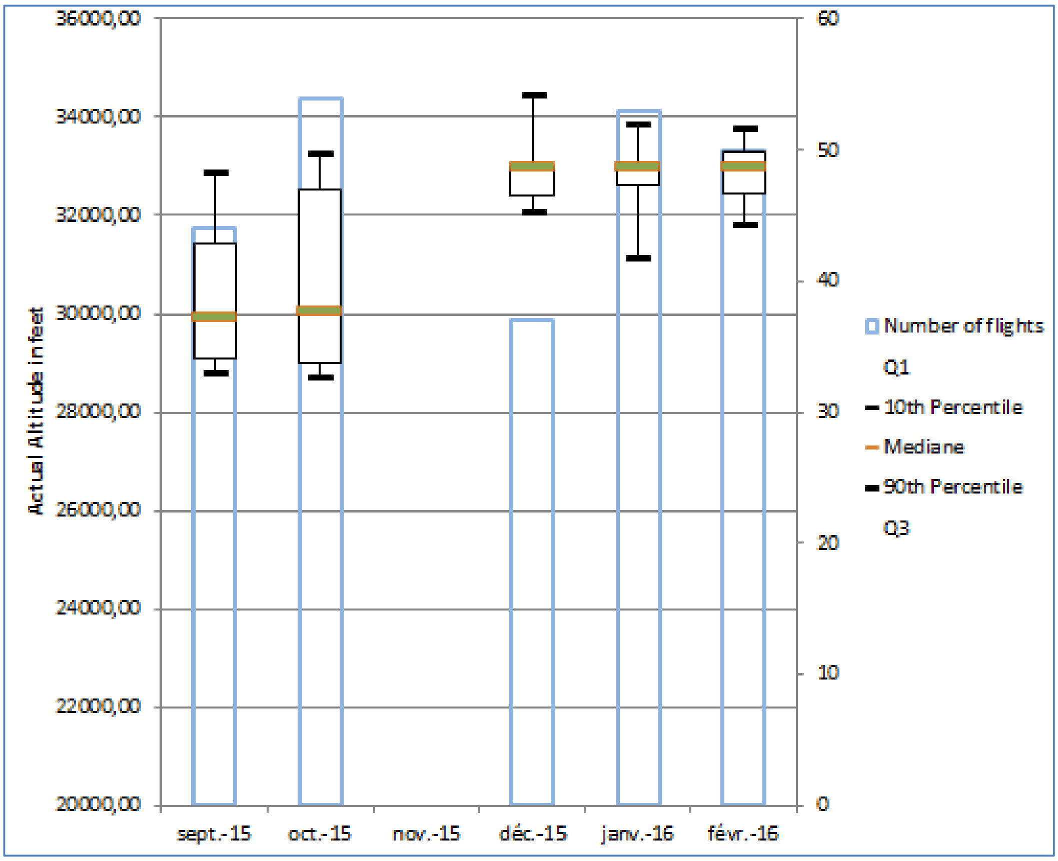



*Figure 122: Actual Altitude distribution at NIMDU per month*

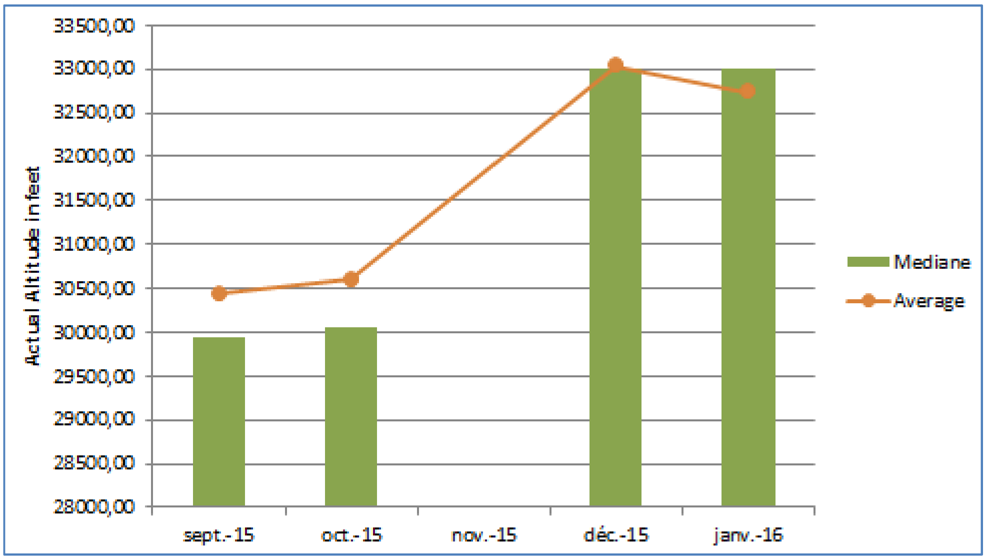



*Figure 123: Evolution of average altitude and mediane altitude at NIMDU before and after ODP step 1 implementation*

All studied data show an important improvement on the altitude flown at OGRUB.

The median value at OGRUB was improved by 3 000 ft and the average value by 2500ft to 3000ft. Proportion of flights that had the opportunity to fly an ODP profile improved also significantly, jumping from **16% to 68%.**

Fuel figures:

Using Airbus Aircraft performance table, we evaluated the fuel savings at 40 kg per flight.

| | |
|---|---|
| Step 1 Fuel benefit for the trial period<br><br>(December 2015 to February 2016) | Gain of 5,6 tons of Fuel |
| Step 1 Fuel benefit annual projection | Gain of 30 tons of Fuel |

## Step 2: STAR implementation Study:

**Baseline Definition and analysis:**

To analyse new STAR publication influence, we studied actual flight data before the introduction of the new STAR. Chosen baseline sample is January and February 2016 (where we can see the improvement coming from the tactical change – step 1).

In total, 103 AF flights were filed via NIMDU[11] routing (South routing).

Adherence to expected FL has been defined with a tolerance of +/- 200 ft. Situation before the introduction of New STAR NEMAL was:

| | "Before STAR publication" situation | | |
|---|---|---|---|
| **NIMDU** | **1 % at FL290** | **44% at FL330** | **68% at FL330 and higher** |

Almost 70 % of ODP profile was flown before the new STAR implementation.
For more details, altitude distribution around OGRUB is displayed on the following graphics:

[11] In the new STAR publication, OGRUB was replaced by NIMDU (4.4NM position difference).

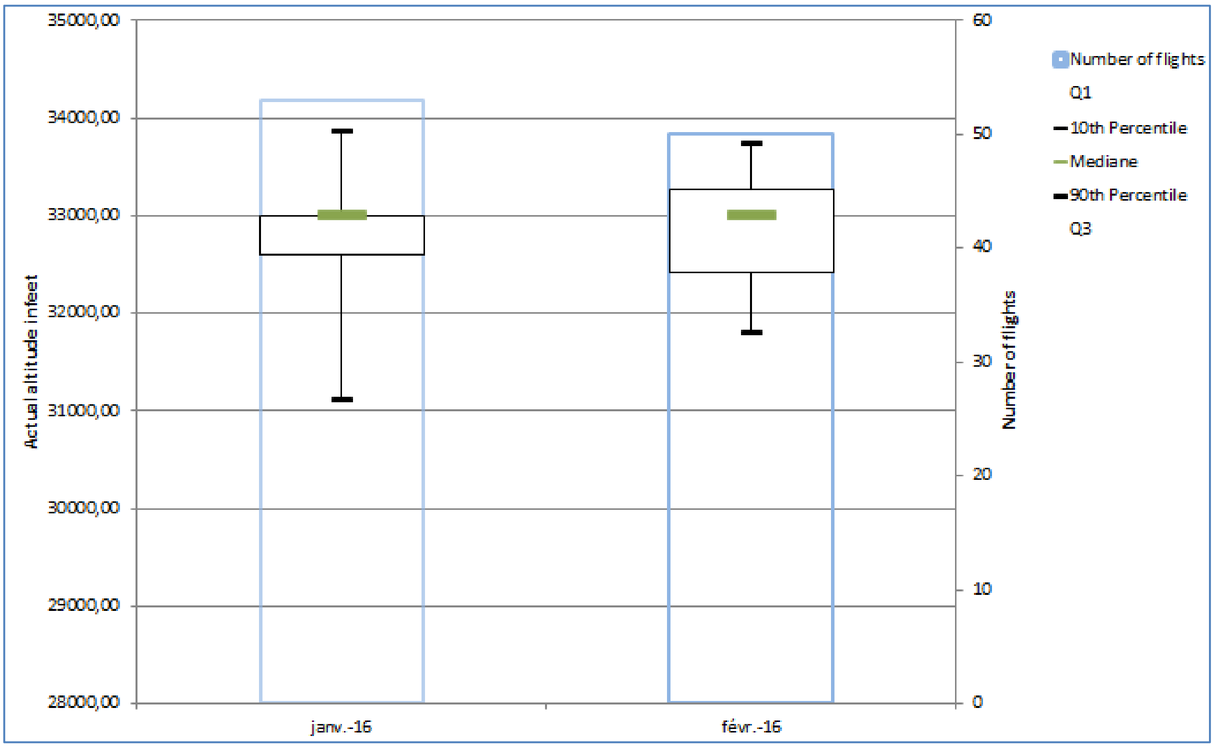



*Figure 124: Number of flights per actual FL in January and February 2016*

**Trial data analysis:**

Impact of New STAR introduction has been studied on flights from March to May 2016: in total, 105 flights were studied.

As you can see on the following graphics, the use of the new STAR NEWAL impacted negatively the number of ODP profiles flown by AF.

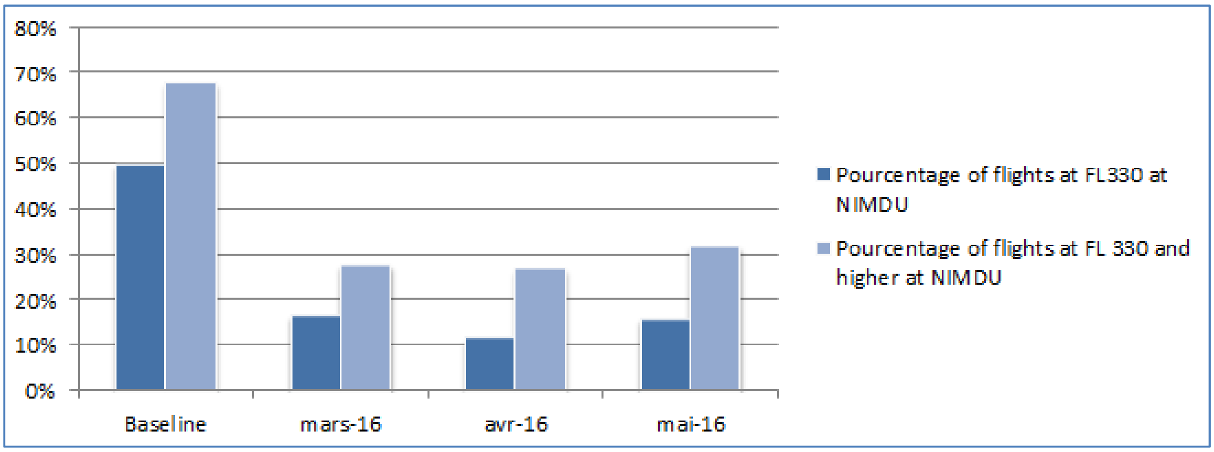



*Figure 125: Evolution of flown ODP profiles before and after ODP step 1 implementation*

ODP profile percentage was reduced from almost 70% to 30%. To confirm this result, flight distribution evolution has been studied in detailed.

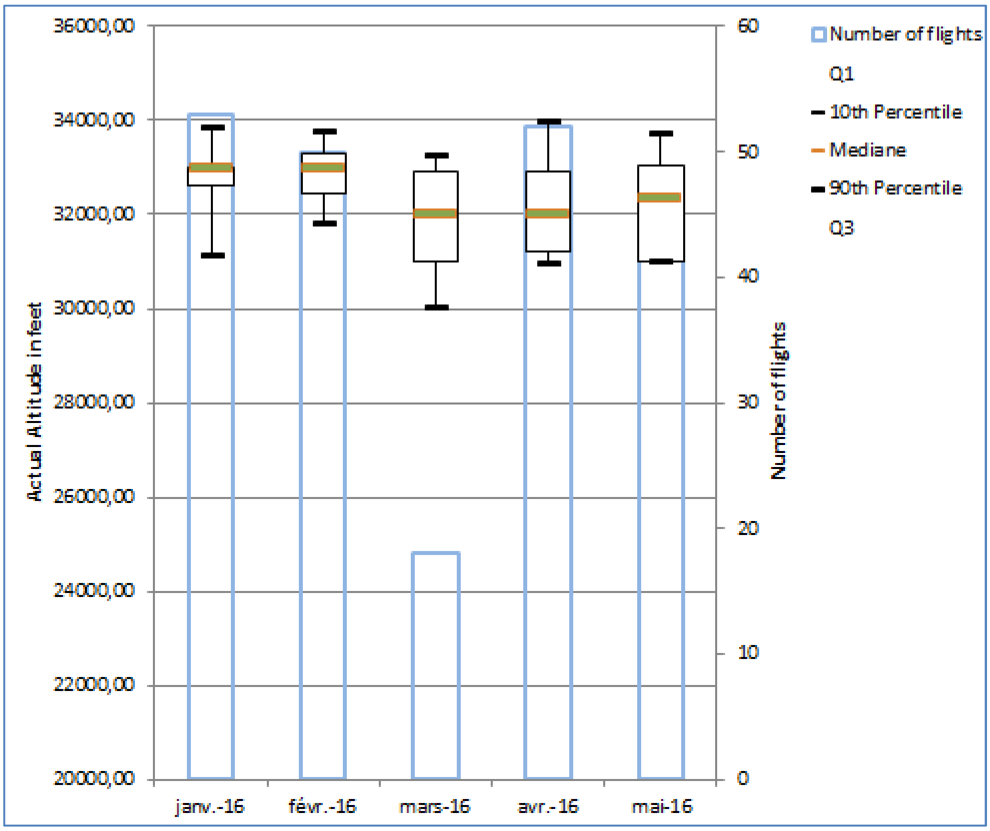



*Figure 126: Actual Altitude distribution at NIMDU per month*

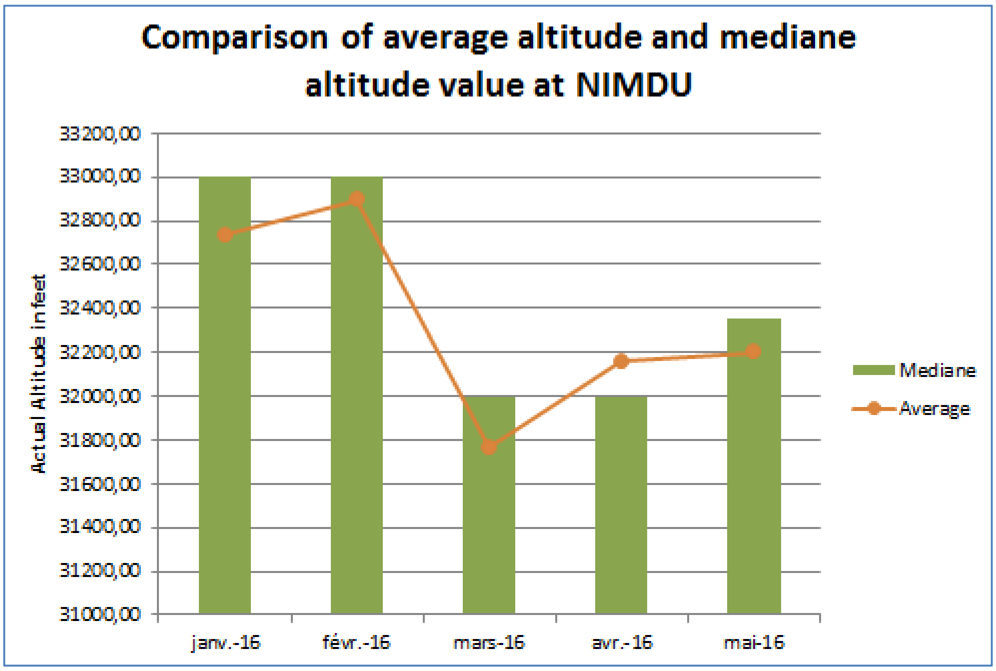
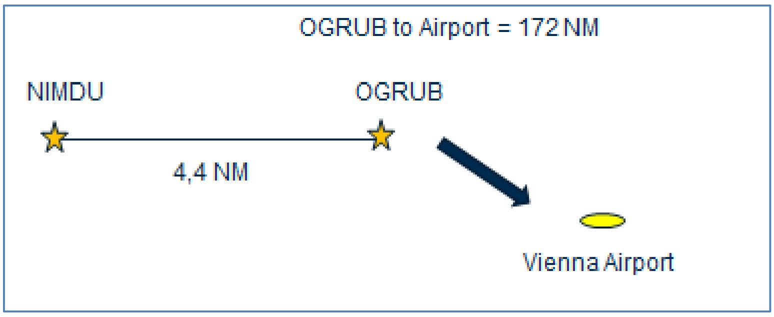



*Figure 127: Evolution of average altitude and mediane altitude at NIMDU before and after ODP step 1 implementation*

As you can see, Median and average values show a clear decrease of altitude at NIMDU compared to the situation before the new STAR use (loss of 700 ft- 800ft).

We study if the new position of “OGRUB” (i.e. NIMDU) is responsible for negative trend. NIMDU is 4,4 NM before OGRUB.




This means that distance from NIMDU to VIE is higher than previously with OGRUB. As explained in WP1, distance to land an airport for an A320 is around 100NM. So, there is 70NM of extra NM. The decrease of altitude at NIMDU is therefore not coming from an “onboard” constraint. Indeed, even with very penalizing operational condition (strong tail wind, high temperature, heavy aircraft,…), A320 can make the FL 170 at BARUG:

- If coming from FL350: TOD 60NM before BARUG – this means that leaving the FL350 at NIMDU is ideal profile
- If coming from FL330 (for heavy A321 for example): TOD 53 NM before BARUG – this means that leaving the FL330 at NIMDU is the ideal profile

Thus, the explanation of this anticipated descent is not linked to aircraft performance and position of NIMDU is not responsible for this anticipation of the descent.
From a Pilot procedures point of view, no change was introduced except the new Phraseo.

To conclude on the reason behind this result, further studies are necessary on the usage and understanding of this new phraseo by operational staff. Studies should also cover controller procedures in order to identify if there were any change of behavior with this new STAR implementation.

**Fuel figures:**

Using Airbus Aircraft performance table, we evaluated the impact of NIMDU routing (NEMAL STAR) is of 10 kg overconsumption per flight.

| | |
|---|---|
| Step 2 Fuel benefit for trial period<br><br>(From March 2016 to May 2016) | Loss of 1 ton of Fuel |
| Step 2 Fuel benefit annual projection | Loss of 7,3 tons of Fuel |

**Total VIE ODP Fuel Figures:**

For the entire scope of Vienna trial, the total figures are:

| | |
|---|---|
| Total Fuel Gain for the trial period<br><br>(From December 2015 to May 2016) | Gain of 4,6 tons of Fuel |
| Total Fuel Gain per year | Gain of 22,7 tons of Fuel |

Fuel Benefits have been reduced by 7,5 % following the new STAR introduction,. As said previously, further investigation should be done with operational staff to identify what could be the bias.

###### 6.7.3.1.1.2.2 Operational subjective Feedback

###### 6.7.3.1.1.2.3 ACC Vienna

The reasons for the negative effect of implementing the new STAR are not completely clear and do need further detailed post implementation analysis as the current results do not seem to be sufficient to exhaustively examine the available findings.

By now the only available valid explanation is the fact that the STAR restriction was published for NIMDU, which is located 4,4NM farther from the airport than the old restriction published for the sector boundary crossing point OGRUB.
It is important to notice that this change of restriction location was necessary to ensure the distance from sector boundary needed for separation of flights to traffic in downstream sector N. The position of point NIMDU west of the sector boundary facilitates the issuance of shorter and easier to understand clearances and their execution by pilots, hence eliminating an identified safety issue.
Consequently the decrease in efficiency on the one hand means an increase in safety on the other hand and a change of restriction position back to the sector boundary is not an option.
Another possible explanation is that before ODP controllers tried to provide good service by coordinating higher entry conditions for individual flights which led to late TOD in sector N in some cases. With the publication of the ODP STAR they might have stopped to do this to an extent as they wanted to consequently stick to the published and to be evaluated procedure although they were briefed that the coordination of higher entry conditions was still possible and appreciated.
This tendency might be corrected by additional controller briefings.

###### 6.7.3.1.1.2.4 SWISS:

Since the new STAR and associated phraseology were officially published and its use is part of daily pilot routine, no feedback was gathered.

Feedback regarding the “descend via” phraseology was evaluated in connection with DEM-008-02 (see 6.8.5.1.1.2.2)

###### 6.7.3.1.1.2.5 Safety

###### 6.7.3.1.1.2.5.1 Air France

At the beginning of the trial, ATCO reported unexpected behaviour of the aircrafts. Indeed, with the new ICAO phraseology (WHEN READY DESCENT VIA XXX), Aircraft is supposed to follow all published constraints without further ATCO instructions. Before the trial, it was checked by AO experts that all constraints have been properly coded. However, ATCO reported that, without their instructions of intermediate FL at NIMDU, Aircrafts ignored the constraint. After investigation, it was found out that FMS automatically withdraw this constraint. The FMS logic is explained below:

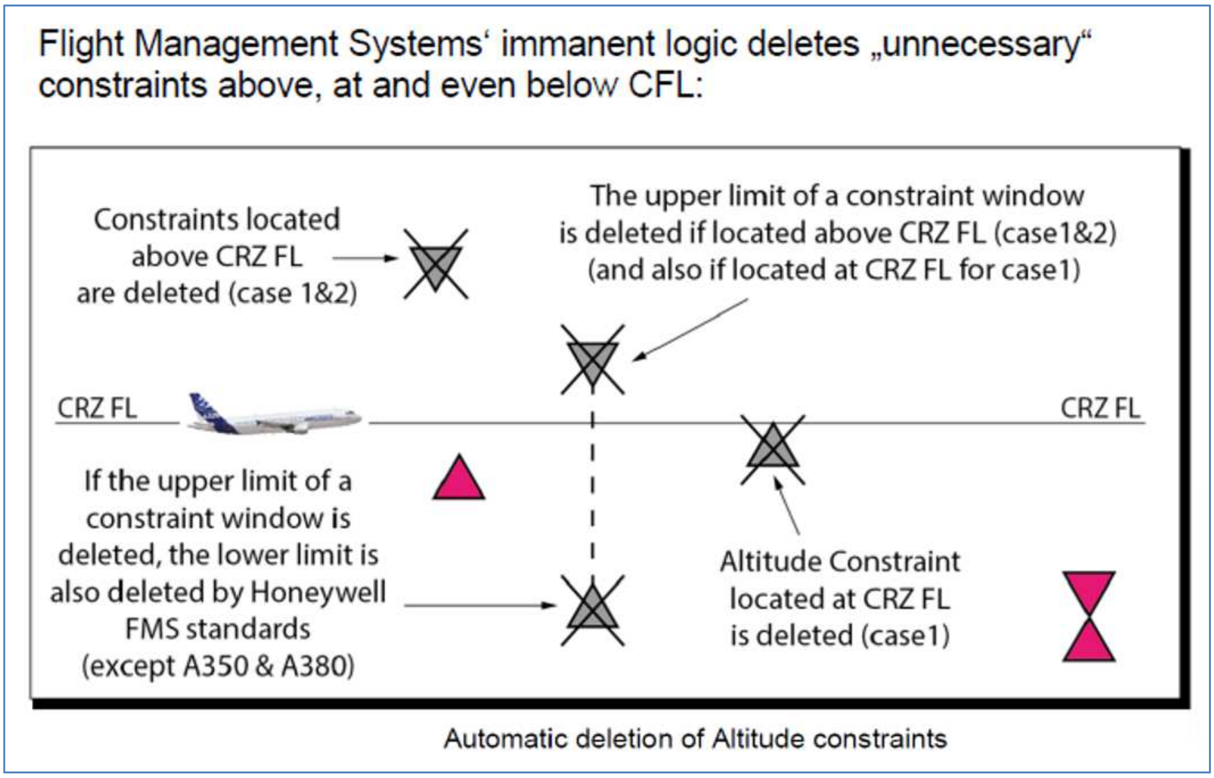



*Figure 128: overview of FMS logic on automatic deletion of altitude constraints*

To raise awareness on this topic to pilots, AF published two communications:

- One on Vienna company information – available in EFB and IPAD with the airport/approach charts
- One in the flight brief

See content below:

**ARRIVAL**

**APPROCHE/ATTERRISSAGE**

**STAR NEMAL 1W :** Le respect de la contrainte à NIMDU [+9000ft, -FL330] est impératif.
C'est une demande forte de la part de l'ATC.
Vérifiez la presence de cette contrainte dans le FMS à la mise en descente.

Translation is: Respect of NIMDU [9000ft, FL330] is mandatory. It is a direct demand from ATC. Once starting the descent, check that NIMDU is still in the FMS.

From the period March to noawadays, there were no Air Safety reports on this arrival. Therefore, for AF point of view and from an operational point of view, there were no safety impacts.

However, this trial did allow experts to raise an important topic to ICAO level about FMS behaviour.

#### 6.7.3.1.2 Results impacting regulation and standardisation initiatives

SWISS:

Modern FPM (Flight Planning Manager) software calculates the aircraft's most economical profile from lift-off from the expected departure runway to touchdown on the expected arrival runway. It takes all known constraints, such as RAD restrictions, into account. It can also be tailored by the user and fed with statistical data.

Currently, SABRE FPM used by SWISS dispatch, does not consider the restrictions at NIMDU and BARUG when calculating the flight's ideal profile. If it was tuned to consider the two constraints, its fuel- and profile calculation would become more conservative and more fuel would have to be loaded as trip fuel. Despite the optimised profile, the overall impact would therefore become negative. By not considering the altitude constraints of the STAR, the trip fuel calculation is optimised and loading of excessive trip fuel is prevented. It is important that future regulations regarding flight planning allow trip fuel optimisation based on statistical data. Descent constraints that might possibly be fuel penalising according to FPM-logic should only have to be considered if statistically relevant. This prevents carriage of excessive trip fuel and improves the overall benefit of ODP-initiatives.

Air France

No specific needs on this exercise

Please see general feedback from ODP on that topic in section 5.

#### 6.7.3.1.3 Unexpected Behaviours/Results

SWISS:

After being informed by Austrocontrol about possible issues regarding unexpected automatic deletion of altitude constraints, a company NOTAM was issued without delay:

"Austria introduced CDO procedures via NEMAL. Check phraseology in CRAR Austria 2.14. When a CRZ-FL at or below FL330 is entered in the FMS at any time during preparation or inflight, CSTR at NIMDU is deleted (CSTR DEL ABOVE CRZ FL).

Check STAR before position NEMAL and re-enter NIMDU constraint (-330) if applicable."

Although Austrocontrol decided to adjust the phraseology shortly thereafter, the NOTAM helped raise awareness regarding ODP and future STAR phraseologies.

Air France:

Unexpected aircraft behaviour (deletion of NIMDU upper limit) => please see explanations in Exercise Results Safety analysis

Unexpected negative impact on Flight efficiency => please see exercise results and conclusion section

#### 6.7.3.1.4 Quality of Demonstration Results

Air France and Swiss:

There was no specific issue concerning the quality of the results achieved in this Exercise.

Fuel assessment limits are described in 5.5.1.

#### 6.7.3.1.5 Significance of Demonstration Results

SWISS:

For this trial data of 224 flights in 3 different timeframes were evaluated. Results are considered significant.

Air France

For this trial, AF studied 208 flights. Results are considered significant.

## 6.7.4 Conclusions and recommendations

### 6.7.4.1 Conclusions

Air France:

In total, 446 AF flights were studied within this ODP trial Results per KPA are:

- Safety: no negative impact
- Flight Efficiency: Positive impact of ODP work is clearly visible. Total Fuel savings are of 4,6 tons for the trial period and of 22,7 tons of fuel for a year.

Swiss:

The average SWISS flight operated with A320-family equipment on the route Zurich – Vienna (LSZH-LOWW) was able to save a considerable amount of fuel during descent thanks to the improvements implemented based on ODP activities. Cross-confirmation with flight data from spring 2014 and comparison of flight data at similar atmospheric and wind-conditions revealed that **descent profile optimisations are accountable up to approximately 70% for the measured fuel savings** as indicated above!
The explanation for the difference in savings between the dynamic phase after inter-sector rearrangements and the static phase after NEMAL 1W implementation most probably lies in working methods of ATCOs that might have changed with the new procedure. The kind of clearance issued by the controller subsequently influences the pilots' descent technique.

A probable scenario before the implementation would be:

- ATCO coordinates higher handover level at sector boundary
- The pilot receives a clearance to descend to FL330, levels off at FL330 and only asks for further descent when approaching the FMS calculated descent profile based on the restriction over BARUG.
- The descent from FL330 to FL170 is done at idle power only.

A probable scenario after the change would be:

- The restriction over NIMDU (FL330 or below) is now published and contained in the FMS
- The ATCO issues a “descend via” clearance to a lower FL (e.g. FL170).
- The pilot doesn’t level off at FL330 but stretches the descent. In order to maintain a minimum rate of descent (e.g. a minimum of 1’000ft/min is normally applied for en-route descents), application of additional thrust during descent is required.

#### 6.7.4.2 Recommendations

SWISS:

It seems likely that the way and intensity of inter-sector coordination has changed after the introduction of the optimised STAR. Changes in ATCO working habits and behaviour should be thoroughly studied in future projects.

Air France:

Vienna results highlight the complexity of ODP procedures and the often competing procedures and working behaviours.

Vienna results illustrates the importance to work in close cooperation between Airlines (especially local airlines) and ANSP as procedures of one stakeholder impact directly the operational performance of the other.

For this flow, we would recommend:

- To study and re-examine the use the new NEMAL STAR which reduces the gain of this improvement.
- Constraints between ACC and APP sectors should also be investigated with regard to possible improvements and their impact on upstream vertical flight paths and TOD positions.

### 6.7.5 Exercise Results for DEM-007-02

#### 6.7.5.1 Summary of Exercise Results

##### 6.7.5.1.1 Results per KPA

A summary is provided in section 5 "Exercises Results" and 6 "Demonstration Exercises reports".

##### 6.7.5.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.7.5.1.1.1.1 Performance Analysis

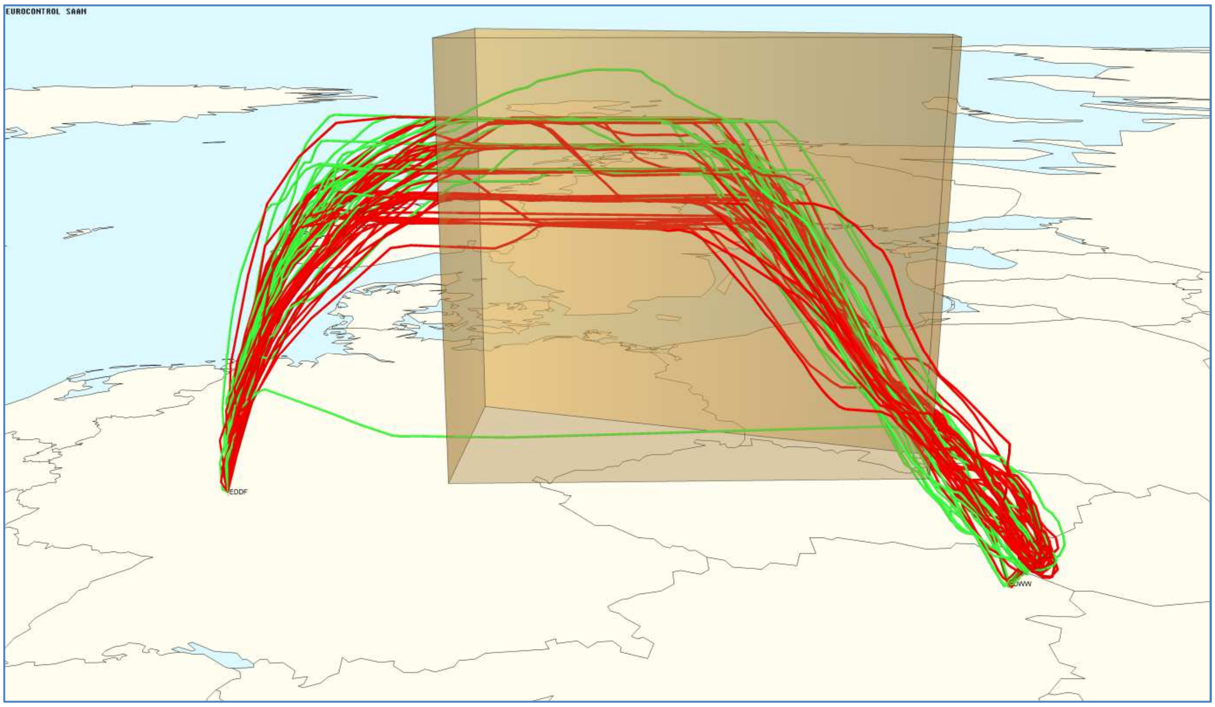


*Figure 129: Reference (red) and ODP (green) radar data recordings for the city pair Frankfurt (EDDF) to Vienna (LOWW) via VENEN*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-007-02 from SAAM perspective are summarized in Figure 98. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.7.5.1.1.1.2 Operational subjective Feedback

<u>Feedback Karlsruhe UAC:</u>

Transfer from Karlsruhe UAC to Vienna ACC in RFL is operational feasible and was implemented WEF 03MAY16 as permanent procedure.

<u>Feedback Wien ACC:</u>

Please refer to section 6.7.3.1.1.1.2.

##### 6.7.5.1.1.2 Assessment Results by Airline Operator

###### 6.7.5.1.1.2.1 Performance Analysis

As precise at the exercise level, AF had no flights on this flow.

DLH traffic into LOWW has been routed via ABUDO (like AF) and was therefore not part of the flow. No other Airline data available.

###### 6.7.5.1.1.2.2 Operational subjective Feedback

No feedback.

#### 6.7.5.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.7.5.1.3 Unexpected Behaviours/Results

None.

#### 6.7.5.1.4 Quality of Demonstration Results

None.

#### 6.7.5.1.5 Significance of Demonstration Results

None.

## 6.7.6 Conclusions and recommendations

### 6.7.6.1 Conclusions

None.

### 6.7.6.2 Recommendations

None.

## 6.8 Demonstration Exercise SCN-0103-008 / Zurich (LSZH/ZRH) Report

### 6.8.1 Exercise Scope

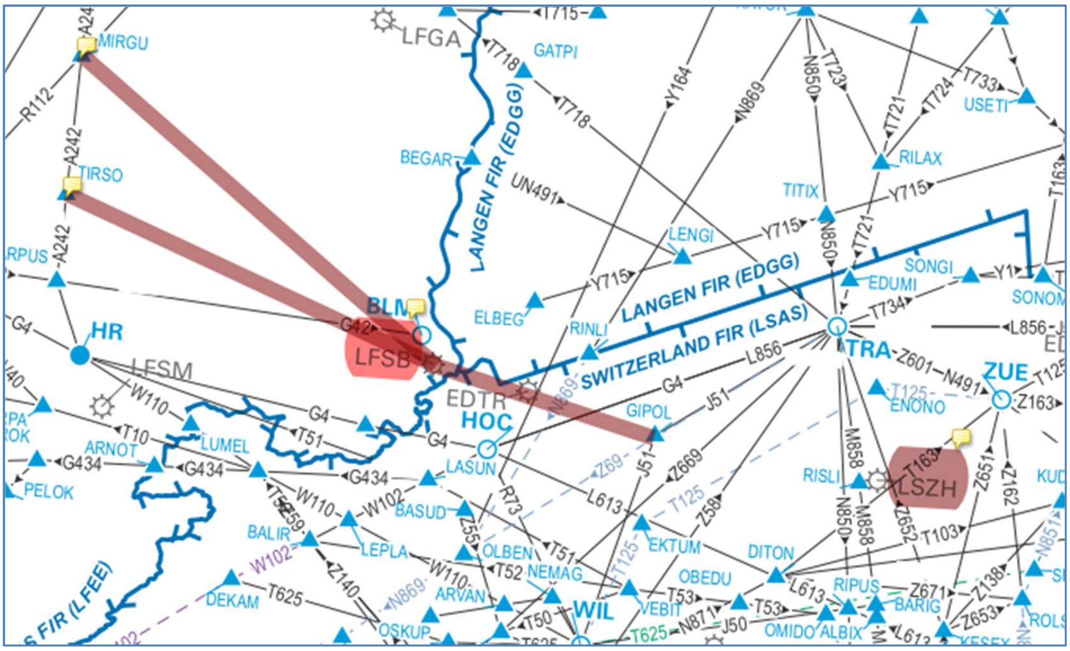



*Figure 130: Trial overview MIRGU-BLM/ TIRSO-BLM to Zurich (LSZH) SCN-0103-008/ EXE-0103-008/ DEM-008-01 (chart based on [21])*

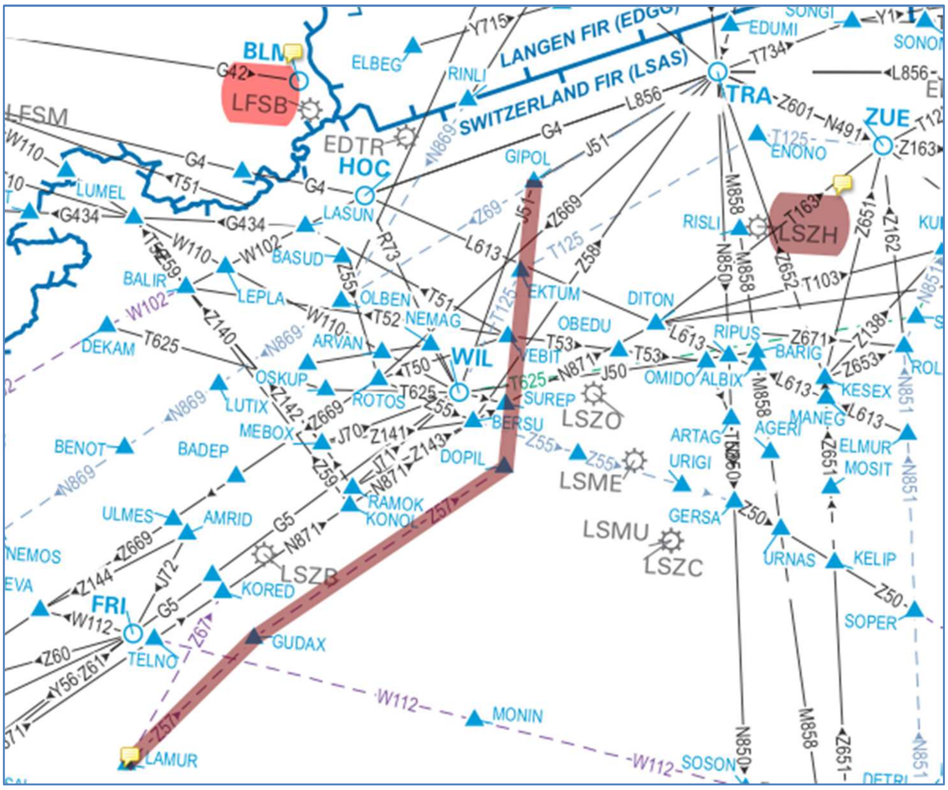



*Figure 131: Trial overview LAMUR-GUDAX-DOPIL to Zurich (LSZH) SCN-0103-008/ EXE-0103-008/ DEM-008-02 (chart based on [21])*

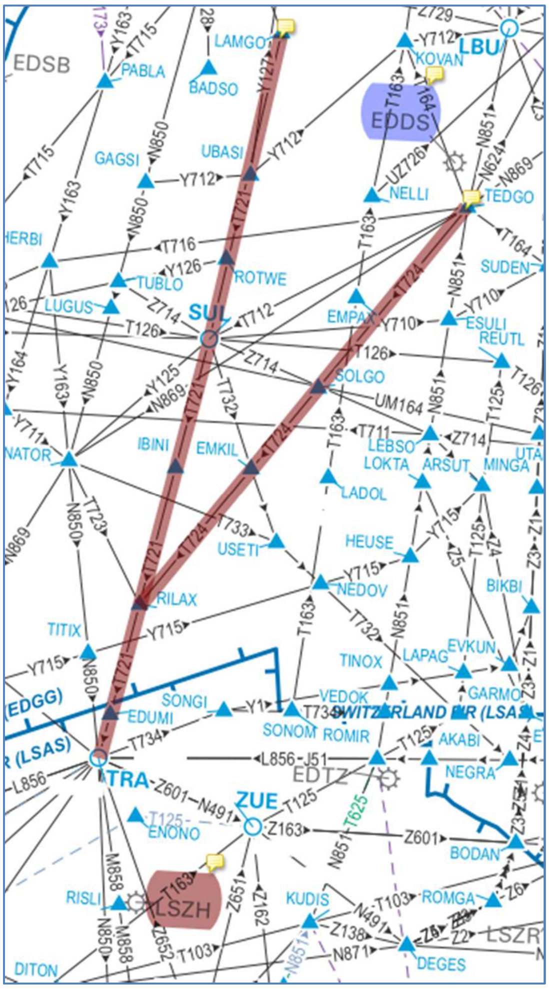



*Figure 132: Trial overview LAMGO/ TEDGO to Zurich (LSZH) SCN-0103-008/ EXE-0103-008/ DEM-008-03 and DEM-008-04 (chart based on [21])*

Overall SAAM calculation results for EXE-0103-08 are as follows:

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| **Increase** | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| **Equal** | 41 | 0,200 | 0 | 0,000 | 3 | -0,460 | 3 | -1,480 | 4 | -0,005 |
| **Decrease** | 0 | 0,000 | 41 | -1,219 | 38 | -62,001 | 38 | -195,850 | 37 | -0,801 |
| **Total** | 41 | 0,200 | 41 | -1,219 | 41 | -62,461 | 41 | -197,330 | 41 | -0,806 |

*Figure 133: Summary of potential gains for ARR to Zurich via BLM, DEM-008-01*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| **Increase** | 0 | 0,000 | 1 | 0,054 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| **Equal** | 36 | 0,110 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| **Decrease** | 0 | 0,000 | 35 | -6,058 | 36 | -531,660 | 36 | -1679,690 | 36 | -9,497 |
| **Total** | 36 | 0,110 | 36 | -6,004 | 36 | -531,660 | 36 | -1679,690 | 36 | -9,497 |

*Figure 134: Summary of potential gains for ARR to Zurich via GUDAX, DEM-008-02*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| **Increase** | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 14 | 1,914 |
| **Equal** | 50 | 0,050 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 1 | 0,001 |
| **Decrease** | 0 | 0,000 | 50 | -33,081 | 50 | -701,065 | 50 | -2215,260 | 35 | -3,945 |
| **Total** | 50 | 0,050 | 50 | -33,081 | 50 | -701,065 | 50 | -2215,260 | 50 | -2,029 |

*Figure 135: Summary of potential gains for ARR to Zurich via LAMGO, DEM-008-03*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 0 | 0,000 | 1 | 1,073 | 1 | 3,390 | 22 | 4,047 |
| Equal | 27 | -0,010 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 27 | -15,619 | 26 | -130,350 | 26 | -411,100 | 5 | -0,268 |
| Total | 27 | -0,010 | 27 | -15,619 | 27 | -129,277 | 27 | -407,710 | 27 | 3,779 |

*Figure 136: Summary of potential gains for ARR to Zurich via TEDGO, DEM-008-04*

## 6.8.2 Conduct of Demonstration Exercise EXE-0103-008

### 6.8.2.1 Exercise Preparation

Based on the outcome of an internal ORE (Operational Risk Evaluation), Tempo RNAV STARs for all SWISS pilots were published in the EFB (electronic flight bag) for the following trials:

- DEM-008-02

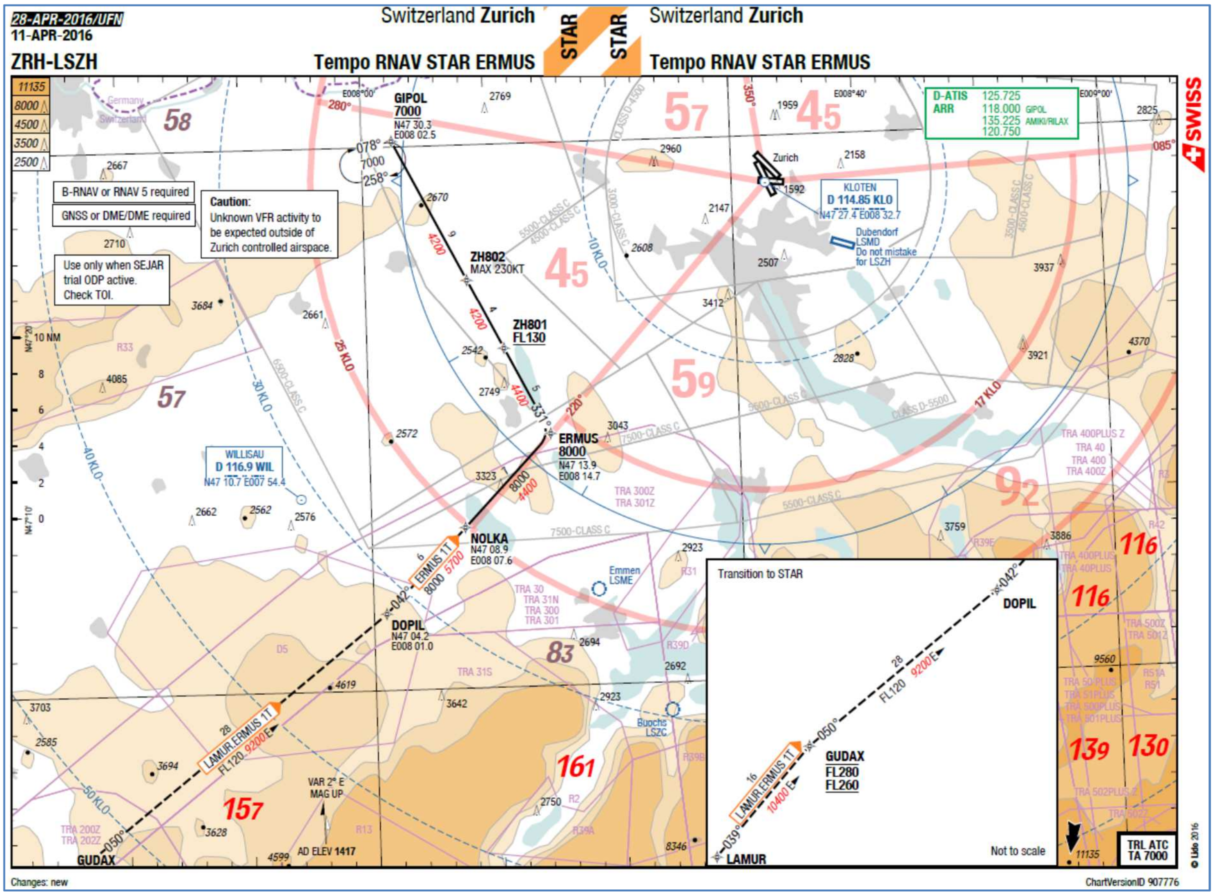



*Figure 137 a): Chart of LSZH Tempo RNAV STAR ERMUS*

- DEM-008-03 and DEM-008-04

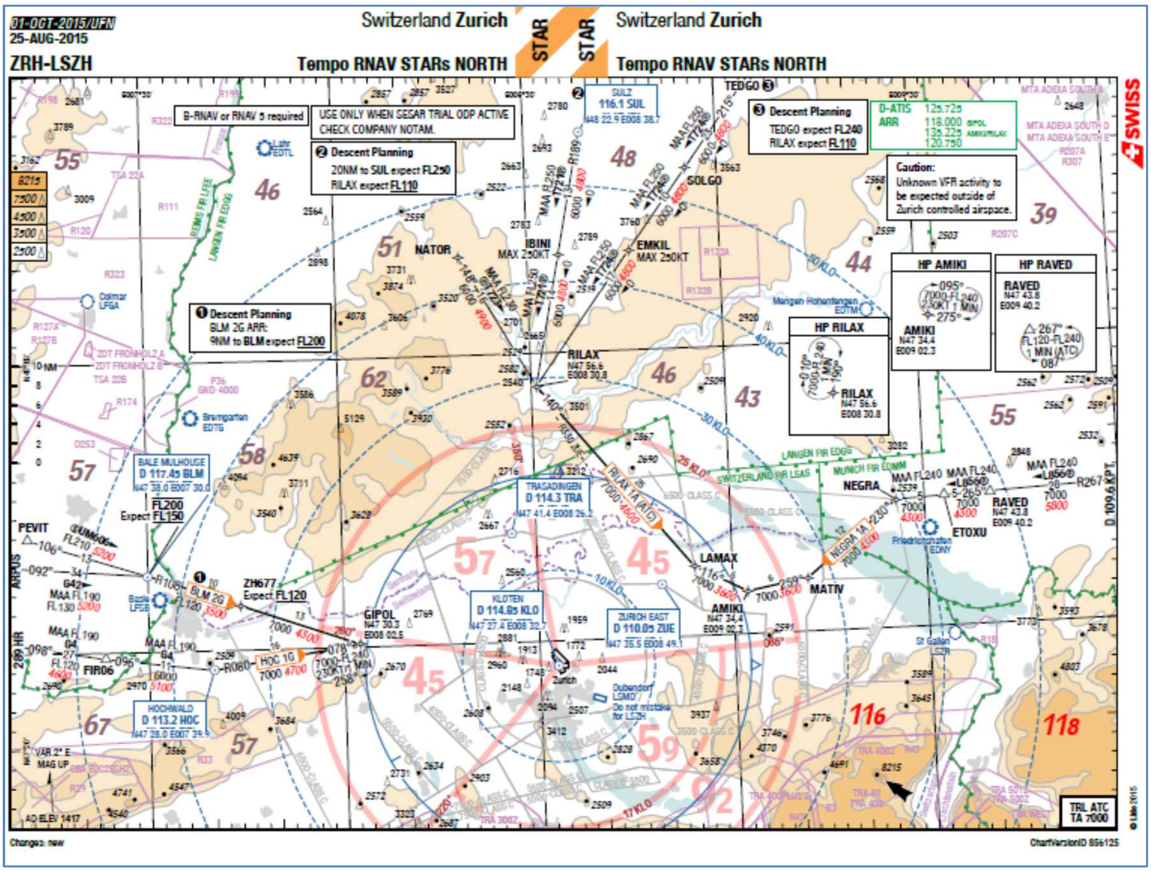
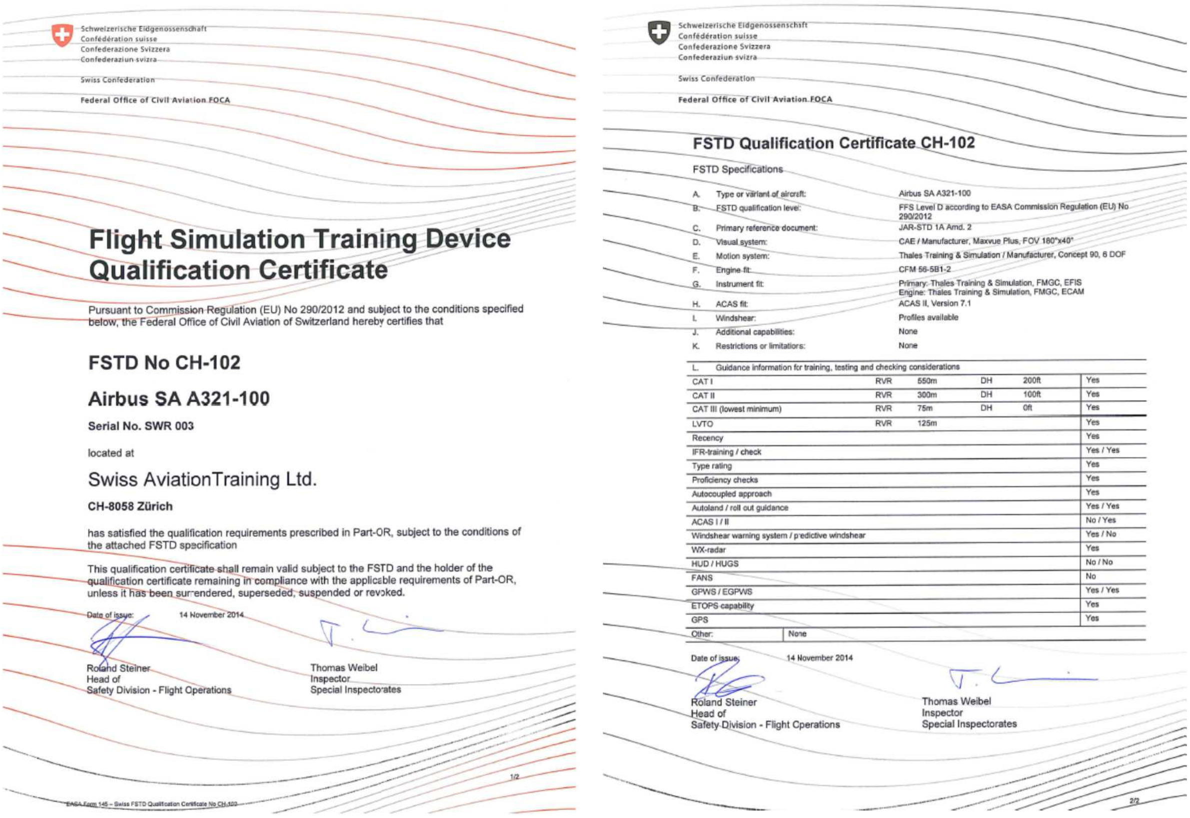



*Figure 138 b): Chart of LSZH Tempo RNAV STARs NORTH*

A simulator exercise for LSZH ODP-profile validation took place in an A321 full flight simulator in cooperation with skyguide. The following equipment was used:



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Office of Civil Aviation FOCA

**Flight Simulation Training Device Qualification Certificate**

Pursuant to Commission Regulation (EU) No 290/2012 and subject to the conditions specified below, the Federal Office of Civil Aviation of Switzerland hereby certifies that

**FSTD No CH-102**

**Airbus SA A321-100**

**Serial No. SWR 003**

located at

Swiss AviationTraining Ltd.

**CH-8058 Zürich**

has satisfied the qualification requirements prescribed in Part-OR, subject to the conditions of the attached FSTD specification

This qualification certificate shall remain valid subject to the FSTD and the holder of the qualification certificate remaining in compliance with the applicable requirements of Part-OR, unless it has been surrendered, superseded, suspended or revoked.

Date of issue: 14 November 2014

Roland Steiner
Head of
Safety Division - Flight Operations

Thomas Weibel
Inspector
Special Inspectorates

1/2

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Office of Civil Aviation FOCA

**FSTD Qualification Certificate CH-102**

FSTD Specifications

| | | |
|---|---|---|
| A. | Type or variant of aircraft: | Airbus SA A321-100 |
| B. | FSTD qualification level: | FFS Level D according to EASA Commission Regulation (EU) No 290/2012 |
| C. | Primary reference document: | JAR-STD 1A Amd. 2 |
| D. | Visual system: | CAE / Manufacturer, Maxvue Plus, FOV 180°x40° |
| E. | Motion system: | Thales Training & Simulation / Manufacturer, Concept 90, 6 DOF |
| F. | Engine fit: | CFM 56-5B1-2 |
| G. | Instrument fit: | Primary: Thales Training & Simulation, FMGC, EFIS<br>Engine: Thales Training & Simulation, FMGC, ECAM |
| H. | ACAS fit: | ACAS II, Version 7.1 |
| I. | Windshear: | Profiles available |
| J. | Additional capabilities: | None |
| K. | Restrictions or limitations: | None |

| L. Guidance information for training, testing and checking considerations | | | | | |
|---|---|---|---|---|---|
| CAT I | RVR | 550m | DH | 200ft | Yes |
| CAT II | RVR | 300m | DH | 100ft | Yes |
| CAT III (lowest minimum) | RVR | 75m | DH | 0ft | Yes |
| LVTO | RVR | 125m | | | Yes |
| Recency | | | | | Yes |
| IFR-training / check | | | | | Yes / Yes |
| Type rating | | | | | Yes |
| Proficiency checks | | | | | Yes |
| Autocoupled approach | | | | | Yes |
| Autoland / roll out guidance | | | | | Yes / Yes |
| ACAS I / II | | | | | No / Yes |
| Windshear warning system / predictive windshear | | | | | Yes / No |
| WX-radar | | | | | Yes |
| HUD / HUGS | | | | | No / No |
| FANS | | | | | No |
| GPWS / EGPWS | | | | | Yes / Yes |
| ETOPS capability | | | | | Yes |
| GPS | | | | | Yes |
| Other: | None | | | | |

Date of issue: 14 November 2014

Roland Steiner
Head of
Safety Division - Flight Operations

Thomas Weibel
Inspector
Special Inspectorates

2/2

*Figure 139: Swiss Aviation Training, Flight Simulation Equipment*

This validation exercise also led to new findings regarding the incompatibility of ATCO and pilot SOPs for dealing with altitude alerting settings (see [16]).

#### 6.8.2.2 Exercise execution

See appropriate sub-chapters of the trial.

#### 6.8.2.3 Deviation from the planned activities

None.

## 6.8.3 Exercise Results for DEM-008-01

### 6.8.3.1 Summary of Exercise Results

#### 6.8.3.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

During the discussion about a possible flight trial via BLM (see above), it became clear that we were dealing with a mismatch between publication and practice.

The BLM 2G RNAV STAR contained a remark for pilots to expect to cross FL190 or above at D9 to BLM. The letter of agreement between Reims ACC and Zurich ACC had been changed without changing the remark in the Swiss AIP from where the remark on the approach plate is subsequently extracted. Thanks to ODP the remark was adjusted in the AIP and now informs the pilot to expect to cross FL190 or above at D13 to BLM, which is the handover restriction agreed on between the two units. Given the fact that most flights inbound to BLM are above FMS-profile, it is essential to feed the FMS with the expected crossing altitudes to avoid undesired level-offs and subsequent thrust increase. This is equally important even if these altitudes are purely for information (e.g. "expect FL…by…"). The FMS-profile would normally like to be much lower at BLM and following it would lead to an expedited descent with a subsequent level-off and the addition of unnecessary power because the ATCO wouldn't be able to assign a lower flight level. By managing the descent profile based on known boundary limitations, the pilot has at least the possibility to manage the flights energy in order to prevent level-offs and/or thrust increase. It is, of course, understood that any surplus energy will eventually have to be destroyed using airbrakes when descending above the FMS-profile. Any additional thrust added during descent will only worsen the flight's energy balance.

###### 6.8.3.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.8.3.1.1.1.1 Performance Analysis

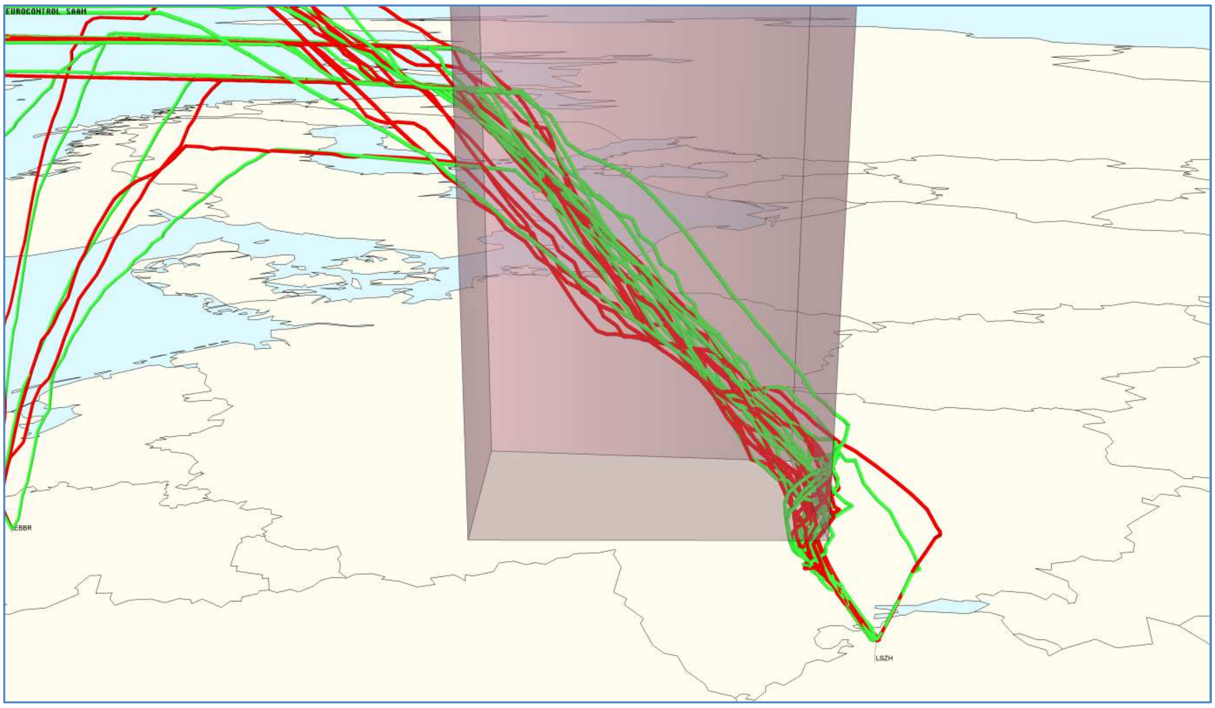



*Figure 140: Reference (red) and ODP (green) radar data recordings for Zurich (LSZH) via BLM*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-008-01 from SAAM perspective are summarized in Figure 115. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.8.3.1.1.1.2 Operational subjective Feedback

Skyguide:

Apart from the LoA adjustments there were no specific trials for LSZH via BLM
DSNA:
No Feedback.

#### 6.8.3.1.1.2 Assessment Results by Airline Operator

##### 6.8.3.1.1.2.1 Performance Analysis

###### 6.8.3.1.1.2.1.1 SWISS

The modifications were officially published on 12 November 2015. For flight data analysis, the flight data of all flights operated with Airbus aircraft to LSZH via BLM between October 1st and December 23rd were analysed.

The following flights were not considered in order to increase the comparability of pre- and post-implementation data:

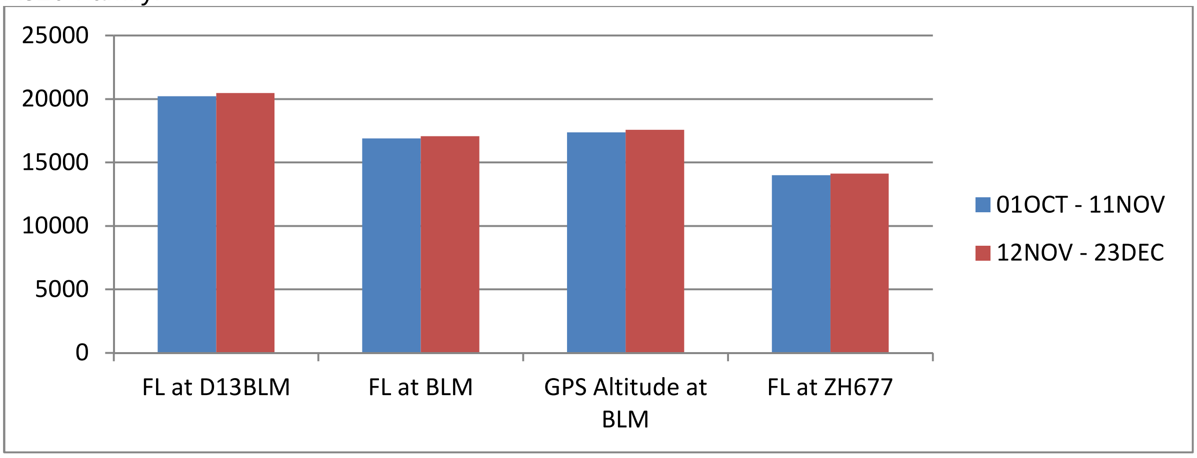
- Flights with a GTD (Ground Track Distance) of more than 115% of the GCD (Great Circle Distance) at a GCD of 200NMf from the landing runway (max. permissible GTD of 230nm at a GCD of 200NM); This filter removes flights that were subject to holding and/or long vectoring and/or extensive weather avoidance during descent

- Flights with a head- or tailwind component in excess of 60kt; This filters out flights that were subject to extreme weather conditions

| | Before publication (01OCT – 11NOV) 42 days | After publication (12NOV – 23DEC) 22 days |
|---|---|---|
| **Total of flights analysed** | **307** | **286** |
| A319 | 9 | 10 |
| A320 | 96 | 99 |
| A321 | 37 | 25 |
| A333 | 119 | 111 |
| A343 | 46 | 41 |

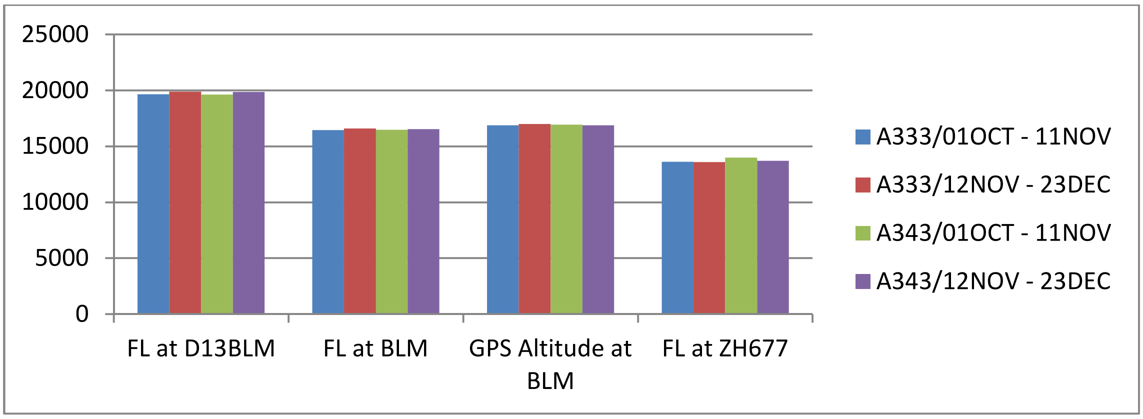
**a) Flight Data per Type**

A320-Family:




The average weights before and after publication of the change are within 1t.

A333 / A343:




The average weights before and after publication of the change are within 1.5t.
Crossing Flight Levels and atmospheric conditions were roughly the same before and after the adjustment of official publications. Since ATCs of Reims and Zurich had already been applying the modified handover conditions for quite some time without having revised official publications, it is obvious why no major change in passing altitudes can be observed.

**b) Wind and CAS:**

| | | D13BLM | | BLM | | ZH677 | |
|---|---|---|---|---|---|---|---|
| | | Ø wind | Ø CAS | Ø wind | Ø CAS | Ø wind | Ø CAS |
| A320 | Before | -4kt | 272kt | **-5kt** | 270kt | -7kt | 262kt |
| | After | -17kt | 272kt | **-19kt** | 270kt | -21kt | 261kt |
| | | | | | | | |
| A330 | Before | -8kt | 274kt | -6kt | **272kt** | -6kt | 264kt |
| | After | -17kt | 270kt | -17kt | **266kt** | -16kt | 259kt |
| | | | | | | | |
| A340 | Before | -9kt | 279kt | -8kt | 279kt | -8kt | 269kt |
| | After | -20kt | 280kt | -19kt | 281kt | -18kt | 272kt |

- (minus) is a tailwind component

The maximum wind difference during descent is around 14knots of tailwind. This only has a minor effect on the profile. If pilots may initiate descent according to FMS-calculation, this shifts the TOD by approximately 3NM. The speed profile of the average flight is the same before and after the publication of the change.

The difference of A330-speeds at BLM shows the importance of applying as little speed control as practicable (refer to WP1 results). If the pilot is not speed restricted he thus may reduce speed when no lower FL is available although the flight is on profile. On the route via BLM this is particularly important for A330-aircraft with outstanding gliding characteristics.

**c) Fuel-consumption**

In order to obtain comparable results, the flight segment between GTD200 (Ground Track Distance to Touchdown at 200NM) and ZH677 is considered for fuel-comparison. The figures for wide body aircraft are more significant because long haul flights are well at their final cruising level at this position. The average weights of analysed flights are within 1.5t at the most. However, this difference in gross weight only causes a minor increase in fuel consumption during descent since both engines are at or close to idle power during an optimised descent regardless of aircraft gross weight.

| | Ø Fuel consumption GTD200 – ZH677 | | | Ø Ground Track Distance GTD200 – ZH677 | | |
|---|---|---|---|---|---|---|
| | A320 | A333 | A343 | A320 | A333 | A343 |
| 01OCT – 11NOV | 624kg | 986kg | 1'156kg | 160NM | 159NM | 158NM |
| 12NOV – 23DEC | 619kg | 954kg | 1'127kg | 160NM | 160NM | 159NM |
| **Δ average** | **-5kg** | **-32kg** | **-29kg** | **0** | **+1NM** | **+1NM** |

After publication of the revised descent planning information on the STAR-chart, flights were able to optimise their TOD thanks to knowing all the mandatory level constraints during descent.

###### 6.8.3.1.1.2.1.2 Air France

Air France agrees on Swiss findings although it couldn't be formally calculated (too much disrupted data on AF side).
Experts believe that publication update is good for pilot awareness although published FL at BLM is still 5000ft upper than the idle path (therefore there is no fuel savings).

###### 6.8.3.1.1.2.2 Operational subjective Feedback

Update of navigational charts and changes of handover levels are part of the pilots' daily routine. Since no specific trials were conducted, operational feedback was not collected.

#### 6.8.3.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.8.3.1.3 Unexpected Behaviours/Results

None.

#### 6.8.3.1.4 Quality of Demonstration Results

None.

#### 6.8.3.1.5 Significance of Demonstration Results

Since no trials were conducted the results are not considered significant from a VFE point of view.

## 6.8.4 Conclusions and recommendations

### 6.8.4.1 Conclusions

It can be highlighted that optimising descent profiles will often only be possible if adjacent sectors are used in a more flexible and interconnected way. This might include temporary release areas during traffic peaks.

It is essential that ANSPs constantly review and revise all handover conditions between their sectors as well as letters of agreement between all units. These agreements should be adjusted to seasonal traffic figures and published so that pilots are more aware of imperative altitude restrictions during descent and thus able to manage the flight's profile as well as its speed. Early ATC-speed assignments and/or speed constraints must be avoided as much as possible so that pilots can balance energy as much as possible (refer to WP1-report). Pre-sequencing for approach should therefore preferably take place during the en-route phase of the flight and not by applying excessive speed control during descent.

#### 6.8.4.2 Recommendations

If the descent profile on a specific route is known to be above the FMS-performance profile, it is essential to inform the pilot about possible descent limitations. The pilot then has the necessary knowledge to delay the descent to fit the limiting constraint and to manage the flight's energy level (altitude and speed) with the purpose of preventing thrust addition during a descent above optimum profile.

### 6.8.5 Exercise Results for DEM-008-02

#### 6.8.5.1 Summary of Exercise Results

The Trial phase took place on the weekend of February April 30th and May 1st during MIL OFF hours and has been compared with the pre-trial and post-trial phase (see table below).

The descent profile via LAMUR – GUDAX – DOPIL – DOPIL1G shows the following characteristics:

- low handover-level between ACC Geneva and ACC Zurich (descending to FL200 to cross GUDAX FL220 or lower)
- after ERMUS, aircraft can only descend below FL130 once passed the crossing point with outbound traffic on the VEBIT-departure route climbing to FL120
- published routing for all landing RWYs lead to the holding at GIPOL but major DCT-routings are assigned when RWY28 or RWY34 are in use
- ATCOs very often apply speed control on this route for sequencing. Pilots are then unable to use the managed speed function (descent speed +/-20kts) to optimise their profile

Most flights via GIPOL for landing on RWY14 at LSZH cannot be cleared to descend below FL130 until clear of departing traffic climbing to FL120 (approximately at trial-waypoint ZH801). Taking this level restriction as a reference for the previous descent path, an altitude window over GUDAX between FL250 and FL280 seems ideal. Due to the direction of flight (eastbound – even levels), it was finally decided that the window reaches from FL260 to FL280 for the duration of the trial.

In most cases, flights arriving from the West are encountering tailwind during most parts of their descent. With the proposed level constraints they would be descending on an optimised descent path or even slightly above. To limit any undesired addition of thrust during the level-off phase at FL130, the speed constraint at ZH802 (MAX 230kt) has been introduced.

Explanation: The FMS commands normal descent speed at or above FL100 and therefore adds thrust after a level off in order to maintain its calculated descent speed. This energy might have to be destroyed again by using airbrakes since further descent to a lower level is often combined with a subsequent speed reduction for sequencing. Setting a speed limit in connection with a known level-off above FL100 (e.g. no continuous descent possible before being well clear of climbing outbound traffic) is an option forcing the FMS to command speed-limit speed and thus reduce speed during level-off.

The suggested optimised profile is a suitable solution taking into account the most likely descent limitation of FL130.
The optimisation was done for traffic to RWY14. However, in order to allow the FMS to calculate its profile in accordance with the published procedure, ATC-speed assignment should be limited as long as possible.

Analysis of altitude window at GUDAX with performance calculation based on the following assumptions:

A320, 64t, Speeds M.76/260kt

| Wind component | Distance to descend from **FL280** to FL130 | Distance to descend from **FL260** to FL130 |
|---|---|---|
| Headwind 40kt | 43NM | 38NM |
| **0** | **49NM** | **43NM** |
| Tailwind 40kt | 54NM | 47NM |

*In-flight performance module of EFB (electronic flight bag) version V5210029/20160531*

### 6.8.5.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

#### 6.8.5.1.1.1 Assessment Results by ANSP and Eurocontrol

##### 6.8.5.1.1.1.1 Performance Analysis

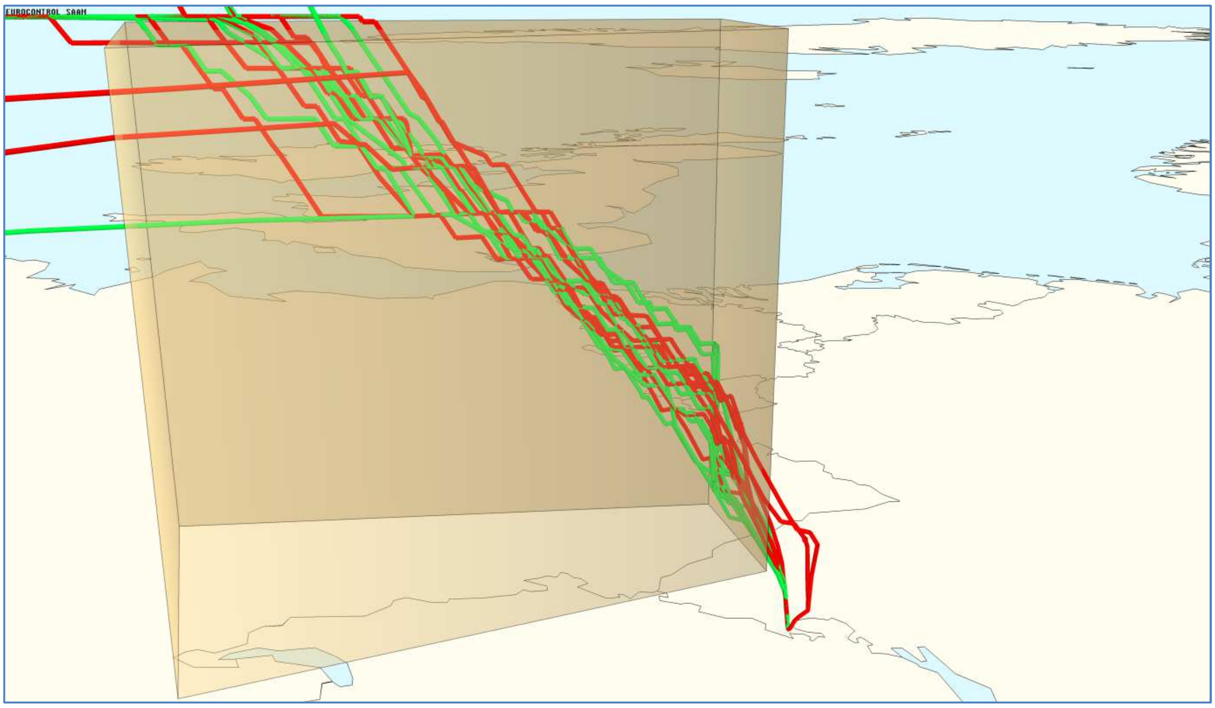


*Figure 141: Reference (red) and ODP (green) radar data recordings for Zurich (LSZH) via GUDAX*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-008-02 from SAAM perspective are summarized in Figure 116. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.8.5.1.1.1.1.1 Skyguide

There had been a total number of 42 planned ODP Trials participants. 83% of planned trial flights were able to perform a continuous descent through GVA and ZRH airspace. Due to tfc situation 40% had to stop or interrupt the continuous descent. 5% could not perform a CDO according trial procedure.

During MIL OFF and low to medium traffic situations the developed CDO/ODP procedure went well.
However, the complex airspace structure and the situation within ZRH TMA (procedurally and politically) limit the possibilities of CDOs. As ZRH APP did not take part in this trial the flow ended at FL130. Sometimes flights suffered from "early speed requests" and holding instructions by APP (s. No.1) some had to deviate due to bad weather.
The trial proved that raising the EFL (FL260-280) over GUDAX (during MIL OFF) is possible although the procedure wasn't perfect during the trial.

###### 6.8.5.1.1.1.2 Operational subjective Feedback

No Feedback.

#### 6.8.5.1.1.2 Assessment Results by Airline Operator

##### 6.8.5.1.1.2.1 Performance Analysis

###### 6.8.5.1.1.2.1.1 SWISS

The trial took place on the weekend of April 30th and May 1st during MIL OFF hours.
For flight data analysis, data of all flights operated with Airbus A320-family aircraft via GUDAX on all weekends between April 9th and May 22nd were considered.

The following flights were not analysed in order to ensure the comparability of data:

- Flights with a cruising FL below FL300 at 200NM from touchdown; This filters out flights that were not affected by the newly created descent window at GUDAX
- Flights with a head- or tailwind component in excess of 60kt during descent; This filters out flights that were subject to extreme weather conditions
- Flights with a GTD (Ground Track Distance) of more than 120% of the GCD (Great Circle Distance) at a GCD of 200NM from the landing runway (max. permissible GTD of 240nm at a GCD of 200NM); This filter removes flights that were subject to holding and/or long vectoring and/or extensive weather avoidance during descent.

The large margin of 20% is required in this case since arrivals via DOPIL are subject to extensive downwind legs for all landing runways.

- Flights without recorded data at either GUDAX or ERMUS, mainly caused due to major fly-bys.

| | Pre-Trial (09/10APR; 16/17APR; 23/24APR; ) 6 days | **Trial (30APR/01MAY) 2 days** | Post-Trial (07/08MAY; 14/15MAY; 21/22MAY) 6 days |
|---|---|---|---|
| **Total of flights analysed** | **54** | **21** | **54** |
| A319 | 5 | 1 | 5 |
| A320 | 21 | 20 | 21 |
| A321 | 28 | - | 28 |

### a) Flight Level analysis

All flights:

| | GTD 200* | GUDAX | ERMUS |
|---|---|---|---|
| Average FL before Trial | FL320 | FL211 | FL137 |
| **Average FL during Trial** | **FL326** | **FL238** | **FL141** |
| Average FL after Trial | FL317 | FL210 | FL141 |

*GTD = Ground Track Distance to Touchdown

Flights with landing RWY14:

| | GTD 200* | GUDAX | ERMUS |
|---|---|---|---|
| Average FL before Trial | FL322 | FL214 | FL142 |
| **Average FL during Trial** | **FL326** | **FL241** | **FL147** |
| Average FL after Trial | FL316 | FL212 | FL143 |

*GTD = Ground Track Distance to Touchdown

The table shows that the average descent profile has been raised during the trial. By being allowed to cross GUDAX at a higher altitude as per current LoA, flights can fly on their optimised profile. Although it is desirable to cross ERMUS below FL130 when expecting a direct approach to runway 34 and in certain cases to runway 14, it is mostly not possible to descend flights to a lower level before this position due to traffic and/or approach sector configuration. This is clearly shown by the average crossing FL at ERMUS.

### b) Atmosphere (True Altitude, Wind and Calibrated Airspeed)

GPS-Altitude versus FL:

| | GTD200 | | | GUDAX | | ERMUS | |
|---|---|---|---|---|---|---|---|
| | GPS | FL | Δ | GPS | FL | GPS | FL |
| Pre-Trial | 31’862ft | 320 | -0.43% | 20’983 | 211 | 13’612 | 137 |
| **Trial** | **32’249ft** | **326** | **-1.08%** | **23’688** | **238** | **14’170** | **141** |
| Post-Trial | 32’163ft | 317 | +1.46% | 21’308 | 210 | 14’292 | 141 |

The atmosphere was colder during the trial weekend than the average atmosphere before and after.

Based on “True Altitude” measurements by GPS, the average flights’ descent between GUDAX and ERMUS encompassed

- 7’371ft before trial
- **9’518ft during trial**
- 7’016ft after trial

Wind and CAS:

| | GTD200 | | GUDAX | | ERMUS | |
|---|---|---|---|---|---|---|
| | Ø wind | Ø CAS | Ø wind | Ø CAS | Ø wind | Ø CAS |
| Before | -25kt | 267kt | -24kt | 272kt | -16kt | 243kt |
| **Trial** | **-9kt** | **274kt** | **-6kt** | **282kt** | **3kt** | **269kt** |
| After | -10kt | 272kt | -12kt | 272kt | -10kt | 256kt |

Although the average tailwind component is smaller during the trial and thus more air distance available for descent, a speed increase can be observed during the trial. This is an indication that the selected window at GUDAX is slightly too high and that most aircraft regained their profile by increasing speed.

### c) Fuel-consumption

In order not to obtain false and incomparable results, only the flight segment between GUDAX and ERMUS is considered for fuel-comparison. The average weight of analysed flights differs by a maximum of 170kg only. This minor difference in average gross weight has virtually no influence on the fuel consumption during descent.

| | Ø Fuel consumption GUDAX - ERMUS | Ø Ground Track Distance GUDAX - ERMUS |
|---|---|---|
| 3 weekends in April | 114kg | 36nm |
| **30 April & 01 May** | **104kg** | **36nm** |
| 3 weekends in May | 125kg | 35nm |

The increased handover FL at GUDAX ensures that the descent between GUDAX and ERMUS can be flow on profile and thus with idle power. The vertical distance flown between these 2 waypoints was up to 2’502ft bigger (measured in true altitude) during the trial and therefore helped saving fuel.

It is very challenging to compare life-data of different flights when assessing the KPIs of a descent profile. Every flight is subject to different wind influences, every flight cruises at a different flight level and every flight receives the descent clearance at a slightly different geographical location. The following figures illustrate this nicely:

Trial weekend (Δ of average weight within 450kg)

| | ΔPA GTD200 - ERMUS | ΔTA GTD200 - ERMUS | ØWind at GTD200 | ØWind at ERMUS | ØSpeed at ERMUS | **ØFuel consumption GTD200 – ERMUS** | GTD flown GTD200 - ERMUS |
|---|---|---|---|---|---|---|---|
| 30 APR | 18’300ft | 18’101ft | -54kt | -19kt | 276kt | **584kg** | 153NM |
| 01 MAY | 18’500ft | 18’059ft | 32kt | 23kt | 263kt | **824kg** | 161NM |
| Both days | 18’500ft | 18’079ft | -9kt | 3kt | 269kt | **710kg** | 157NM |

Note the wind change of over 80kt in head-/tailwind component from day 1 to day 2! The fuel figures illustrate that the wind has a very big impact on fuel consumption for the same GTD. Unfortunately, the current ATC-system is all ground based (geographical sector boundaries, constraints at waypoints etc.) and the optimum aircraft profile is, of course, based on air distance! These two models need to be carefully balanced and it is therefore essential to consider prevailing winds when designing an optimised descent profile.

##### 6.8.5.1.1.2.2 Operational subjective Feedback

For pilot feedback on the profile and this trial in general, see reference [22].

The new phraseology to "descend via" is considered unambiguous by a large majority of the pilots. Some pilots had the impression that the word "via" may be missed too easily due to its shortness. The thorough checking of pilot readbacks is certainly of utmost importance when "via"-clearances are used.

### 6.8.5.1.2 Results impacting regulation and standardisation initiatives

Initially, the partners had intended to introduce a FL-window at DOPIL to further enhance the procedure. This idea was abandoned due to differences in perception of how to deal with flight guidance settings. This disagreement was discovered during an ODP-profile validation session in an A320 simulator.

Some ATC-systems monitor the pilot selected altitude for early recognition of possible level-busts. The downlink of the altitude set on the altitude-alerting system (sent by mode-S transponder) is then compared to the "cleared FL"-input inserted by the ATCO on the aircraft's label on his HMI. While ATM-systems without paper strips rely on detection tools that need to be fed with this kind of input data, the altitude-alerting system is handled by the pilots according to company regulations and/or their tactical needs.

It must be understood that any setting of the flight guidance system is entirely up to the pilot and cannot be subject to ATC-procedures. In an environment of full-4D flying, FMS-calculations and predictions will eventually be shared downlinks. The use of the flight guidance is, however, entirely up to the pilot and has to be used according to aircraft manufacturer specification and the company's operating procedures.

Current CPR-processing software generates an advisory/alerting message for every instance that the pilot's and the ATCO's setting don't match. An increase in advisory/alerting messages without contribution to safety has to be avoided and a software based solution for the ground systems to be found.

The basic operating procedures of Boeing shall serve as example:

> *"The following altitude setting technique is normally used during published instrument arrivals and approaches when waypoints with altitude constraints are not closely spaced:*
> *- set altitude* ***to the next constraint or clearance altitude, whichever will be reached first***

> *- **just prior to reaching the constraint**, when compliance with the constraint is assured, and cleared to the next constraint, reset the altitude alerting system to the next constraint."*

The intention of having the ATCO clear the arrival to "descend via ERMUS 1T to FL130" and simultaneously introduce an altitude window at DOPIL above FL170 was therefore abandoned for this trial. Pilots would be required to first set FL170 and then the lower level, while ATCOs would be required to immediately put FL130 as the cleared level on the aircraft's label. This would generate a false warning for every descending aircraft, lead to additional RT-transmissions for clarification and be the source of negative training for ATCOs when dealing with warnings.

**Conclusion:**
Modern ACCs operate without the use of paper strips. In addition, conflict detection tools require input data in accordance with a flight's lateral and vertical ATC-clearance (routing and altitude). When using the descent phraseology "descend via…to FL…", ATCO and pilot might set different inputs in their system based on their own procedures. Since it is not acceptable that the use of flight guidance systems shall be dictated by architectural requirements of the ATC-ground system, the solution will have to be developed as a kind of suitable suppression logic for unnecessary alerts. Until the implementation of such logic, the "descend via…to FL…" has to be used with the necessary awareness regarding different altitude-alerting setting procedures applied by different airline operators and/or aircraft manufacturers.

#### 6.8.5.1.3 Unexpected Behaviours/Results

None.

#### 6.8.5.1.4 Quality of Demonstration Results

None.

#### 6.8.5.1.5 Significance of Demonstration Results

None.

## 6.8.6 Conclusions and recommendations

### 6.8.6.1 Conclusions

The suggested optimised profile is a suitable solution taking into account the most likely descent limitation of FL130.
The optimisation was done for traffic to RWY14. However, in order to allow the FMS to calculate its profile in accordance with the published procedure, ATC-speed assignment should be limited as long as possible.

### 6.8.6.2 Recommendations

The opinion of SWISS is, that whenever there is a restriction that is known to be valid most of the time, it is best to publish it and to have the FMS calculate an optimised descent profile based on these known restrictions. That increases the probability of being able to perform most parts of the descent with the power at or close to idle and therefore safes fuel.

Skyguide the following recommendations

- During MIL OFF the trial procedure (GUDAX FL260-280) is possible and desirable for AO's (an adaption of the LoA is recommended/required concerning LSGG departures via KORED)
- A short interview with SWISS pilots provided overall positive feedback - as expected, a light A319 will still claim to be below profile, a heavy A321 is slightly above it.
- A "silent handover at EFL250" to ZRH WEST should be possible as flights are laterally separated from LSGG departures inbound KORED (subject to further investigation).
- AMAN/XMAN should prevent additional speed request and unnecessary holding instructions. (see 1.2)

## 6.8.7 Exercise Results for DEM-008-03

### 6.8.7.1 Summary of Exercise Results

The desirable TOD from FL390 for a heavy A320 in no-wind condition (64'000KG, ISA, CAS 270kt) is approximately 9NM before SUNEG. The shifting of the handover point by 10NM creates an almost optimum profile with regards to the compulsory constraint at RILAX.

#### 6.8.7.1.1 Results per KPA

A summary is provided in section 5 "Exercises Results" and 6 "Demonstration Exercises reports".

##### 6.8.7.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.8.7.1.1.1.1 Performance Analysis

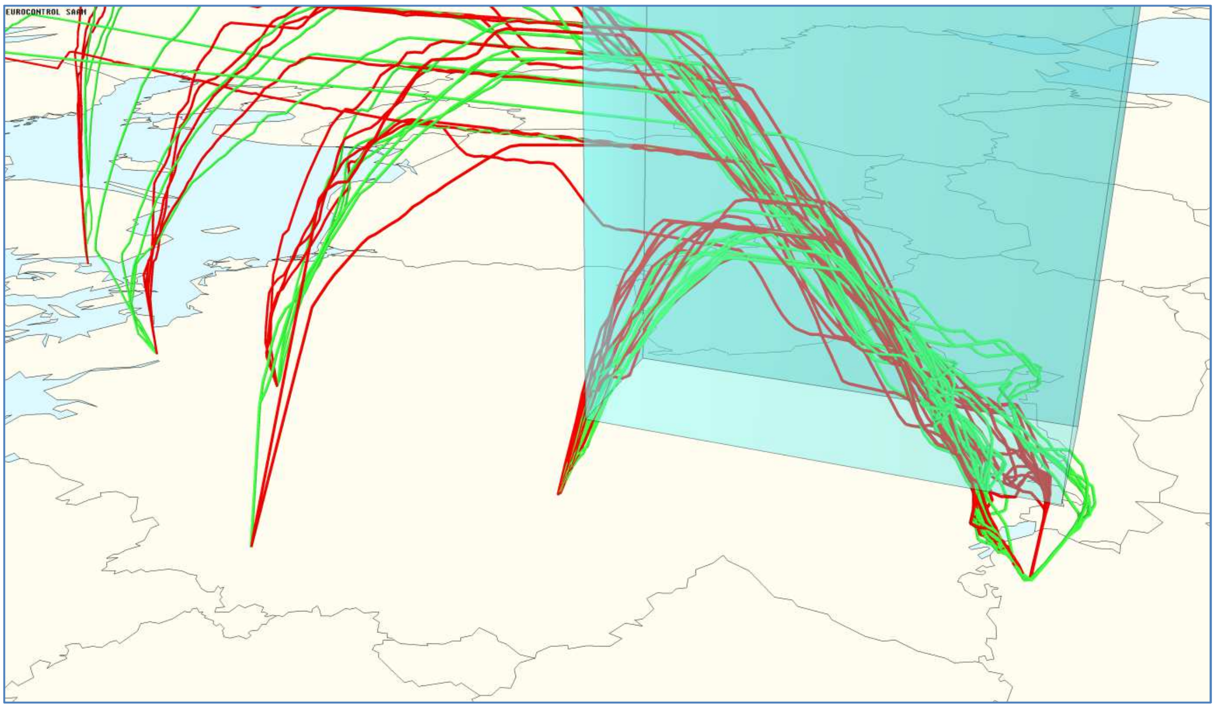


*Figure 142: Reference (red) and ODP (green) radar data recordings for Zurich (LSZH) via LAMGO-RILAX*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-008-03 from SAAM perspective are summarized in Figure 117. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

#### 6.8.7.1.1.1.1.1 Skyguide

There had been a total number of 253 ODP Trials participants. 34% of them were able to perform a CDO procedure as described in the DR. 66% did not perform a CDO. Reasons for non-execution were: weather, traffic, late handover, different routing, badly briefed flight crews.

Since Skyguide is only responsible for 2000 ft of the CDO (from FL150 to FL130) there is no major influence by ZRH ACC. Separation problems should already be solved within LANGEN airspace (due to converging inbound tracks from IBINI and EMKIL). During periods of low to medium traffic a continuous descent without interruption is possible. In high traffic periods (inbound rush) or complex situations we suffer from early speed requests and/or holding instructions by ZRH APP. As APP did not take part in this trial the flow ended at FL130.

#### 6.8.7.1.1.1.2 Operational subjective Feedback

EDGG: The 10 NM shift of the hand over point between Rhein UAC and Langen ACC proved operationally useful and was implemented permanently following the trial. Separation problems with converging inbound traffic via IBINI and EMKIL from two different sectors in Langen ACC could be solved by change of the sector structure. This will be examined in future.

Feedback Karlsruhe UAC:

A 10NM later transfer from Karlsruhe UAC to Langen ACC (20NM prior SUL at FL250 instead of LAMGO at FL250) is operational feasible and was implemented WEF 17SEP15 as permanent procedure.

### 6.8.7.1.1.2 Assessment Results by Airline Operator

#### 6.8.7.1.1.2.1 Performance Analysis

##### 6.8.7.1.1.2.1.1 SWISS

The trial took place during the week from 05OCT to 11OCT 2015.
For flight data analysis, data of all flights operated with Airbus aircraft via LAMGO between September 1st and October 11th were analysed.

The following flights were not considered in order to ensure the comparability of data:

- Approaches to RWY28 and RWY34: The pilots' descent technique changes when the landing runway lies further away than the straight-in option
- Flights with a head- or tailwind component in excess of 60kt during descent; This filters out flights that were subject to extreme weather conditions
- Flights with a GTD (Ground Track Distance) of more than 115% of the GCD (Great Circle Distance) at a GCD of 200NM from the landing runway (max. permissible GTD of 230nm at a GCD of 200NM); This filter removes flights that were subject to holding and/or long vectoring and/or extensive weather avoidance during descent.
- Flights entering the holding pattern at RILAX
- Flights without recorded data at either LAMGO, IBINI, D20SUL or RILAX (mainly caused due to major fly-bys, e.g. due weather)

| | Pre-LoA change (01SEP – 16SEP) 17 days | **After LoA change (17SEP – 04OCT) 18days** | **Trial (05OCT – 11OCT) 7 days** |
|---|---|---|---|
| **Total of flights considered** | **59** | **56** | **34** |
| A319 | 2 | 2 | 2 |
| A320 | 40 | 34 | 23 |
| A321 | 17 | 20 | 9 |

**a) Flight Level analysis**

| | | **GTD 200*** | **LAMGO+** | **D20SUL+** | **IBINI+** | **RILAX** |
|---|---|---|---|---|---|---|
| A320-Family | Ø FL BEFORE LoA change | FL350 | FL254 | FL234 | FL158 | FL125 |
| | Ø FL AFTER LoA change | FL354 | **FL257** | **FL236** | FL159 | FL124 |
| | **Ø FL DURING trial** | **FL356** | **FL264** | **FL244** | **FL159** | **FL123** |

*GTD = Ground Track Distance to Touchdown

+due to the high number of fly-bys, LAMGO, D20SUL and IBINI are defined as large boxes rather than waypoints. Therefore, some data are derived abeam the waypoints' exact geographical locations.

### b) Atmosphere (True Altitude, Wind and Calibrated Airspeed)

GPS-Altitude versus FL:

| | GTD200 | | | LAMGO | | | RILAX | | |
|---|---|---|---|---|---|---|---|---|---|
| | GPS | FL | Δ | GPS | FL | Δ | GPS | FL | Δ |
| Pre-LoA change | 35'407ft | 350 | 1.2% | 25'934ft | 254 | 2.1% | 12'774ft | 125 | 2.2% |
| Post-LoA change | 36'100ft | 354 | 2% | 26'300ft | 257 | 2.3% | 12'767ft | 124 | 3.0% |
| **Trial** | **35'996ft** | **356** | **1.1%** | **26'910ft** | **264** | **1.9%** | **12'551ft** | **123** | **2%** |

The atmosphere was slightly warmer during the period after the LoA change.

Based on "True Altitude" measurements by GPS, the average flights' descent between LAMGO and RILAX encompassed

- 13'160ft pre-LoA change
- 13'533ft post-LoA change
- **14'359ft during trial**

Wind and CAS:

| | LAMGO | | D20SUL | | IBINI | | RILAX | |
|---|---|---|---|---|---|---|---|---|
| | Ø wind | Ø CAS | Ø wind | Ø CAS | Ø wind | Ø CAS | Ø wind | ØCAS |
| Pre- LoA change | 8kt | 281kt | 8kt | 281kt | 6kt | 262kt | 4kt | 245kt |
| Post- LoA change | 5kt | 279kt | 5kt | 278kt | 2kt | 256kt | 1kt | 242kt |
| **Trial** | **1kt** | **280kt** | **1kt** | **279kt** | **0kt** | **261kt** | **0kt** | **242kt** |

The average wind and speed remain the same during the three phases of the measuring period. Interestingly, the speed limit between IBINI and RILAX during the trial period is not reflected in the average CAS. Speed at RILAX is, however, always below 250kt despite the flight crossing RILAX well above FL100 in all cases. This shows that SWISS pilots are well familiar with the particularity of their home base and select to perform a speed reduction while performing a level-off above FL100. It would be interesting to know if the approach controller needed to assign less speeds during the trial. If this is the case, the speed limit point might prove useful for smoothing the inbound flow. If ATCOs get no benefit out of such a speed limit point, there is no confirmation of its usefulness. Unfortunately, LSZH Approach was not part of ODP trials.

### c) Fuel-consumption

In order not to obtain false and incomparable results, only the flight segment between LAMGO and RILAX is considered for fuel-comparison. The average weight of analysed flights differs by a maximum of 1’288kg. This difference in gross weight has some influence on the fuel consumption during descent.

| | Ø Fuel consumption LAMGO - RILAX | Ø Ground Track Distance LAMGO - RILAX |
|---|---|---|
| 01 September – 16 September | 196kg | 57.2nm |
| 17 September – 04 October | 179kg | 57.2nm |
| **05 October – 11 October** | **156kg** | **57.1nm** |

The average ground track distance (GTD) is within 1nm during all three phases of the measuring period.
The average fuel saving during intermediate descent is about 8.7% from pre-LoA change to post-LoA change.
The average fuel saving during intermediate descent is about 12.8% from post-LoA change to trial phase.

###### 6.8.7.1.1.2.2 Operational subjective Feedback

Pilot feedback can be found in 5.3.3.3.7.2. Descent planning information is generally appreciated by pilots and considered useful. For an optimised flow that is not entirely designed as a CDO from TOD to IAA (Intermediate Approach Altitude) the use of an FMS-guided FG-mode (managed descent / VNAV descent) is considered to be of marginal benefit and is mainly used to initiate a descent only.

#### 6.8.7.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.8.7.1.3 Unexpected Behaviours/Results

None.

#### 6.8.7.1.4 Quality of Demonstration Results

None.

#### 6.8.7.1.5 Significance of Demonstration Results

The FMC (Flight Management Computer) divides the flight in different flight phases. The performance and trajectory calculation for each of these phases is based on assumptions contained in the FMS. The descent phase is active when leaving cruising altitude and lasts until activation of the approach phase (AIRBUS) or selection of speed intervention for configuring the aircraft (BOEING). The FMC descent phase contains 3 speed definitions for descent: Mach number, Descent speed and Transition speed, which is normally referenced to the airport limiting speed of 250knots below FL100.

When descending via RILAX to land on RWY14 at LSZH, the FMC calculated flight path aims at crossing RILAX around FL100 at a speed of 250kt. Due to the DVO-restriction the approach controller is unable to assign any lower FL than FL110 and the FMS thus captures the altitude set in the altitude alerting system, in most cases FL110. Upon capturing this intermediate altitude above FL100, the following happens:
-Speed reduction to transition speed (250kt) is not triggered due to the level-off above FL100.
-The auto-throttle system increases thrust to continue level flight at normal Descent speed (e.g. 270kt).
-Since the flight was close to its ideal idle descent profile, any thrust increase is wasted energy that has to be destroyed by using airbrakes at a later stage of the approach.
Regarding possible energy management optimisations, the results of this trial are considered significant.

## 6.8.8 Conclusions and recommendations

### 6.8.8.1 Conclusions

The average SWISS trial flight on an inbound route via RILAX to LSZH RWY 14 burned less fuel than comparable flights before the trial. This result could be achieved thanks to the publication of a special SESAR-RNAV chart (see figure 120 b)) providing the pilots with expected crossing altitudes and a speed limit at IBINI. Three contributing factors made this success possible:

1. Higher handover FL between Rhein Radar and Langen Radar: avoids intermediate level-offs during this part of the descent. A prevented level-off has a very positive impact on a flight's descent fuel burn.
2. Better predictability: more realistic descent profile calculation by the FMS combined with increased pilot awareness of what to expect assists pilots in following an optimised profile.
3. By improving the quality of descent planning information and introducing a speed limit that is in accordance with ATC-descent capabilities the overall fuel consumption of flights on a straight-in approach can be reduced.

Flights that are not able to perform a straight-in approach are normally subject to speed reduction and equally benefit from a more realistic FMS calculated profile if this speed limit is known to the FMS. In order to allow for an optimised descent in accordance with speed limits, ATCOs should in turn reduce the amount of vertical speed assignments for extended periods!

### 6.8.8.2 Recommendations

Early speed limits should be avoided for the flight guidance system to trade speed and altitude as long as possible when descending on its calculated profile. However, in order to enable the FMC to calculate an optimised descent profile that contains a compulsory level-off just above FL100, it is best to prevent thrust addition by anticipating the speed reduction to transition speed. A speed limit point above FL100 is thus desirable in such cases.

Regarding Skyguide:

- AMAN/XMAN should prevent additional speed request and unnecessary holding instructions. (AMAN/XMAN should give speed instructions (as soon as possible) as it will have an influence on the top of descent and the profile which is flown. This might mean an adaption of the ODP in the cockpit, but will guarantee the optimum profile when the speed is known)
- A descent window (constraint e.g. FL130-150) overhead IBINI/EMKIL (LoR) and a speed constraint would be helpful to "smoothen" the descent profile (change of LoA between LANGEN/LANGEN LOW and ZRH)

## 6.8.9 Exercise Results for DEM-008-04

### 6.8.9.1 Summary of Exercise Results

#### 6.8.9.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

##### 6.8.9.1.1.1 Assessment Results by ANSP and Eurocontrol

###### 6.8.9.1.1.1.1 Performance Analysis

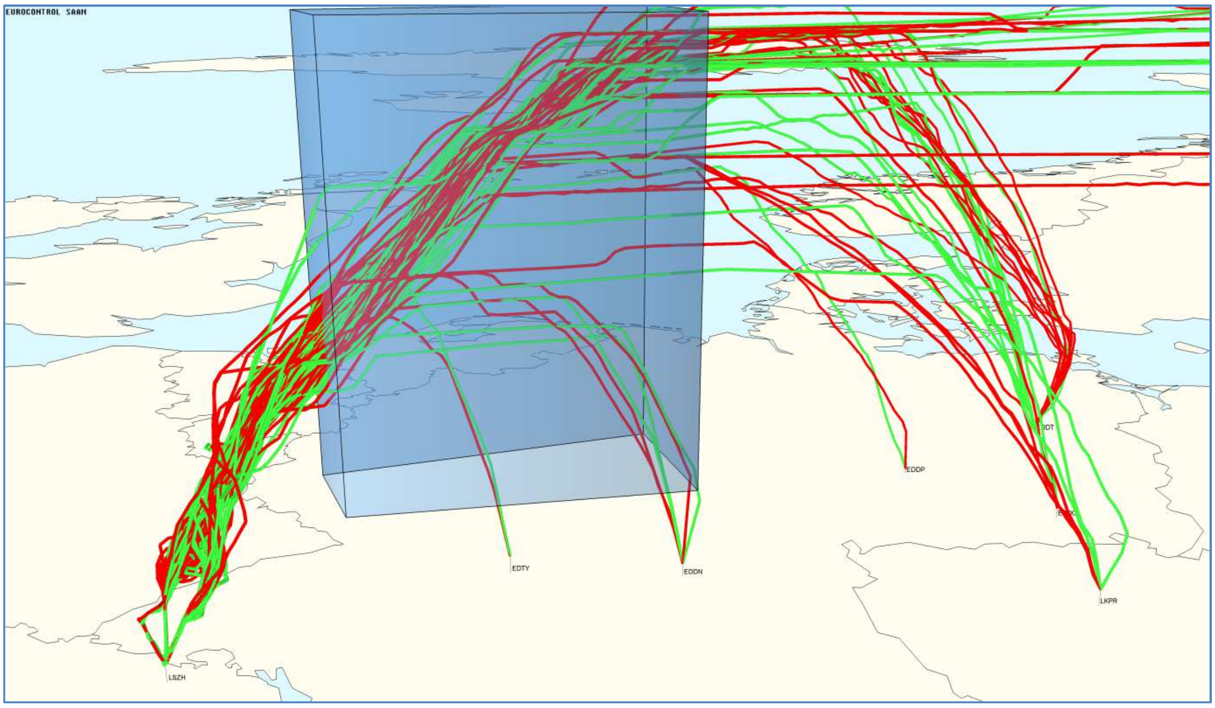



*Figure 143: Reference (red) and ODP (green) radar data recordings for Zurich (LSZH) via TEDGO*

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-008-04 from SAAM perspective are summarized in Figure 118. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.8.9.1.1.1.1.1 Skyguide

There had been a total number of 253 ODP Trials participants. 34% of them were able to perform a CDO procedure as described in the DR. 66% did not perform a CDO. Reasons for non-execution were: weather, traffic, late handover, different routing, badly briefed flight crews.

Since Skyguide is only responsible for 2000 ft of the CDO (from FL150 to FL130) there is no major influence by ZRH ACC. Separation problems should already be solved within LANGEN airspace (due to converging inbound tracks from IBINI and EMKIL). During periods of low to medium traffic a continuous descent without interruption is possible. In high traffic periods (inbound rush) or complex situations we suffer from early speed requests and/or holding instructions by ZRH APP. As APP did not take part in this trial the flow ended at FL130.

###### 6.8.9.1.1.1.2 Operational subjective Feedback

EDGG: Separation problems with converging inbound traffic via IBINI and EMKIL from two different sectors in Langen ACC could be solved by change of the sector structure. This will be examined in future.

#### 6.8.9.1.1.2 Assessment Results by Airline Operator

##### 6.8.9.1.1.2.1 Performance Analysis

###### 6.8.9.1.1.2.1.1 SWISS

The trial took place during the week from 05OCT to 11OCT 2015.
For flight data analysis, data of all flights operated with Airbus aircraft via TEDGO between September 1st and October 11th were analysed.

The following flights were not considered in order to ensure the comparability of data:

- Approaches to RWY28 and RWY34: The pilots' descent technique changes when the landing runway lies further away than the straight-in option
- Flights with a head- or tailwind component in excess of 60kt during descent; This filters out flights that were subject to extreme weather conditions
- Flights with a GTD (Ground Track Distance) of more than 115% of the GCD (Great Circle Distance) at a GCD of 200NM from the landing runway (max. permissible GTD of 230nm at a GCD of 200NM); This filter removes flights that were subject to holding and/or long vectoring and/or extensive weather avoidance during descent.
- Flights entering the holding pattern at RILAX
- Flights without recorded data at either TEDGO or RILAX, mainly caused due to major fly-bys (e.g. due weather)

| | Pre-Trial (01SEP – 04OCT) 34 days | **Trial (05OCT – 11OCT) 7 days** |
|---|---|---|
| **Total of flights considered** | **126** | **42** |
| A319 | 6 | 2 |
| A320 | 66 | 25 |
| A321 | 12 | 4 |
| A330-300 | 9 | 3 |
| A340-300 | 33 | 8 |

### a) Flight Level analysis

| | | GTD 200* | TEDGO+ | EMKIL+ | RILAX |
|---|---|---|---|---|---|
| A320-Family | Average FL BEFORE trial | FL364 | FL283 | FL188 | FL123 |
| | **Average FL DURING trial** | **FL367** | **FL285** | **FL187** | **FL125** |
| | | | | | |
| A330-300 & A340-300 | Average FL BEFORE trial | FL378 | FL274 | FL182 | FL118 |
| | **Average FL DURING trial** | **FL393** | **FL280** | **FL181** | **FL118** |

*GTD = Ground Track Distance to Touchdown
+due to the high number of fly-bys, TEDGO and EMKIL are defined as large boxes rather than waypoints. Therefore, data are not derived at the waypoints' exact geographical locations

This table shows that the average descent profile at TEDGO is above the handover FL specified in the LoA and it can be assumed that active coordination for descending flights normally takes place. No major change can be observed between pre-trial and trial phase.

### b) Atmosphere (True Altitude, Wind and Calibrated Airspeed)

GPS-Altitude versus FL (A320 data only):

| | GTD200 | | | TEDGO | | | RILAX | | |
|---|---|---|---|---|---|---|---|---|---|
| | GPS | FL | Δ | GPS | FL | Δ | GPS | FL | Δ |
| Pre-Trial | 37'022 ft | 364 | 1.7% | 28'955 ft | 283 | 2.3% | 12'622 ft | 123 | 2.6% |
| **Trial** | **37'150 ft** | **367** | **1.2%** | **29'000 ft** | **285** | **1.8%** | **12'729 ft** | **125** | **1.8%** |

The atmosphere was slightly colder during the trial week than the average atmosphere before the trial.

Based on "True Altitude" measurements by GPS, the average flights' descent between TEDGO and RILAX encompassed

- 16'333ft before trial
- **16'271ft during trial**

Wind and CAS:

| | TEDGO | | | EMKIL | | | RILAX | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ø wind | Ø CAS A320 | Ø CAS A330/340 | Ø wind | Ø CAS A320 | Ø CAS A330/A340 | Ø wind | Ø CAS A320 | ØCAS A330/A340 |
| Before | 13kt | 275kt | 291kt | 8kt | 267kt | 279kt | 3kt | 244kt | 257kt |
| **Trial** | **14kt** | **275kt** | **286kt** | **7kt** | **266kt** | **285kt** | **3kt** | **234kt** | **253kt** |

The average wind and speed remain the same before and during the trial. Speed reduction at RILAX is greater during trials.

### c) Fuel-consumption

A319/A320/A321

In order not to obtain false and incomparable results, only the flight segment between TEDGO and RILAX is considered for fuel-comparison. The average weight of analysed flights differs by 100kg only. This minor difference in gross weight has virtually no influence on the fuel consumption during descent.

| | Ø Fuel consumption TEDGO - RILAX | Ø Ground Track Distance TEDGO - RILAX |
|---|---|---|
| 01 September – 04 October | 202kg | 66.0nm |
| **05 October – 11 October** | **194kg** | **66.1nm** |

The average ground track distance (GTD) is within 1nm and mean headwinds were stronger during the trial weekend.

The average fuel saving during intermediate descent is about 4% of the fuel burned on that route segment.

A330

The average weight of analysed flights differs by approximately 4'600kg. Since the descent is limited by ATC-constraints, this difference in weight only has a minor influence on descent profile calculation and thus fuel consumption.

| | Ø Fuel consumption TEDGO - RILAX | Ø Ground Track Distance TEDGO - RILAX |
|---|---|---|
| 01 September – 04 October | 363kg | 66.0nm |
| **05 October – 11 October** | **319kg** | **66.5nm** |

The average ground track distance (GTD) is within 1nm and mean headwinds were stronger during the trial weekend.
The average fuel saving during intermediate descent is about 14% of the fuel burned on that route segment. Due to the very small sample size during the trial week (3 flights only), this result has to be noted with great caution!

A340

The average weight of analysed flights differs by approximately 2’100kg. Since the descent is limited by ATC-constraints, this difference in weight only has a minor influence on descent profile calculation and thus fuel consumption.

| | Ø Fuel consumption TEDGO - RILAX | Ø Ground Track Distance TEDGO - RILAX |
|---|---|---|
| 01 September – 04 October | 390kg | 65.7nm |
| **05 October – 11 October** | **367kg** | **66.6nm** |

The average ground track distance (GTD) is within 1nm and mean headwinds were stronger during the trial weekend.
The average fuel saving during intermediate descent is about 6% of the fuel burned on that route segment.

###### 6.8.9.1.1.2.2 Operational subjective Feedback

###### 6.8.9.1.1.2.2.1 SWISS

Pilot feedback can be found in 5.3.3.3.7.2. Descent planning information is generally appreciated by pilots and considered useful. For an optimised flow that is not entirely designed as a CDO from TOD to IAA (Intermediate Approach Altitude) the use of an FMS-guided FG-mode (managed descent / VNAV descent) is considered to be of marginal benefit and is mainly used to initiate a descent only.

#### 6.8.9.1.2 Results impacting regulation and standardisation initiatives

None.

##### 6.8.9.1.3 Unexpected Behaviours/Results

None.

##### 6.8.9.1.4 Quality of Demonstration Results

None.

##### 6.8.9.1.5 Significance of Demonstration Results

### 6.8.10 Conclusions and recommendations

#### 6.8.10.1 Conclusions

Normally early speed limits should be avoided for the flight guidance system to trade speed and altitude as long as possible when descending on its calculated profile. However, in order to enable the FMC to calculate an optimised descent profile that contains a compulsory level-off just above FL100, it is best to prevent thrust addition by anticipating the speed reduction to transition speed. A speed limit point above FL100 is thus desirable in such cases.

#### 6.8.10.2 Recommendations

From SWISS' point of view, it is essential to improve the quality of descent planning information and introduce a speed limit that is in accordance with ATC-descent capabilities on a straight-in approach if a steady descent path cannot be assured. . In order to allow for an optimised descent despite such a speed limit point, ATCOs should in turn refrain from using vertical speed assignments as much as possible!

The desirable TOD from FL390 for a heavy A320 (64'000KG, ISA, CAS 270kt) in no-wind condition is approximately 14NM after DKB. During hours of low sector load, pre-descents before DKB should be avoided as much as possible.

Regarding Skyguide:

- AMAN/XMAN should prevent additional speed request and unnecessary holding instructions. (AMAN/XMAN should give speed instructions (as soon as possible) as it will have an influence on the top of descent and the profile which is flown. This might mean an adaption of the ODP in the cockpit, but will guarantee the optimum profile when the speed is known)
- A descent window (constraint e.g. FL130-150) overhead IBINI/EMKIL (LoR) and a speed constraint would be helpful to "smoothen" the descent profile (change of LoA between LANGEN/LANGEN LOW and ZRH)

# 6.9 Demonstration Exercise SCN-0103-009 / Berlin-Tegel (EDDT/TXL) Report

## 6.9.1 Exercise Scope

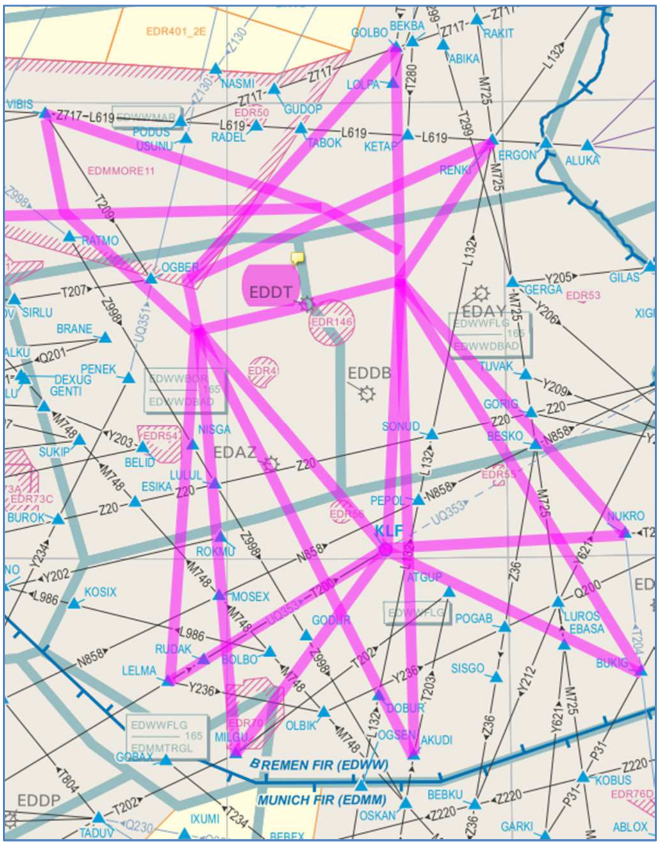



Figure 144: Trial overview Berlin Tegel (EDDT) SCN-0103-008/ EXE-0103-009/ DEM-009-01 to DEM-009-04 (chart based on [21])

Overall SAAM calculation results for EXE-0103-09 are as follows:

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 1 | 0,061 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 34 | 0,000 | 2 | 0,011 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 31 | -2,316 | 34 | -122,817 | 34 | -388,120 | 34 | -1,783 |
| Total | 34 | 0,000 | 34 | -2,244 | 34 | -122,817 | 34 | -388,120 | 34 | -1,783 |

Figure 145: Summary of potential gains for ARR to Berlin-Tegel via AKUDI, DEM-009-02 (RWY 08) and DEM-009-04 (RWY 26)

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 0 | 0,000 | 1 | 0,860 | 1 | 2,700 | 1 | 0,016 |
| Equal | 3 | -0,020 | 1 | -0,002 | 0 | 0,000 | 0 | 0,000 | 1 | -0,002 |
| Decrease | 0 | 0,000 | 2 | -0,039 | 2 | -1,280 | 2 | -4,030 | 1 | -0,006 |
| Total | 3 | -0,020 | 3 | -0,041 | 3 | -0,420 | 3 | -1,330 | 3 | 0,008 |

Figure 146: Summary of potential gains for ARR to Berlin-Tegel via BUKIG/NURKO, DEM-009-02 (RWY 08) and DEM-009-04 (RWY 26)

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 52 | 0,130 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 52 | -15,095 | 52 | -679,000 | 52 | -2146,430 | 52 | -8,310 |
| Total | 52 | 0,130 | 52 | -15,095 | 52 | -679,000 | 52 | -2146,430 | 52 | -8,310 |

*Figure 147: Summary of potential gains for ARR to Berlin-Tegel via GIRIT, DEM-009-01 (RWY 08) and DEM-009-03 (RWY 26)*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 5 | -0,030 | 3 | -0,014 | 3 | -0,627 | 3 | -1,980 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 2 | -0,118 | 2 | -2,186 | 2 | -6,920 | 5 | -0,033 |
| Total | 5 | -0,030 | 5 | -0,132 | 5 | -2,813 | 5 | -8,900 | 5 | -0,033 |

*Figure 148: Summary of potential gains for ARR to Berlin-Tegel via GOLBO, DEM-009-024 (RWY 08) and DEM-009-03 (RWY 26)*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 12 | 0,703 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 78 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 66 | -17,716 | 78 | -1460,696 | 78 | -4616,010 | 78 | -23,439 |
| Total | 78 | 0,000 | 78 | -17,013 | 78 | -1460,696 | 78 | -4616,010 | 78 | -23,439 |

*Figure 149: Summary of potential gains for ARR to Berlin-Tegel via LELMA, DEM-009-02 (RWY 08) and DEM-009-04 (RWY 26)*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 1 | 0,009 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 1 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 0 | 0,000 | 1 | -0,792 | 1 | -2,500 | 1 | -0,004 |
| Total | 1 | 0,000 | 1 | 0,009 | 1 | -0,792 | 1 | -2,500 | 1 | -0,004 |

*Figure 150: Summary of potential gains for ARR to Berlin-Tegel via MILGU, DEM-009-02 (RWY 08) and DEM-009-04 (RWY 26)*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 1 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 1 | -0,053 | 1 | -1,510 | 1 | -4,780 | 1 | -0,019 |
| Total | 1 | 0,000 | 1 | -0,053 | 1 | -1,510 | 1 | -4,780 | 1 | -0,019 |

*Figure 151: Summary of potential gains for ARR to Berlin-Tegel via RENKI, DEM-009-01 (RWY 08) and DEM-009-03 (RWY 26)*

| Status | Length (NM) | | Time (min) | | Fuel (kg) | | CO2 (kg) | | NOx (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total | Nb flights | Total |
| Increase | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Equal | 4 | -0,020 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 | 0 | 0,000 |
| Decrease | 0 | 0,000 | 4 | -1,041 | 4 | -59,373 | 4 | -187,030 | 4 | -0,797 |
| Total | 4 | -0,020 | 4 | -1,041 | 4 | -59,373 | 4 | -187,030 | 4 | -0,797 |

*Figure 152: Summary of potential gains for ARR to Berlin-Tegel via VIBIS/NURKO, DEM-009-02 (RWY 08) and DEM-009-04 (RWY 26)*

## 6.9.2 Conduct of Demonstration Exercise EXE-0103-009

### 6.9.2.1 Exercise Preparation

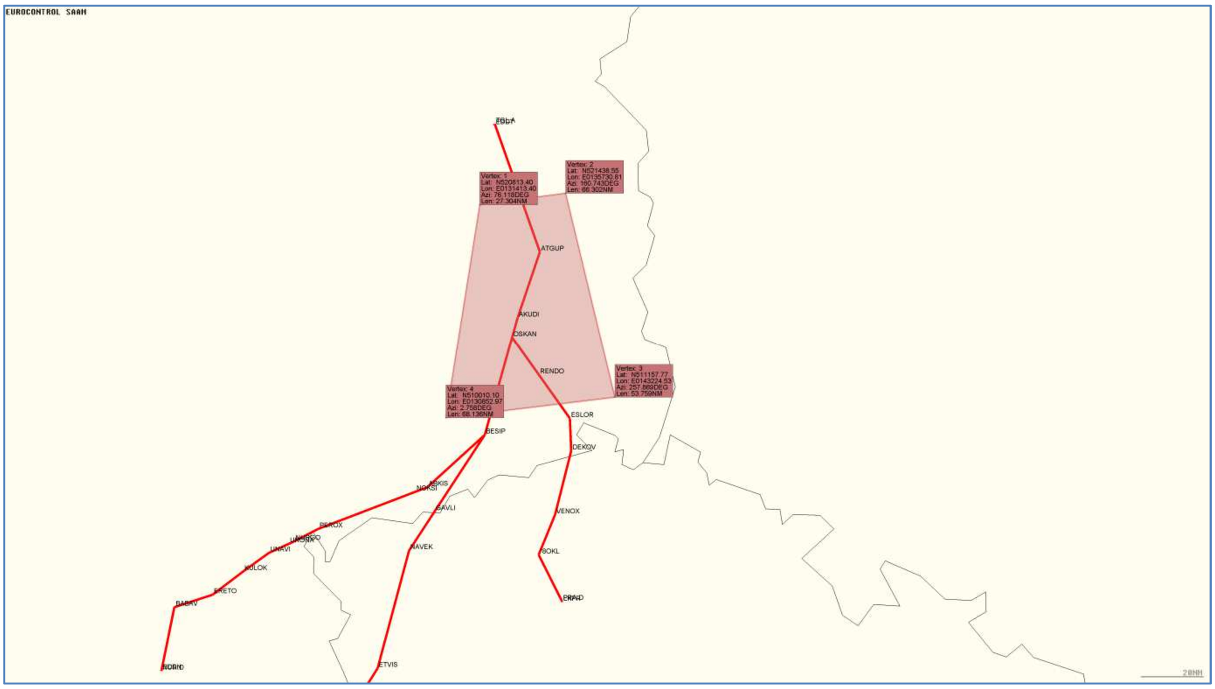



*Figure 153: Trial overview and the measurement window for Berlin Tegel (EDDT) via AKUDI*

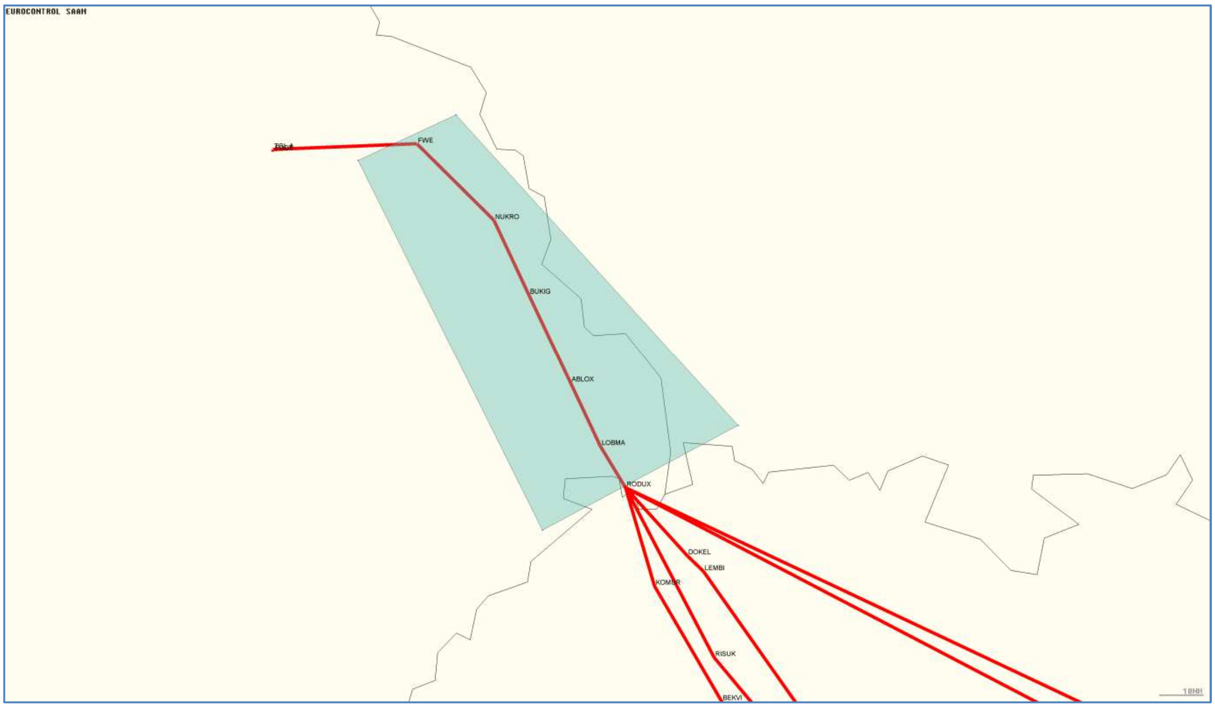



*Figure 154: Trial overview and the measurement window for Berlin Tegel (EDDT) via BUKIG*

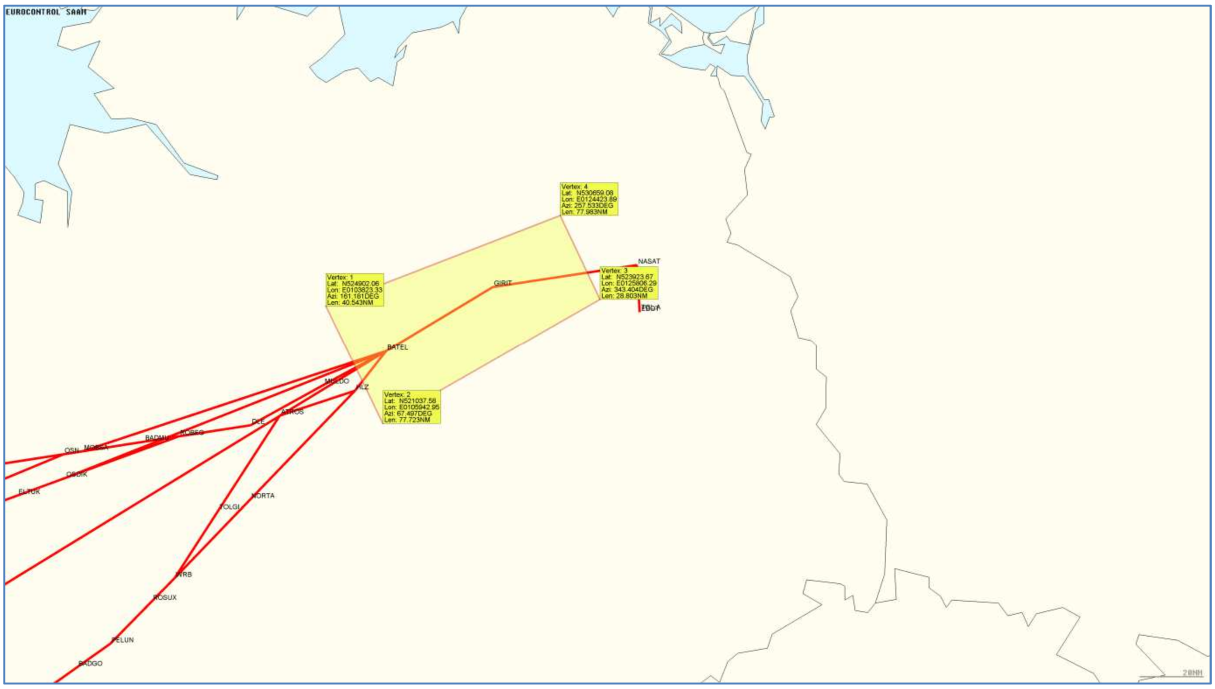



*Figure 155: Trial overview and the measurement window for Berlin Tegel (EDDT) via GIRIT*

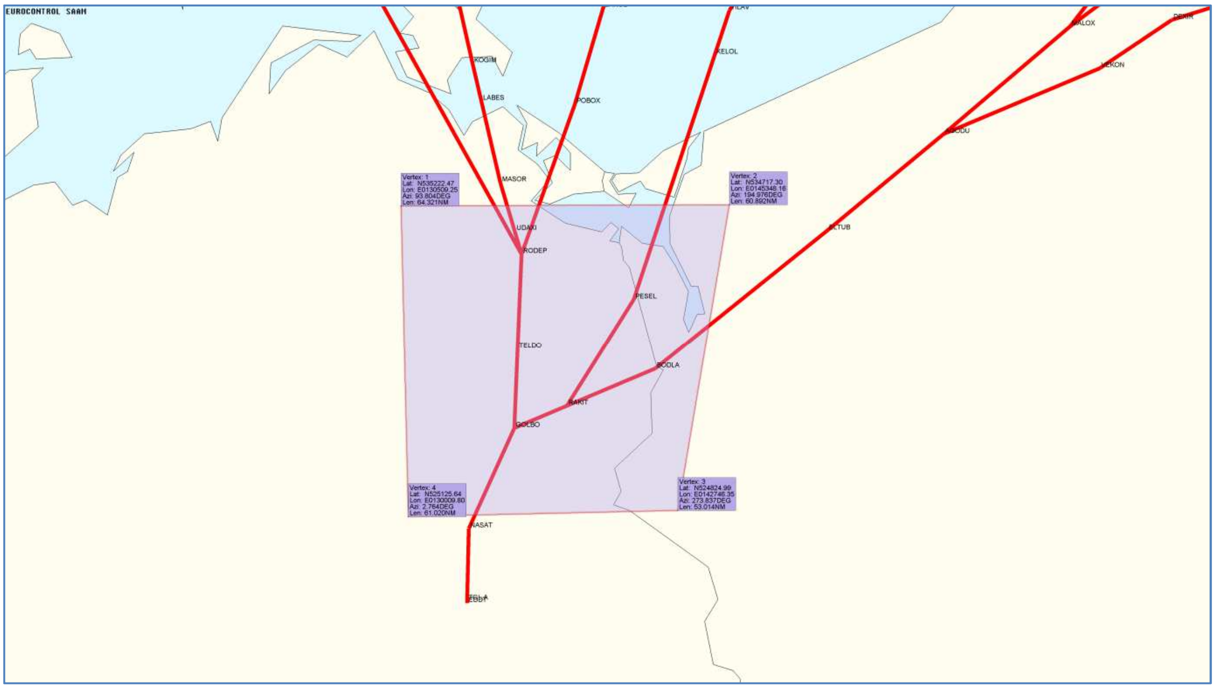



*Figure 156: Trial overview and the measurement window for Berlin Tegel (EDDT) via GOLBO*

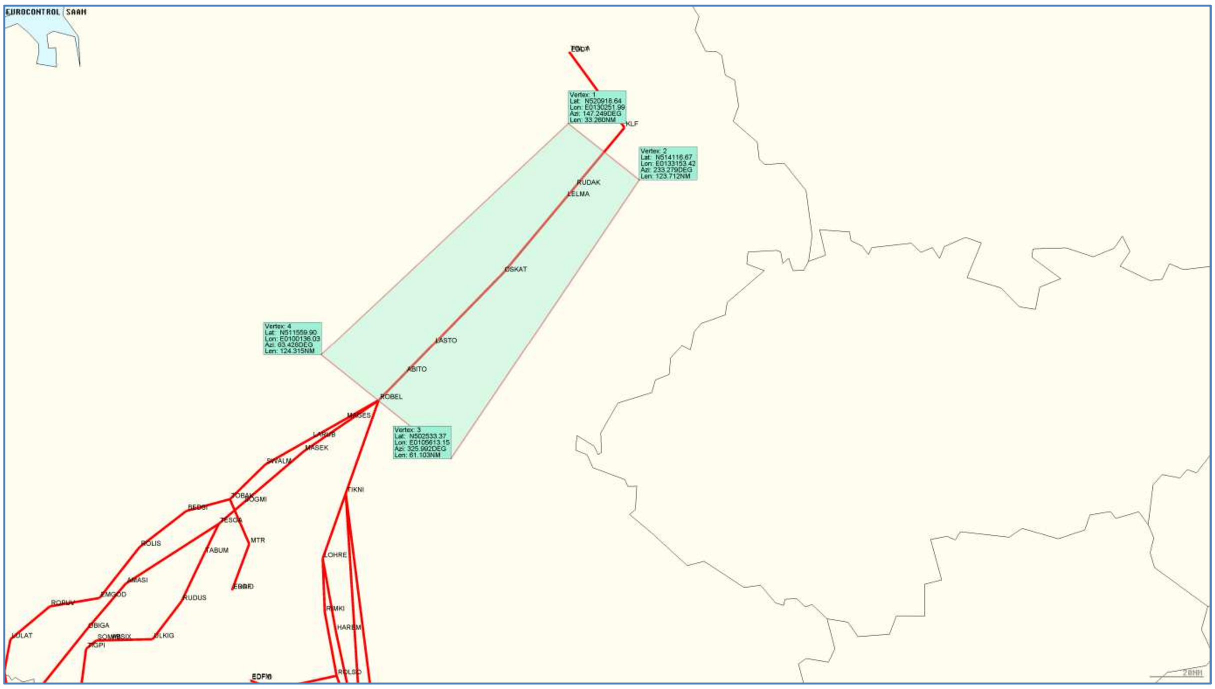


Figure 157: Trial overview and the measurement window for Berlin Tegel (EDDT) via LELMA

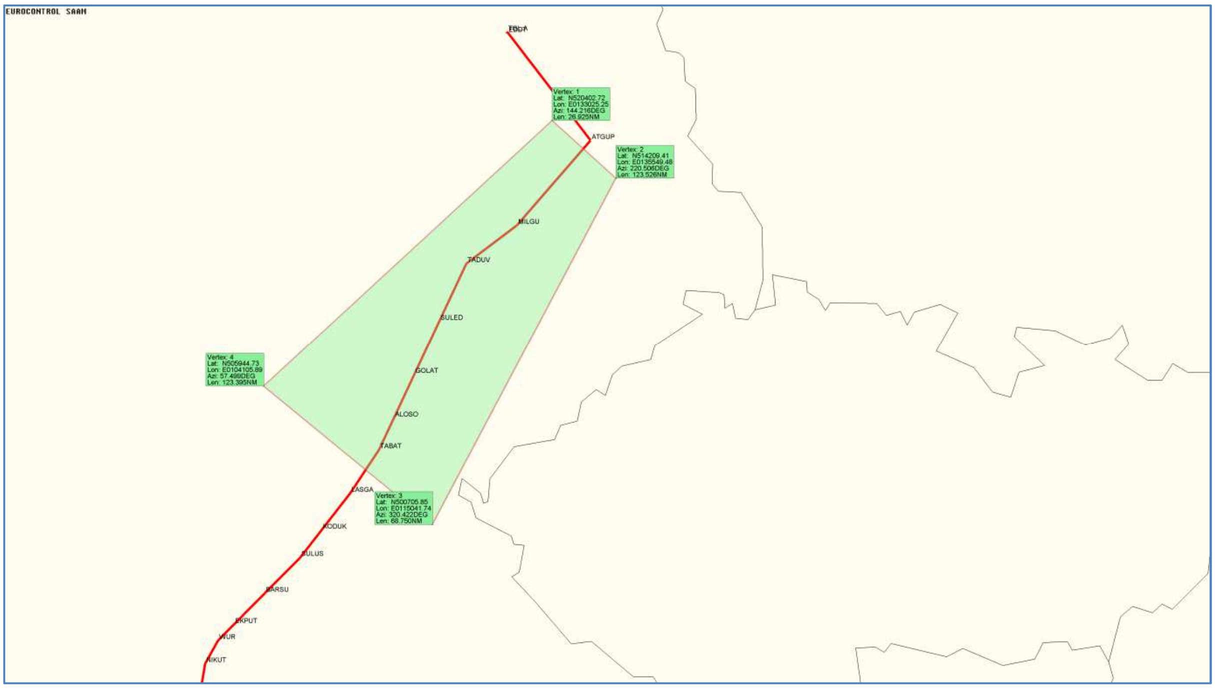


Figure 158: Trial overview and the measurement window for Berlin Tegel (EDDT) via MILGU

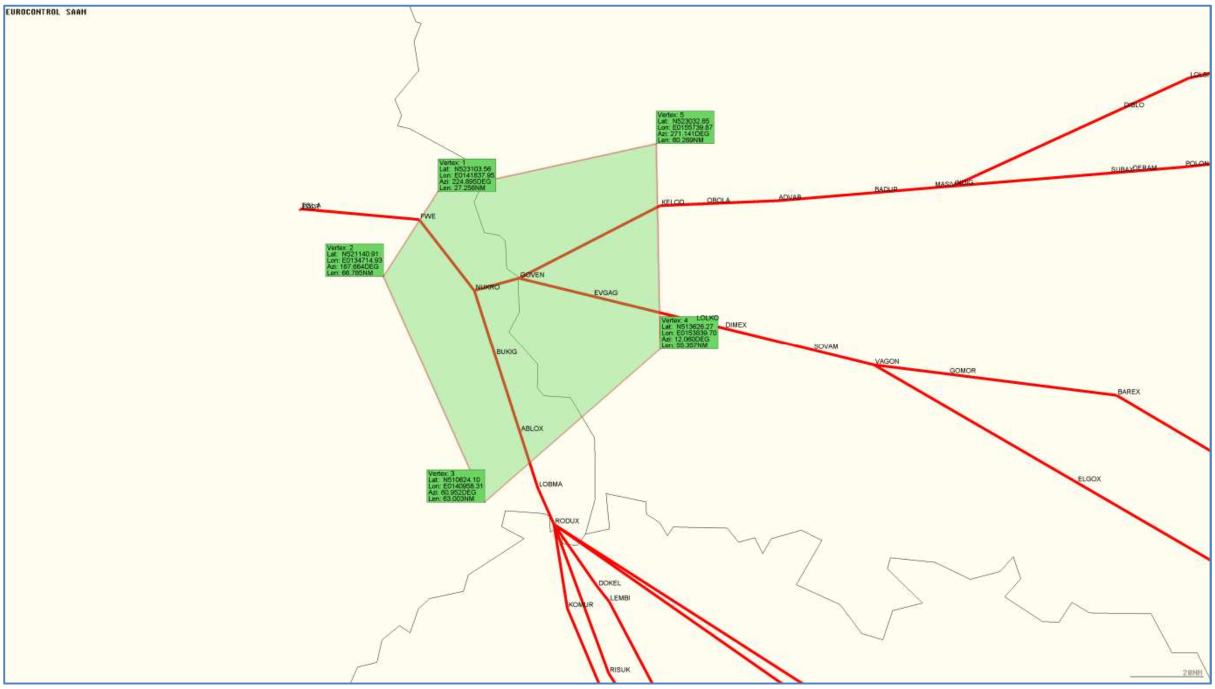



*Figure 159: Trial overview and the measurement window for Berlin Tegel (EDDT) via NUKRO*

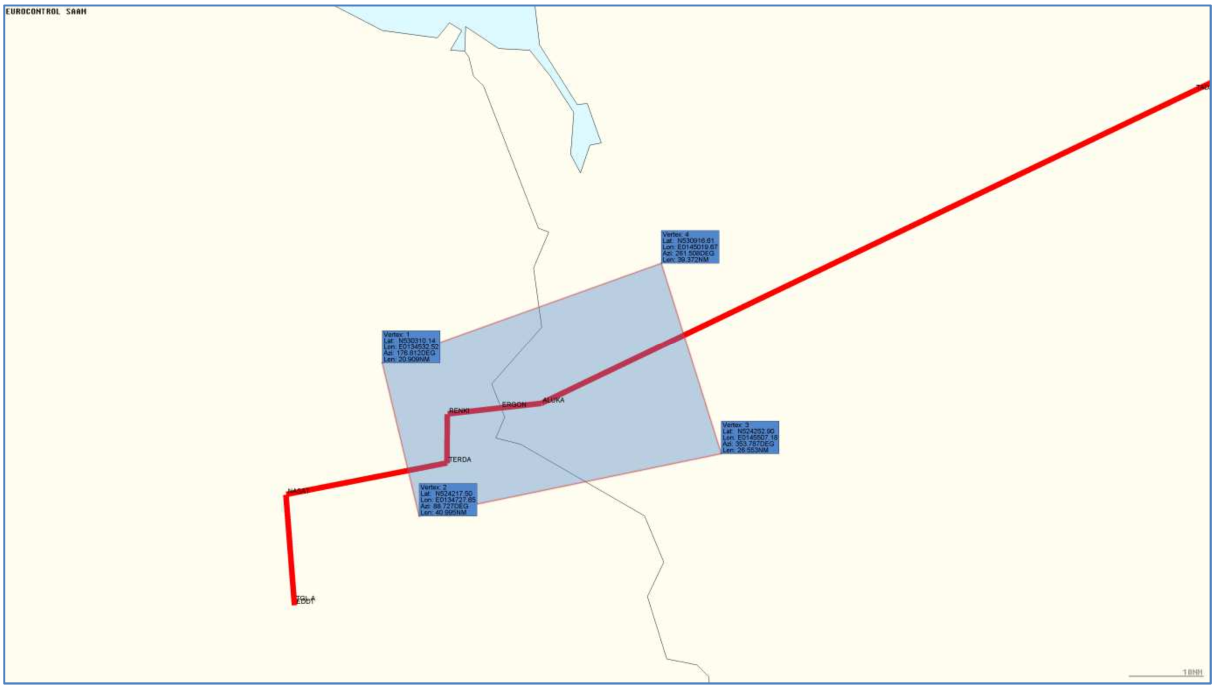



*Figure 160: Trial overview and the measurement window for Berlin Tegel (EDDT) via RENKI*

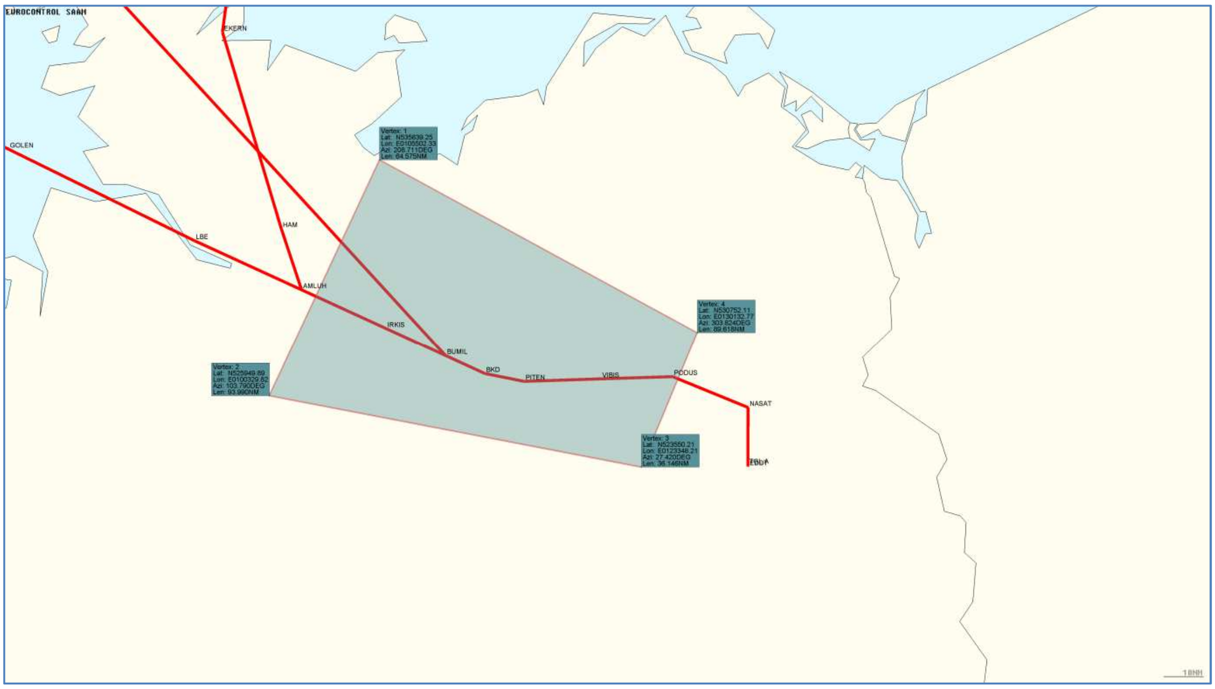



*Figure 161: Trial overview and the measurement window for Berlin Tegel (EDDT) via VIBISI*

### 6.9.2.2 Exercise execution

None.

### 6.9.2.3 Deviation from the planned activities

None.

## 6.9.3 Exercise Results for DEM-009-01

This demonstration exercises focused on EDDT Arrivals for RWY08 NORTH via GIRIT, VIBIS, GOLBO and RENKI.

### 6.9.3.1 Summary of Exercise Results

#### 6.9.3.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

##### 6.9.3.1.1.1 Assessment Results by ANSP and Eurocontrol

Overall, from Bremen ACC perspective it shows that for the Berlin area the descent profile in low to medium traffic times is already close to a CDO descent profile. Therefore the results of performance gains is limited.

###### 6.9.3.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-009-01 from SAAM perspective are summarized in chapter 6.9.1 Figure 126 till Figure 133. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.9.3.1.1.1.2 Operational subjective Feedback

From Bremen ACC point of view, either after implementation pilots were asking or it was offered by ATC to comply with the published CDA procedures.

##### 6.9.3.1.1.2 Assessment Results by Airline Operator

###### 6.9.3.1.1.2.1 Performance Analysis

AF inputs:
AF couldn't produce an analysis for Berlin flights due to the delay on the project implementation. In AF, latest IT manual extraction for ODP were planed and done in mid-June based on provided planning so latest data were May data. No additional extraction could be organised after.

DLH had no flights on this routing.

###### 6.9.3.1.1.2.2 Operational subjective Feedback

DLH had no flights on this routing.

#### 6.9.3.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.9.3.1.3 Unexpected Behaviours/Results

Bremen ACC did not see any unexpected behaviour like reported by Austro Control regarding the FMS Deletion issue.

#### 6.9.3.1.4 Quality of Demonstration Results

None.

#### 6.9.3.1.5 Significance of Demonstration Results

None.

## 6.9.4 Conclusions and recommendations

### 6.9.4.1 Conclusions

None.

### 6.9.4.2 Recommendations

None.

## 6.9.5 Exercise Results for DEM-009-02

This demonstration exercises focused on EDDT Arrivals for RWY08 SOUTH via LELMA, MILGU, AKUDI, BUKIG and NUKRO.

### 6.9.5.1 Summary of Exercise Results

#### 6.9.5.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

##### 6.9.5.1.1.1 Assessment Results by ANSP and Eurocontrol

Overall, from Bremen ACC perspective it shows that for the Berlin area the descent profile in low to medium traffic times is already close to a CDO descent profile. Therefore the results of performance gains is limited.

###### 6.9.5.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-009-02 from SAAM perspective are summarized in chapter 6.9.1 Figure 126 till Figure 133. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.9.5.1.1.1.2 Operational subjective Feedback

Either after implementation pilots were asking or it was offered by ATC to comply with the published CDA procedures.

##### 6.9.5.1.1.2 Assessment Results by Airline Operator

###### 6.9.5.1.1.2.1 Performance Analysis

No Airline data available. DLH had no flights on this routing.

###### 6.9.5.1.1.2.2 Operational subjective Feedback

No Airline data available. DLH had no flights on this routing.

#### 6.9.5.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.9.5.1.3 Unexpected Behaviours/Results

Bremen ACC did not see any unexpected behaviour like reported by Austro Control regarding the FMS Deletion issue.

##### 6.9.5.1.4 Quality of Demonstration Results

None.

##### 6.9.5.1.5 Significance of Demonstration Results

None.

### 6.9.6 Conclusions and recommendations

#### 6.9.6.1 Conclusions

None.

#### 6.9.6.2 Recommendations

None.

### 6.9.7 Exercise Results for DEM-009-03

This demonstration exercises focused on EDDT Arrivals for RWY26 NORTH via GIRIT, VIBIS, GOLBO and RENKI.

#### 6.9.7.1 Summary of Exercise Results

##### 6.9.7.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

###### 6.9.7.1.1.1 Assessment Results by ANSP and Eurocontrol

Overall, from Bremen ACC perspective it shows that for the Berlin area the descent profile in low to medium traffic times is already close to a CDO descent profile. Therefore the results of performance gains is limited.

###### 6.9.7.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-009-03 from SAAM perspective are summarized in chapter 6.9.1 Figure 126 till Figure 133. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.9.7.1.1.1.2 Operational subjective Feedback

After implementation either pilots were asking or it was offered by ATC to comply with the published CDA procedures. In one case the crew started to comply with procedure, but broke off after some minutes because it did not found/handle the procedure in the FMC. In another case the crew levelled off at FL100 asking for further descent, even that there isn't such constraint published on the VIBIS1R/1T. It states to be between FL70 and FL100. Being cleared for the profile the further descent could have been done.

##### 6.9.7.1.1.2 Assessment Results by Airline Operator

###### 6.9.7.1.1.2.1 Performance Analysis

No Airline data available. DLH had no flights on this routing.

###### 6.9.7.1.1.2.2 Operational subjective Feedback

No Airline data available. DLH had no flights on this routing.

#### 6.9.7.1.2 Results impacting regulation and standardisation initiatives

#### 6.9.7.1.3 Unexpected Behaviours/Results

Bremen ACC did not see any unexpected behaviour like reported by Austro Control except for the flow via "VIBIS" case (see above).

#### 6.9.7.1.4 Quality of Demonstration Results

None.

#### 6.9.7.1.5 Significance of Demonstration Results

None.

## 6.9.8 Conclusions and recommendations

### 6.9.8.1 Conclusions

None.

### 6.9.8.2 Recommendations

None.

## 6.9.9 Exercise Results for DEM-009-04

This demonstration exercises focused on EDDT Arrivals for RWY26 SOUTH via LELMA, MILGU, AKUDI, BUKIG and NUKRO.

### 6.9.9.1 Summary of Exercise Results

On average, there is no change in levels, neither in cruise nor in descent after the implementation of the CDO-option!

#### 6.9.9.1.1 Results per KPA

A summary is provided in section 5 “Exercises Results” and 6 “Demonstration Exercises reports”.

##### 6.9.9.1.1.1 Assessment Results by ANSP and Eurocontrol

Overall, from Bremen ACC perspective it shows that for the Berlin area the descent profile in low to medium traffic times is already close to a CDO descent profile. Therefore the results of performance gains is limited.

###### 6.9.9.1.1.1.1 Performance Analysis

The profile evaluation was based on the SAAM scenario economy module. A detailed description of the methodology can be found in chapter 5.3.3.2.1 and the calculated potential gains for DEM-009-04 from SAAM perspective are summarized in chapter 6.9.1 Figure 126 till Figure 133. In case of missing airline data the estimated benefit based on the SAAM assessment can be seen as a potential target figure with certain assumptions concerning the day of assessment and the limitation of analysis tool.

###### 6.9.9.1.1.1.2 Operational subjective Feedback

After implementation either pilots were asking or it was offered by ATC to comply with the published CDA procedures. In one case the crew started to comply with the procedure, but broke off after some minutes because it did not found/handle the procedure in the FMC.

##### 6.9.9.1.1.2 Assessment Results by Airline Operator

###### 6.9.9.1.1.2.1 Performance Analysis

No Airline data available. DLH had no flights on this routing.

###### 6.9.9.1.1.2.2 Operational subjective Feedback

No Airline data available. DLH had no flights on this routing.

6.9.9.1.1.2.2.1 SWISS

The partial implementation took place on 23 June 2016. The new STAR cannot be filed but might be tactically offered to the pilot based on operational capabilities.

For flight data analysis, data of all flights operated with Airbus aircraft via LELMA between May 12th and August 04th were analysed.

The following flights were not considered in order to ensure the comparability of data:

- Approaches to RWY08; There are too many "direct to" clearances with associated fly-bys when proceeding for straight-in to RWY08
- Flights with a head- or tailwind component in excess of 60kt during descent; This filters out flights that were subject to extreme weather conditions
- Flights without recorded data at either LELMA or KLF (mainly caused due to major fly-bys)

| | Before CDO-STAR introduction (12MAY – 22JUN) 42 days | **After CDO-STAR introduction (23JUN – 04AUG) 44 days** |
|---|---|---|
| **Total of flights considered** | **76** | **109** |
| A319 | 2 | 3 |
| A320 | 63 | 91 |
| A321 | 11 | 15 |

### a) Flight Level analysis

| | GTD 200* | LELMA | KLF+ |
|---|---|---|---|
| **Ø FL BEFORE CDO-intro** | **FL364** | **FL206** | **FL126** |
| **Ø FL AFTER CDO-intro** | **FL363** | **FL206** | **FL127** |

*GTD = Ground Track Distance to Touchdown
+due to the high number of fly-bys, KLF is defined as box rather than waypoint. Therefore, some data are derived abeam the waypoint's exact geographical location.

### b) Atmosphere (True Altitude, Wind and Calibrated Airspeed)

GPS-Altitude versus FL:

| | GTD200 | | | LELMA | | | KLF | | |
|---|---|---|---|---|---|---|---|---|---|
| | GPS | FL | Δ | GPS | FL | Δ | GPS | FL | Δ |
| BEFORE CDO-intro | 36'768ft | 364 | 1.01% | 20'898ft | 206 | 1.45% | 12'749ft | 126 | 1.18% |
| AFTER CDO-intro | 37'307ft | 363 | 2.77% | 21'201ft | 206 | 2.92% | 13'108ft | 127 | 3.21% |

The atmosphere was considerably warmer during the period after the CDO-introduction.

Based on "True Altitude" measurements by GPS, the average flights' descent between LELMA and KLF encompassed

- 8'149ft BEFORE CDO-intro
- 8'093ft AFTER CDO-intro

Wind and CAS:

| | GTD200 | | LELMA | | KLF | |
|---|---|---|---|---|---|---|
| | Ø wind | Ø CAS | Ø wind | Ø CAS | Ø wind | ØCAS |
| BEFORE CDO-intro | -15kt | 252kt | -18kt | 286kt | -13kt | 282kt |
| AFTER CDO-intro | -25kt | 253kt | -29kt | 287kt | -19kt | 282kt |

The average speeds remain the same during the two measuring periods.
Although the average CAS is the same in both scenarios, stronger tailwind in combination with faster ground speed (due to higher TAS in warmer atmosphere) leads to less flight time between LELMA and KLF. A fuel saving can thus be expected simply due to the prevailing atmospheric condition and irrespective of any CDO-assignment.

**c) Fuel-consumption**

In order not to obtain false and incomparable results, only the flight segment between LELMA and KLF is considered for fuel-comparison. The average weight of analysed flights differs by a maximum of 634kg. This difference in gross weight only has a minor influence on the fuel consumption during descent.

| | Ø Fuel consumption LELMA - KLF | Ø Ground Track Distance LELMA - KLF |
|---|---|---|
| 12 May – 22 June | 77kg | 29nm |
| 23 June – 04 August | 74kg | 29.4nm |

The average ground track distance (GTD) is within 1nm during the two measuring periods.

The measured fuel saving during intermediate descent after the introduction of CDOs is about 0.39%.

#### 6.9.9.1.2 Results impacting regulation and standardisation initiatives

None.

#### 6.9.9.1.3 Unexpected Behaviours/Results

Bremen ACC did not see any unexpected behaviour like reported by Austro Control (Automatic FMS deletions) except for the flow via “VIBIS” case (see above).

#### 6.9.9.1.4 Quality of Demonstration Results

None.

#### 6.9.9.1.5 Significance of Demonstration Results

None.

### 6.9.10 Conclusions and recommendations

#### 6.9.10.1 Conclusions

Considering the atmospheric differences between the two measuring periods, there is no evidence of any saving on this route despite the partial introduction of CDOs. The similarity of crossing FLs at different measuring points clearly indicates that SWISS pilots always aim for an optimised descent based on their experience even if no published procedure is available. Nevertheless, a publication is always desirable in order to increase predictability and ensure proper trajectory planning.

#### 6.9.10.2 Recommendations

Published CDOs that can neither be filed nor regularly flown are to be avoided. FMS-reprogramming to change a STAR containing mandatory altitude restrictions when already in descent increases the risk of misunderstandings and errors without considerable gain in flight efficiency. In cases where a certain profile can be expected most of the time it is preferable to enhance existing STAR publications with descent planning information (expect FL…) unless the clearance to “descend via…” is beneficial for ATC-purposes and can be assigned before the TOD.

**Bremen ACC:**

The existing STARs do contain already an altitude restriction called descent planning table. It corresponds at least with published transition to final procedures (without “CDO”). For high traffic situations, we need to have the conventional STARs to be filed, what we assume as the general case. The published CDO transition to final procedures are published on top of that to allow benefit during low traffic time. Furthermore, during the meeting of the noise abatement commission for the airport Berlin-Tegel, held April 07, 2016, the Technical University Berlin (TU Berlin) gave a presentation, showing that even before the publication of the CDO procedures approaches to Berlin-Tegel airport were following a CDO profile. Details may be found on website of the FLK Berlin-Tegel (“Präsentation ‘Lärmfachliche Analyse CDO-Verfahren Berlin-Tegel’”).

# 7 Summary of the Communication Activities

## 7.1 Internal and external Communication activities of the ODP partner

***Air France and HOP!***

| Media | Lead | Target audience | Status | Deviation |
|---|---|---|---|---|
| Articles in internal media | AF, HOP! | Staff | done | N |
| Sustainability Annual report | AF, HOP! | External stakeholder | done | N |
| Press release (national/regional) | AF, HOP! | Complete audience (See details in section above) | done | N |
| Corporate magazine/newsletters : (corporate magazine, SESAR magazine) | AF, HOP! | Passengers/customers | done | N |
| Corporate website : (interactive link to SJU) | AF, HOP! | Passengers/customers | open | Y |
| Trade Events : World ATM congress Paris Air Show Aviation and Environment summit | tbd | All | open | Y |
| On board magazine | HOP! | Passengers/customers | done | N |

**Table 33: Air France and HOP! Communication Plan**

***Austro Control Österreichische Gesellschaft für Zivilluftfahrt mbH***

| Media | Lead | Target audience | Status | Deviation |
|---|---|---|---|---|
| Press release | DFS + all project partners | Austrian Special-interest media; Aviation community | Done | N |
| ACG Intranet News | ACG | ACG staff | Done | N |
| ACG Internet News | ACG | Public | Done | N |
| Aviation News Stakeholder magazine | ACG | Aviation community | Done | N |
| Austro Control News Stakeholder newsletter | ACG | External Stakeholders | Done | N |
| ACG News/Intranet Video | ACG | ACG staff | Done | N |
| ACG Intranet news | ACG | ACG staff | Done | N |

| | | | | |
|---|---|---|---|---|
| 2nd Press release | DFS<br>+ all project partners | Austrian<br>Special-interest media;<br>Aviation community | Open | N<br>As stated in DFS table below, there will be a joined press release provided by DFS at the end of the project |

**Table 34: Austro Control Communication Plan**

### *DFS Deutsche Flugsicherung GmbH*

| Media | Lead | Target audience | Status | Deviation |
|---|---|---|---|---|
| Intranet newsflash at project beginning | DFS | DFS staff | Done | N |
| Intranet newsflash with project results and outlook at the end | DFS | DFS staff | open | N<br>Publication in October, shortly after project close out |
| Press release | DFS<br>+ all project partners | International trade media<br>Indirectly aviation community | Done | N |
| DFS internet pages<br>To be reproduced in the partner's communication channels | DFS + partners | External stakeholders | Done | N |
| Direct – DFS employee magazine | DFS | DFS staff | Done | N |
| Transmission – stakeholder magazine | DFS | External stakeholders of DFS | open | N<br>next edition of trans-mission magazine incl. the project results |

| | | | | |
|---|---|---|---|---|
| 2nd press release | DFS<br>+ all project partners | International trade media<br>Indirectly the aviation community | open | N<br>Publication in October or November, shortly after project close out |
| Innovation im Fokus | DFS | Technical staff and stakeholders | Done | N |
| Journalist background talks | DFS | General media | Done | Y<br>Completed in 2015. |

**Table 35: DFS Communication Plan**

### *Deutsche Lufthansa AG*

| Media | Lead | Target audience | Status | Deviation |
|---|---|---|---|---|
| Crewportal | DLH | DLH pilots | Done | N |
| eBase (Intranet) | DLH | DLH staff | Done | N |
| eBase | DLH | DLH staff | Done | N |
| eBase | DLH | DLH staff | Done | N<br>Will be published with all SESAR activity results by November 2016 |
| Crewportal | DLH | DLH pilots | Done | N<br>Will be published with all SESAR activity results by November 2016 |
| One, eBase | DLH | DLH staff | Done | N<br>Will be published with all SESAR activity results by |

| | | | | |
|---|---|---|---|---|
| | | | | November 2016 |

**Table 36: DLH Communication Plan**

### *Direction des Services de la Navigation Aérienne*

| Media | Lead | Target audience | Status | Deviation |
|---|---|---|---|---|
| Intranet news | DSNA | DSNA staff | open | Maybe, no feedback provided |
| DSNA national publication (magazine) | DSNA | DSNA staff | open | Maybe, no feedback provided |
| DSNA internal operational documentation | DSNA | DSNA staff | open | Maybe, no feedback provided |
| Annual report 2015 | DSNA | DSNA stakeholders | open | Maybe, no feedback provided |

**Table 37: DSNA Communication Plan**

### *Eurocontrol (NMD and MUAC)*

| Media | Lead | Target audience | Status | Deviation |
|---|---|---|---|---|
| Intranet news | MUAC | MUAC staff | Done | N |
| Intranet news – project results | MUAC | MUAC staff | open | N<br>shortly after the project close out |
| MUAC internet pages | DFS | External stakeholders | Done | N |
| Annual report 2015 | MUAC | MUAC stakeholders | Done | N |

**Table 38: MUAC Communication Plan**

### *Skyguide Schweizerische Aktiengesellschaft für zivile und militärische Flugsicherung*

| Media | Lead | Target audience | Status | Deviation |
|---|---|---|---|---|
| Intranet newsflash | Skyguide | Skyguide staff | Done 1 8/04/16 | N |
| Internet website | Skyguide | External stakeholders | Done 09/16 | N |

| | | | | |
|---|---|---|---|---|
| Intranet newsflash | Skyguide | Skyguide staff | Done 09/16 | N |
| FABEC Com material (newsletter, newsflash,…) | FABEC ComCell | FABEC staff | open | N. Will be done at FABEC level shortly after ODP results are available. Chairman FABEC ComCell is awaiting the results. |
| Annual report | Skyguide | External stakeholders | Done<br>in annual report 2015 | N |

**Table 39: skyguide Communication Plan**

***Swiss International Air Lines***

| Media | Lead | Target audience | Status | Deviation |
|---|---|---|---|---|
| SWISS On-Board Magazine (monthly, Print) | SWISS | SWISS passengers (external) | done | N |
| SWISS Employee Journal “AIRMAIL” (monthly, Print and Online) | SWISS | SWISS employees (internal) | done | N |

**Table 40: SWISS Communication Plan**

## 7.2 Consortium Video

A short educational and awareness rising video was produced with joined efforts and will be published on SESAR Channels and distributed in the partners intranet.

# 8 Next Steps

## 8.1 Conclusions

The project goal was to demonstrate large scale cross-border **optimised** profiles. It can be clearly said that the development and implementation of cross-border descents and CDO routings is possible even in high density airspaces. However, with today's commonly used methods and rigid sector boundaries, it requires good preparation work and a proper understanding of each other's working methods to avoid early descents.

In densely used airspaces **optimum** profiles might not be achievable most of the time. The most common reasons that lead to constraints for arriving aircraft are:

- Crossing traffic flows of significant proportions.
- ATC control sectors that need to be avoided in order to prevent situations of excessive workload.
- Limitations in Approach airspace (e.g. hand-over conditions, terrain)
- Military airspaces, such as exercise areas (e.g. TRAs) etc.

The analysis of the results of the exercises shows that current VFE is not always at optimum level in the planning phase, but tactical interventions and clearances are already of benefit for airline operators.

The project demonstrated overall performance gains in vertical profile optimisation. However, compared to HFE gains, achieving VFE gains requires bigger efforts for preparation, design and implementation.

For a wider-spread implementation of CDOs or optimised profiles, new concepts including airspace re-design and support tools are needed in order to minimise workload and limit the impact on working environments. However, in high density traffic areas, even airspace re-design and improvement on support tools will not enable CDO without impacting capacity. This certainly also applies for CCOs, even if not investigated in detail by this project.

Although concepts and tools should be designed so they can be applied and used Europe wide or even worldwide, the demonstrations clearly showed that specific solutions can only be negotiated locally. This conclusion was unanimously drawn by all partners while analysing traffic flows for possible improvements during WP2 activities. Topography, airspace usage, prevailing weather conditions and the fleet-mix of home-carriers are different at each airport. Tailored solutions are therefore required and based on a locally driven optimisation process a win-win situation should result.

ODP work highlighted this complexity to build a design solution meeting at the same time flight efficiency and capacity objectives for highly frequented airspaces and airports. Fully optimised trajectories of aircraft cannot be accommodated for all flights without impacting capacity in the current airspace structure. So, tailored solutions were designed to be feasible in the framework of ODP.

Airlines and ANSPs worked on short term solutions. In most cases, those changes were linked to a RAD or a LoA update, allowing to delay the descent from cruise FL and to reduce level off on the trajectory. Some of the solutions can now be permanently or at least seasonally implemented. This clearly indicates the possibility for more frequent or even seasonal LoA adjustments. Especially handover conditions that are designed for peak seasons should be re-evaluated for possible profile optimisations outside peak times.

The results are summed up in the Table 15.

Even though FE improvements are limited, ODP is seen as a significant first step for future optimisation efforts:

- It continues to establish awareness  about flight efficiency for ANSP daily work
- It shows the importance for collaboration between airlines and ANSPs: an optimised design should take constraints and needs of both parties into account; operational procedures should be developed in full awareness of constraints by ATC (separation) and constraints by cockpit crews (FMS behaviour, potential weather impact); In some cases, although new STARS, based on higher handover levels and thus optimised descent calculations have been implemented, AOs observed some negative impact on FE compared to purely tactical improvements.
- It launched the work on the connection between CDO and current AMANs in use. Long-term development of future XMANs involving AOs is an important enabler to allow more and better CDOs.

## 8.2 Recommendations

As stated in chapter 8.1 optimised profiles can be implemented but in most cases there needs to be comprehensive approach addressing all performance areas to avoid negative impacts. It should be assessed what could be achieved by an optimisation and what the downsides might be. All aspects need to be carefully balanced to find the best solution.  Based on the results of the CDO Development work package (WP2), options for optimised profiles or CDOs should primarily be investigated in areas with low traffic or at times of low traffic load so that they can be trialled starting at cruising FL by allowing the pilots to “descend when ready”.
When performing an assessment of possible cross-border descent optimisation, the following aspects should be considered:

- Descending and climbing traffic needs to be **harmonised** as one air traffic entity and should not be optimised separately. This point is even more valid and inevitable for airspaces of high traffic density.
- **Flexible LoA procedures** (e.g. seasonal handover conditions, RWY dependent handover conditions) need to be applied to achieve the best possible optimisation for a given traffic situation.
- The level of **awareness and current working methods** of ATCOs and Pilots need to be considered to fit into the “new” way of working with optimised flows or CDOs (same for CCOs for trajectory based operation).
- **The further development of ATM Systems and support tools (e.g. AMAN/XMAN)** needs to be in accordance with the aircraft’s capabilities to follow an optimised descent profile. Procedures involving all affected sectors shall be developed in a way that AMAN/XMAN calculated speed or time constraints can be relayed to the pilot

before starting descent. This way, FMS trajectories will be in accordance with the expected profile and in turn assist to reduce controller workload and increase predictability.

- The prevailing **aircraft types** using a certain routing have to be taken into account (e.g. fleet mix of home carriers). The optimum descent angles depend, to a large extent, on aircraft types and their actual performance (e.g. depending on weather, load, weight etc.). This needs to be taken into account as the simple classification as short, medium or long-haul for an airport might not be sufficient. Work Package 1 offers guidance on the profiles. If used, altitude windows should be defined to cater for the optimised profile of the most commonly used aircraft type and environmental situation at a given airport.
- Airline operator procedures have an influence on profiles; this includes guidelines on cost index, speed constraints (e.g. max. IAS 250kt below FL100) or regulations on climb and/or descent speeds (e.g. max. ROC/ROD +/-1'500ft/min. when approaching cleared altitude due to TCAS). These factors all have an additional influence on desirable profiles too. Therefore, **Airlines' and Manufactures'** (incl. FMS providers) view and capabilities should be considered in the design of profiles as well. Since optimised profiles or CDOs start up to 180NM before the airport, this might require a change in cockpit procedures and better pilot awareness regarding possible mandatory constraints in upper airspace. (see ref. [15] issue).
- It is necessary that the requirements to use a procedure and/or routing do fit the **equipment** of those who are intended to use the procedure/routing. Therefore a general knowledge about current and planned avionics equipment needs to be implied.
- To calculate such routing benefits, tools have to be developed further. Such tools need to consider a commonly agreed framework including airlines' requirements.
- Overall, for complex implementations, the PBN steps defined in the ERNIP Part 1 need to be followed thoroughly.

Since the evaluation of various demonstration exercises and implementations come to different conclusions and recommendations, the detailed descriptions can be found in chapter 5 "Exercises Results" under each exercise.

As stated in chapter 8.1 to move forward on optimised profile implementation, the ODP project team would recommend:

- ➢ Better CDM process to be put in place for procedure design including in particular local Airlines. This would prevent negative output of a new design implementation (inadequate phrase, pilot not managing the flight as expected…)
- ➢ Definition of operational conditions that could allow a better use of CDO: time windows, period of the year.
- ➢ Research of innovative solutions of airspace design and AMAN data use. In particular in that part, research could be done on the balance between CCO and CDO as well as sectorisation between ACC and Approach control.

### 8.2.1 Selected Altitude Issue

Airlines, Manufacturers and ANSPs should jointly work on the compatibility of the Cockpit and ATCO procedures with regards to safety nets, preventing level-busts.

The long term solution to this appears to be technology led and based on the need for amended downlinked data that shows the real intent of the aircraft. Already ANSPs are using downlinked data especially for safety purposes. For those ANSP thinking of employing downlinked selected altitude, airlines believe they should exercise great caution in doing so on SID and STAR with steps and hard level requirements. There are significant safety gains from selected level downlink, but the potential for ambiguities between displayed information and the actual intent on SID/STAR needs to be carefully addressed. Airlines strongly advise ANSP against dictating flight crews on which flight guidance mode to operate as a means of resolving this. It is against the basic principles of task sharing between flight crews and ATCOs to press a pilot to use a particular mode of his flight guidance system that satisfies an ATM-safety net but which is at odds to the flight crew operating manual (FCOM) and might actually increase the risk of level deviation.

No 'how' solution is available at this stage but these following themes and principles are directly relevant to the mode S selected level subject:

- Ensure that the technical performance and integrity meets the trust needs of the operator/user, accounting for / taking account of the natural human tendency to over rely on highly reliable automation and be biased by large data sets.
- Design the human machine interface to optimise situational awareness and workload.
- Don't hold users responsible for reasonable decisions based on information/data that is incorrect but credible.
- Ensure that new or changed operator/user technical tools work in a coherent and collaborative way with other internal and external systems and technology.
- Align and ensure compatibility of the air/ground data and procedure interfaces.
- Operator/user training on the use of automated systems should include:
  - Clarity on the underlying system logic, functions, modes, design assumptions, data fusion
  - How to evaluate the automation information/solutions in the operational context that the automation may not be able to recognise
  - How to adapt cognitive work flows to incorporate the automation information/solutions offered into core role and practices
- In service SMS monitoring processes should be designed to identify and address emergent behaviour of humans using the system in operation.
- Technical design performance assumptions and predictions should be routinely reviewed, assessed, validated, and updated in service

# 9 References

## 9.1 Applicable Documents

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

## 9.2 Reference Documents

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

[1] ATM Master Plan -> https://www.atmmasterplan.eu

[2] Operational Focus Area, Programme Guidance, Edition 03.00.00, date 04/05/2012

[3] SJU Communication Guidelines

[4] SESAR Joint Undertaking, B.05 Performance Assessment Methodology for Step1, 00.01.00, 08/04/2011

[5] SESAR Joint Undertaking, B.05 Guidance on list of Key Performance Indicators for Step 1 Performance Assessment, 00.01.00, 30/09/2011

[6] SESAR Joint Undertaking, B.05 Updated Performance Assessment Methodology for Step 1 Edition 2, 00.01.04, 19/12/2012

[7] SESAR Joint Undertaking, B.05 Guidance on KPIs and Data Collection Version 1 (2014), 00.01.00, 30/10/2014

[8] SESAR document "Environmental impact assessment as part of the global SESAR validation approach" (16.06.03)

[9] ICAO Annex 5 Units of Measurement to be Used in Air and Ground Operations

[10] SAS study on CCDs and CDAs, 04 May, 2011

[11] ODP Project Handbook -> ODP PHB 00.01.01, current version

[12] ODP Risk Management Plan -> ODP RMP 00.01.01, current version

[13] Fast Time Simulation Report RIMET (EDDF via RIMET)

[14] Final CAPAN Report for Wien_ACC_North_Sector_CDO_V1

[15] Automatic deletion of FMS constraints issue paper

[16] Selected altitude issue paper

[17] ODP Risk Register

[18] ODP Safety Plan

[19] ODP Safety Common Part document

[20] ODP Trial Descent Profile Calculator

[21] Eurocontrol, regional charts, ERC - 09/L Lower Chart (Benelux - Germany - Poland), October 2015
URL: http://www.eurocontrol.int/articles/eurocontrol-regional-charts-erc

[22] Questionnaire results DEM-008-02 LSZH_GUDAX Trial

[23] Paper: Use of MCP FCU Altitude in Europe and Register 6216, Fort Lauderdale from 27 January to 30 January 2014

**[24]** Hartmut Fricke, Christian Seiß & Robert Herrmann (2015), Fuel and Energy Benchmark Analysis of Continuous Descent Operations, Why CDO flight efficiency potential has not yet been utilized, 11th USA/Europe Air Traffic Management Research and Development Seminar (ATM2015)

**[25]** Commission Implementing Regulation (EU) No 390/2013 of 3 May 2013 laying down a performance scheme for air navigation services and network functions, Official Journal of the European Union L 128/1, 09th May 2016

# Appendix A KPA Results

| Exercise Title / Airport | Demonstration ID | Source | Nbr, of flights for the exercises | KPA / KPI: Horizontal Flight Efficiency (HFE): Distance in NM | Horizontal Flight Efficiency (HFE): Time in min | Environmental Sustainability: Fuel in kg | Environmental Sustainability: $CO_2$ in kg | Environmental Sustainability: NOX | Vertical Flight Efficiency (VFE): Average feets higher | Remarks (e.g. results source) |
|---|---|---|---|---|---|---|---|---|---|---|
| Bale-Mulhouse (LFSB/BSL) | DEM-001-01 | SAAM | 10 | -99,144 | -7,983 | -427,912 | -1352,21 | -6,441 | n/a | simulation |
| | | FANOMOS | 86 | n/a | -82,56 | n/a | n/a | n/a | 465 | measurement, uncertain (variance is of comparable magnitude as results) |
| Frankfurt (EDDF/FRA) | DEM-002-01 | SAAM | 48 | 0,16 | 1,359 | -446,36 | -1409,12 | -8,995 | n/a | simulation |
| | | BADA | 30 | n/a | n/a | -4287,09 | n/a | n/a | n/a | calculation, uncertain (variance per flight is of comparable magnitude as results) |
| | DEM-002-02 | SAAM | 48 | 0,16 | 1,359 | -446,36 | -1409,12 | -8,995 | n/a | simulation |
| | DEM-002-03 | SAAM | 48 | 0,16 | 1,359 | -446,36 | -1409,12 | -8,995 | n/a | simulation |
| | | Aviaso (DLH) | 1559 | n/a | n/a | > -10 (per flight) | n/a | n/a | 737 | measurement |
| | DEM-002-04 | SAAM | 116 | 0,12 | -15,704 | -1615,23 | -5102,12 | -31,3 | n/a | simulation |
| | | Aviaso (DLH) | 200 | | | -2600 | | | 2050 | measurement, A320 family only (65% of DLH aircraft), flights from southeast over ERNAS excluded |
| | DEM-002-05 | SAAM | 116 | 0,12 | -15,704 | -1615,23 | -5102,12 | -31,3 | n/a | simulation |
| | DEM-002-06 | SAAM | 116 | 0,12 | -15,704 | -1615,23 | -5102,12 | -31,3 | n/a | simulation |
| | DEM-002-07 | SAAM | 15 | -501,652 | -87,058 | -3557,992 | -11243,13 | -34,084 | n/a | simulation |
| | | SAAM | 11 | 0 | -24,706 | -946,41 | -2990,67 | -0,822 | n/a | simulation |
| | | FANOMOS | 187 | n/a | -40,52 | n/a | n/a | n/a | 1010 | measurement, uncertain (variance is of comparable magnitude as results) |
| | | HPO!, AF | 38 | n/a | n/a | -418 | -1316,7 | n/a | 5000 | measurement, VFE, Embraer Ejet only |
| | | HPO!, AF | 38 | n/a | n/a | -3344 | -10533,6 | n/a | n/a | measurement, HFE, Embraer Ejet only |
| | | Aviaso (DLH) | 260 | 2080 | n/a | -6500 | n/a | n/a | n/a | measurement, A320 family only, for flights above FL230 |
| | DEM-002-08 | SAAM | 36 | -0,120 | 31,825 | 1268,956 | 4012,44 | -0,132 | n/a | simulation |
| | | Aviaso (DLH) | n/a | n/a | n/a | n/a | n/a | n/a | 575 | measurement |
| | DEM-002-09 | AirTOp | n/a | n/a | n/a | n/a | n/a | n/a | n/a | only fast time simulation, no environmental KPA |
| | DEM-002-10 | SAAM | 55 | 0,214 | -12,665 | -1190,85 | -3763,77 | -20,962 | n/a | simulation only |
| | | Aviaso (DLH) | 22 | n/a | n/a | -330 | n/a | n/a | -429 | measurement, uncertain (variance is of comparable magnitude as results), short range (B737, A320 family) |
| | | Aviaso (DLH) | 22 | n/a | n/a | -220 | n/a | n/a | 2120 | calculation, short range (B737, A320 family) |
| Geneva (LSGG/GVA) | DEM-003-01 | SAAM | 19 | -0,02 | -0,374 | -72,51 | -229,06 | -1,408 | n/a | simulation |
| | | SWISS | 53 | -29,7 | n/a | -1643 | n/a | n/a | 625 | measurement, higher altitude (GPS) values for NATOR |
| | | SWISS | 53 | n/a | n/a | -1849,7 | n/a | n/a | 4000 | calculation (potential) |
| Munich (EDDM/MUC) | DEM-004-01 | SAAM | 16 | -0,03 | -2,371 | -272,899 | -862,19 | -5,847 | n/a | simulation |
| | | HOP!, AF | 146 | n/a | n/a | 700 | n/a | n/a | 3000 | measurement |
| | | Aviaso (DLH) | 2578 | n/a | n/a | 14776 | n/a | n/a | 2343 | measurement |
| | DEM-004-02 | SAAM | 4 | -0,03 | 0,14 | 2,099 | 6,62 | 0,019 | n/a | simulation |
| | DEM-004-03 | SAAM | 43 | 0,04 | 0,831 | -2306,273 | -7287,53 | -48,384 | n/a | simulation |
| | | SWISS | 1 | n/a | n/a | -123,6 | n/a | n/a | 7000 | calculation, A340-600 potential gain |
| | | SWISS | 1 | n/a | n/a | -46,6 | n/a | n/a | 7000 | calculation, A320 potential gain |
| | DEM-004-04 | SAAM | 39 | 0,04 | 0,753 | -223,35 | -705,6 | -3,629 | n/a | simulation |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Aviaso (DLH) | n/a | n/a | n/a | > -10 (per flight) | n/a | n/a | 1166 | measurement, the variance if fuel measurement is of comparable magnitude as the results. |
| | DEM-004-05 | SAAM | 120 | -0,76 | -75,159 | -3106,253 | -9815,687 | -31,222 | n/a | simulation |
| | DEM-004-06 | SAAM | 39 | 0,04 | 0,753 | -223,35 | -705,6 | -3,629 | n/a | simulation |
| | | Aviaso (DLH) | 5800 | n/a | n/a | n/a | n/a | n/a | 576 | measurement, A320 family, the variance if fuel measurement is of comparable magnitude as the results. |
| Strasbourg (LFST/SXB) | DEM-005-01 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | simulation |
| | DEM-005-02 | SAAM | 3 | 0 | -2,863 | -35,948 | -113,59 | 2,221 | n/a | simulation |
| Stuttgart (EDDS/STR) | DEM-006-01 | SAAM | 1 | 0 | 0,159 | -37,06 | -117,1 | -0,757 | n/a | simulation |
| | DEM-006-02 | SAAM | 26 | 0,03 | 2,867 | -807,457 | -2550,879 | -17,91 | n/a | simulation |
| | DEM-006-03 | SAAM | 5 | 0 | -727 | -25,521 | -80,62 | -0,274 | n/a | simulation |
| | | HOP!, AF | 259 | n/a | n/a | -0,50% | n/a | n/a | 1000 | measurement, no absolute value for fuel |
| Vienna (LOWW/VIE | DEM-007-01 | SAAM | 40 | -0,06 | 1,364 | -353,52 | -1118,9 | -7,199 | n/a | simulation |
| | | SWISS | 81 | n/a | n/a | -2532 | n/a | n/a | 556 | measurement, altitude change for UNKEN and fuel measurement for improvement of inter-sector handover copmared to reference |
| | | SWISS | 87 | n/a | n/a | -2949,3 | n/a | n/a | 286 | measurement, altitude change for UNKEN and fuel measurement for full implementation NEMAL 1W copmared to reference |
| | | HOP!, AF | 140 | n/a | n/a | 5600 | n/a | n/a | 2500 | measurement, altitude change for NIMDU and fuel measurement for improvement of inter-sector handover copmared to reference |
| | | HOP!, AF | 105 | n/a | n/a | 4600 | n/a | n/a | 1700 | measurement, altitude change for NIMDU and fuel measurement for full implementation NEMAL 1W copmared to reference |
| | DEM-007-02 | SAAM | 29 | 0,1 | 3,23 | -643,839 | -2034,36 | -12,496 | n/a | simulation |
| Zurich (LSZH/ZRH) | DEM-008-01 | SAAM | 41 | 0,2 | -1,219 | -62,461 | -197,33 | -0,806 | n/a | simulation |
| | | SWISS | 286 | 152 | n/a | -5411 | n/a | n/a | 0 | measurement |
| | DEM-008-02 | SAAM | 36 | 0,11 | -6,004 | -531,66 | -1679,69 | -9,497 | n/a | simulation |
| | | SWISS | 21 | 10,5 | n/a | -325,5 | n/a | n/a | 2147 | measurement |
| | DEM-008-03 | SAAM | 50 | 0,05 | -33,081 | -701,066 | -2215,26 | -2,029 | n/a | simulation |
| | | SWISS | 34 | 3,4 | n/a | -1360 | n/a | n/a | n/a | measurement |
| | DEM-008-04 | SAAM | 27 | -0,01 | -15,619 | -123,277 | -407,71 | 3,779 | n/a | simulation |
| | | SWISS | 42 | 11,8 | n/a | -564 | n/a | n/a | 100 | measurement |
| Berlin-Tegel (EDDT/TXL) | DEM-009-01 | SAAM | 178 | 0,06 | -35,61 | -2327,421 | -7355,1 | -34,377 | n/a | simulation |
| | DEM-009-02 | SAAM | 178 | 0,06 | -35,61 | -2327,421 | -7355,1 | -34,377 | n/a | simulation |
| | DEM-009-03 | SAAM | 178 | 0,06 | -35,61 | -2327,421 | -7355,1 | -34,377 | n/a | simulation |
| | DEM-009-04 | SAAM | 178 | 0,06 | -35,61 | -2327,421 | -7355,1 | -34,377 | n/a | simulation |
| | | SWISS | 109 | 43,6 | n/a | -327 | n/a | n/a | 0 | measurement |

# Appendix B Supplement: Communication Material

Consortial Kick-off in the project was communicated to the aviation media and e.g. through SJU:

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Home > Newsroom > News > Optimised descents from cruising altitude until landing: Towards "green" skies

OPTIMISED DESCENTS FROM CRUISING ALTITUDE UNTIL LANDING: TOWARDS "GREEN" SKIES

26/05/2015

A consortium of European air navigation service providers and airlines has recently been formed to explore optimised descent profiles (ODP) from upper airspace to terminal manoeuvring areas. The goal is to improve vertical flight efficiency and environmental sustainability while also considering capacity aspects.

Following free route projects and continuous descent operations at numerous airports, the focus for optimisation now lies on the route segment between cruising altitude and the terminal manoeuvring areas around airports.

The air navigation service providers of Germany (DFS Deutsche Flugsicherung), Austria (Austro Control), France (DSNA) and Switzerland (Skyguide), as well as EUROCONTROL's Maastricht Upper Area Control Centre (MUAC) aim to develop optimised descent procedures for certain approach paths to the airports of Basel, Berlin-Tegel, Frankfurt, Geneva, Munich, Strasbourg, Stuttgart, Vienna and Zurich.

The project will conduct fast-time and real-time simulations as well as several cross-border exercises, developing continuous descent profiles at the highest level possible for aircraft coming from both free route and conventional route airspaces. Cross-centre arrival management systems (XMAN) and their applicability in the context of continuous descent operations will also be examined.

The results will be verified by test flights in cooperation with the airline operators and consortium members Air France, Deutsche Lufthansa, SWISS and their affiliated airlines (among them HOP!, Austrian Airlines, Germanwings).

The consortium, which is under the lead of DFS, is co-funded by the SESAR Joint Undertaking. The final project results are expected to be available by September 2016.

ODP is one of several SESAR demonstration activities co-funded by the SESAR Joint Undertaking, the public-private partnership that pools the knowledge and resources of the entire European air traffic management community to deliver solutions for a modernised ATM, enabling highly efficient aviation in Europe. To date, more than 30,000 flight trials have been conducted providing concrete and tangible evidence of the benefits offered by SESAR solutions in day-to-day operations.

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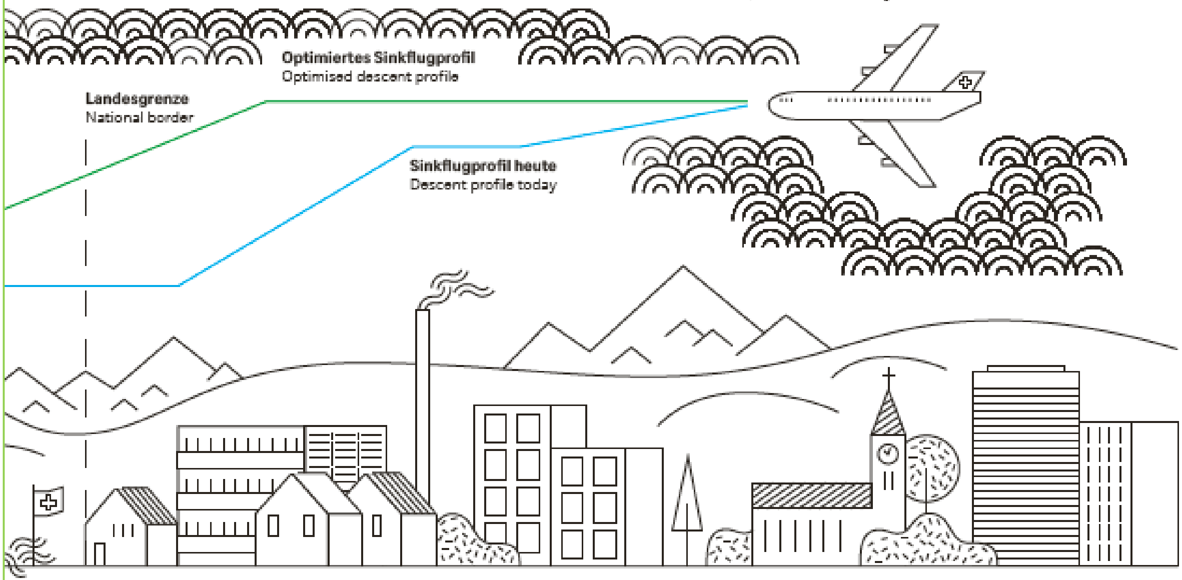
Phone: +32 (0)2 507 80 30

*Figure 162: communication of project start through SJU website*

In Swiss Magazine April 2016 following article was published in German and English:

Text: Thomas Hirt, SFO B777 & Project Pilot ODP / Illustration: Raffinerie




SWISS is playing an active part in Optimised Descent Profiles, an EU-funded demonstration project[1] that is designed to enhance the descents of flights to airports in Europe by adopting procedures for more flexible air traffic management. This in turn should reduce the fuel consumption – and thus the carbon emissions – of the flights.

Aircraft today have both high-performance wings with outstanding glide characteristics and on-board computers that can constantly calculate an aircraft's optimum descent profile based on the current wind conditions. Ideally, after it has completed its climb, an aircraft will remain at its cruising altitude as long as possible, since this is where it will consume the least fuel. Once the aircraft has started its descent, the engines' thrust will be reduced all the way to idle, and the aircraft will glide down to the airport with no additional engine power until shortly before landing. It's a procedure that reduces the aircraft's fuel consumption and – as a result – cuts its carbon emissions, too. It's also pleasant for the passengers as it minimises engine noise and smooths out the change in cabin air pressure as the aircraft descends.

In view of the high traffic volumes they handle, but also of their differing technical control centre capabilities, the air navigation services providers (ANSPs) of some European countries have concluded agreements that lay down clearly what altitude restrictions must be observed at what points. These agreements specify the flight level at which a flight should be handed over from one air traffic controller to another, and thus also dictate an aircraft's descent profile. As a result, the ideal flight profile calculated by the on-board computer – the profile that the flight's pilots would prefer to follow – is all too rarely flown.

The ANSPs of some European nations are striving under the SESAR[2] demonstration projects to find ways to bring more flexibility into these traffic handovers in the next few years. This could be done by providing more separation between the airways currently used, and/or by replacing the present fixed handover levels with so-called altitude windows that the on-board computer will be aware of.

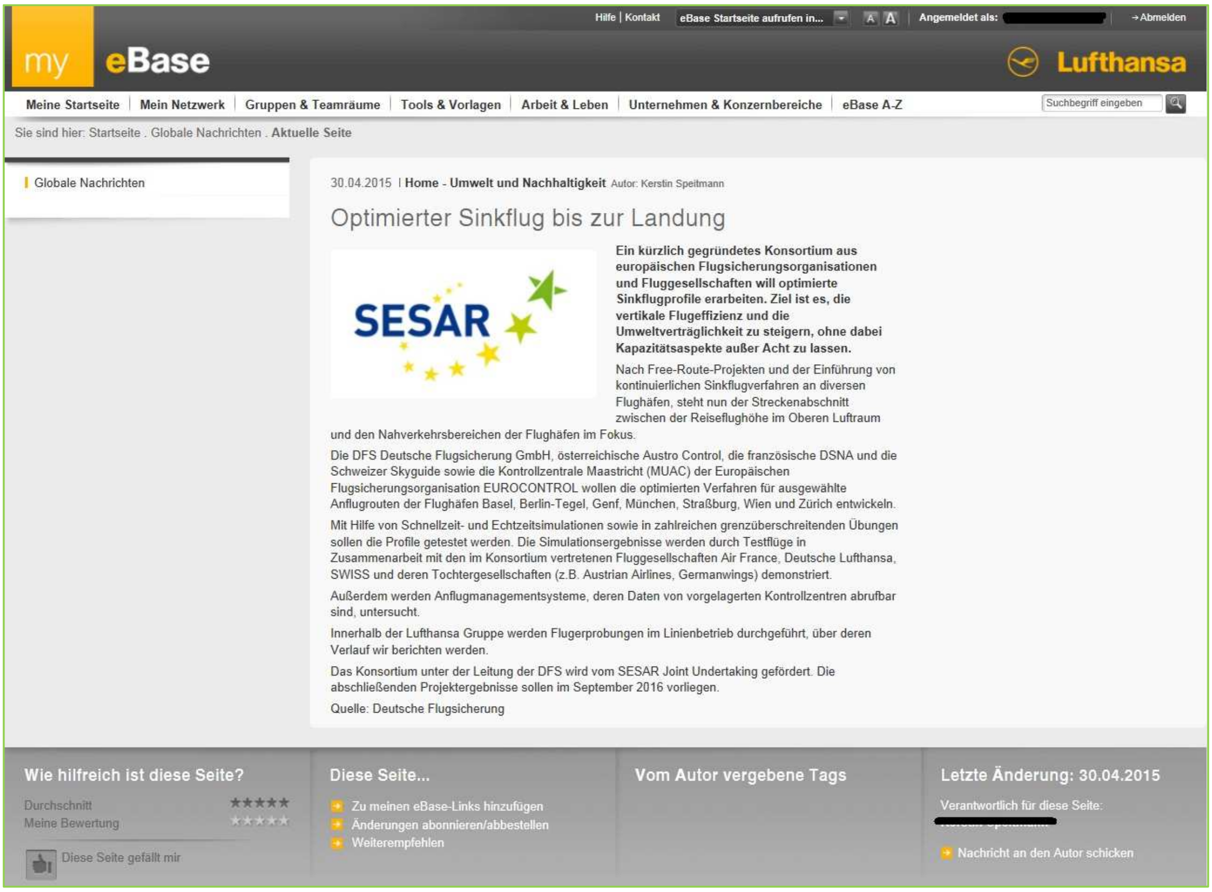
But the procedures and technical requirements for all this still need to be created and duly trialled. Europe's Optimised Descent Profiles or ODP project was launched to ensure that the viability of new concepts of this kind is demonstrated and that possible shortcomings are addressed in a coordinated manner. The project, in which SWISS is substantially involved, seeks to determine how more flexible approaches could be adopted without reducing the capacity of the airspace concerned. To this end, the project partners are currently optimising descents to Frankfurt, Munich, Stuttgart, Berlin, Vienna, Geneva and Zurich airports.

[1] Supervised by SJU (SESAR Joint Undertaking)
[2] SESAR = Single European Sky ATM Research Program

**Environmental Care** 113

*Figure 163: English version of ODP article in Swiss Magazine April 2016*

Luftahnsa eBase website:



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Globale Nachrichten

30.04.2015 | Home - Umwelt und Nachhaltigkeit Autor: Kerstin Speitmann

Optimierter Sinkflug bis zur Landung

SESAR

**Ein kürzlich gegründetes Konsortium aus europäischen Flugsicherungsorganisationen und Fluggesellschaften will optimierte Sinkflugprofile erarbeiten. Ziel ist es, die vertikale Flugeffizienz und die Umweltverträglichkeit zu steigern, ohne dabei Kapazitätsaspekte außer Acht zu lassen.**

Nach Free-Route-Projekten und der Einführung von kontinuierlichen Sinkflugverfahren an diversen Flughäfen, steht nun der Streckenabschnitt zwischen der Reiseflughöhe im Oberen Luftraum und den Nahverkehrsbereichen der Flughäfen im Fokus.

Die DFS Deutsche Flugsicherung GmbH, österreichische Austro Control, die französische DSNA und die Schweizer Skyguide sowie die Kontrollzentrale Maastricht (MUAC) der Europäischen Flugsicherungsorganisation EUROCONTROL wollen die optimierten Verfahren für ausgewählte Anflugrouten der Flughäfen Basel, Berlin-Tegel, Genf, München, Straßburg, Wien und Zürich entwickeln.

Mit Hilfe von Schnellzeit- und Echtzeitsimulationen sowie in zahlreichen grenzüberschreitenden Übungen sollen die Profile getestet werden. Die Simulationsergebnisse werden durch Testflüge in Zusammenarbeit mit den im Konsortium vertretenen Fluggesellschaften Air France, Deutsche Lufthansa, SWISS und deren Tochtergesellschaften (z.B. Austrian Airlines, Germanwings) demonstriert.

Außerdem werden Anflugmanagementsysteme, deren Daten von vorgelagerten Kontrollzentren abrufbar sind, untersucht.

Innerhalb der Lufthansa Gruppe werden Flugerprobungen im Linienbetrieb durchgeführt, über deren Verlauf wir berichten werden.

Das Konsortium unter der Leitung der DFS wird vom SESAR Joint Undertaking gefördert. Die abschließenden Projektergebnisse sollen im September 2016 vorliegen.

Quelle: Deutsche Flugsicherung

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Vom Autor vergebene Tags

Letzte Änderung: 30.04.2015
Verantwortlich für diese Seite: [redacted]
Nachricht an den Autor schicken

*Figure 164: ODP article on Lufthansa eBase portal*

Austro Control website publication:

austro CONTROL

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# Optimierter Sinkflug von der Reiseflughöhe bis zur Landung wird untersucht

**Konsortium untersucht umweltfreundlichere Verfahren.**

*ACC Wien*

Ein kürzlich gegründetes Konsortium aus europäischen Flugsicherungsorganisationen und Fluggesellschaften will optimierte Sinkflugprofile erarbeiten. Ziel ist es, die vertikale Flugeffizienz und die Umweltverträglichkeit zu steigern, ohne dabei Kapazitätsaspekte außer Acht zu lassen.

Nach Free-Route-Projekten und der Einführung von kontinuierlichen Sinkflugverfahren an diversen Flughäfen, steht nun der Streckenabschnitt zwischen der Reiseflughöhe im Oberen Luftraum und den Nahverkehrsbereichen der Flughäfen im Fokus.

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Außerdem werden Anflugmanagementsysteme, deren Daten von vorgelagerten Kontrollzentren abrufbar sind, im Zusammenhang mit CDO-Verfahren untersucht.

Das Konsortium unter der Leitung der DFS wird vom SESAR Joint Undertaking gefördert. Die abschließenden Projektergebnisse sollen im September 2016 vorliegen.

**Hintergrund:**

SESAR: Das Single European Sky ATM Research Programme (SESAR) ist ein von der Europäischen Kommission und EUROCONTROL ins Leben gerufenes Public-Private Partnership zur Vereinheitlichung, Harmonisierung und Synchronisierung der Dienste im Rahmen eines modernen europäischen Flugverkehrsmanagements. Das Projekt zur Optimierung von Sinkflugprofilen ist eines von zahlreichen vom SESAR Joint Undertaking mitfinanzierten Demonstrationsaktivitäten. Mit Hilfe der mehr als 30.000 bis heute durchgeführten Testflüge konnte der Nutzen der im Rahmen von SESAR entwickelten Lösungen für die tägliche Arbeit konkret und greifbar nachgewiesen werden.
**www.sesarju.eu**

Cross-Centre-Arrival-Management (XMAN) Systeme sind übergreifende Anflugmanagementsysteme. Informationen, die bisher nur den Lotsen der Anflugkontrolle zur Verfügung standen, werden damit auch den vorgelagerten Kontrollzentralen angezeigt. Die Planung wird so auf einen Radius von bis zu 200 NM erweitert. Flugzeuge können früher in eine optimale Anflugreihenfolge gebracht und Warteschleifen vermieden werden.

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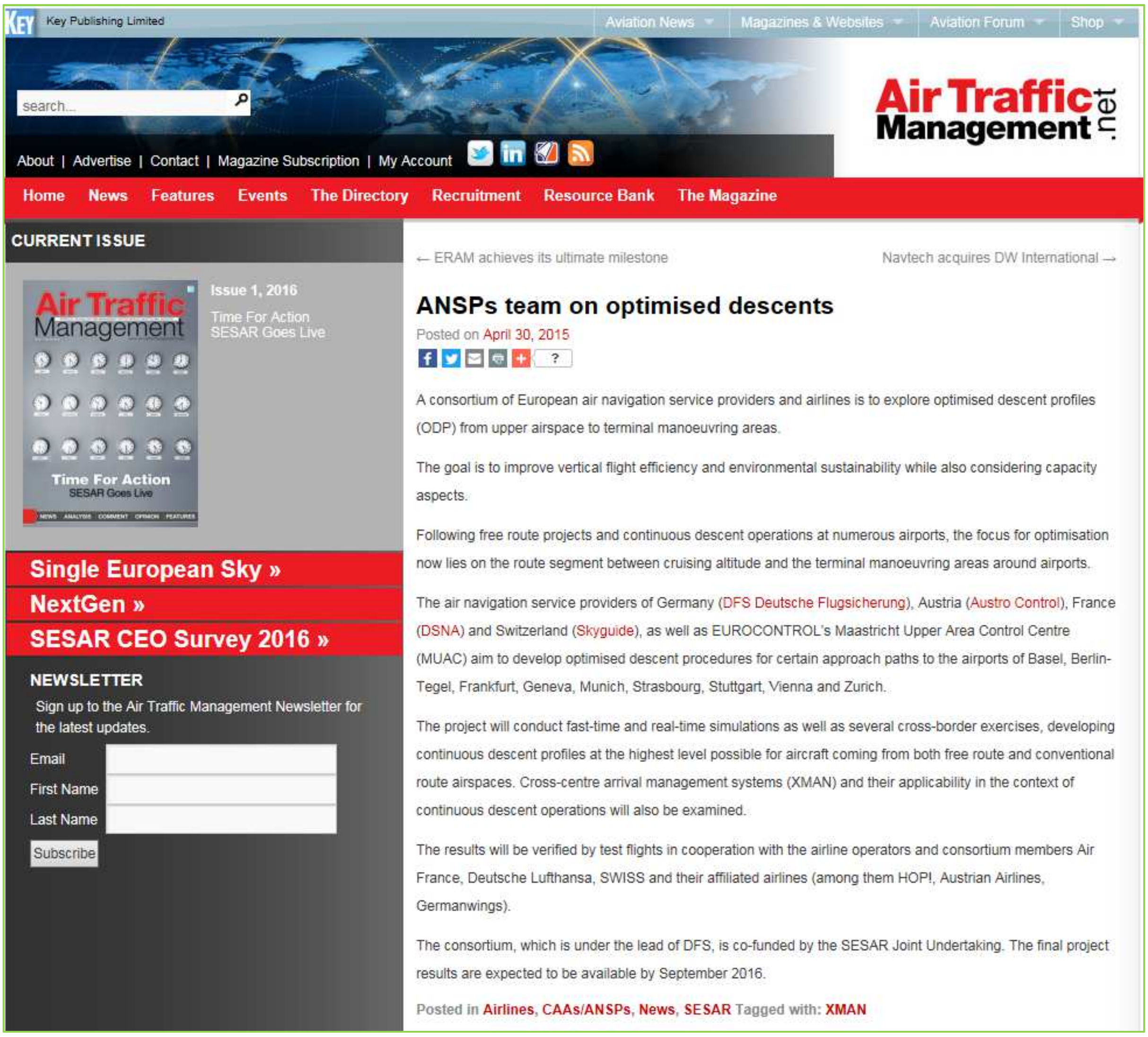
*Figure 165: ODP article on ACG website*

Airtrafficmanagement.net publication: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**ANSPs team on optimised descents**

Posted on April 30, 2015

A consortium of European air navigation service providers and airlines is to explore optimised descent profiles (ODP) from upper airspace to terminal manoeuvring areas.

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The results will be verified by test flights in cooperation with the airline operators and consortium members Air France, Deutsche Lufthansa, SWISS and their affiliated airlines (among them HOP!, Austrian Airlines, Germanwings).

The consortium, which is under the lead of DFS, is co-funded by the SESAR Joint Undertaking. The final project results are expected to be available by September 2016.

Posted in Airlines, CAAs/ANSPs, News, SESAR Tagged with: XMAN

*Figure 166: ODP article on http://www.airtrafficmanagement.net/*

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## Towards "green" skies: Optimised descents from cruising altitude until landing

30 APRIL 2015

A consortium of European air navigation service providers and airlines has recently been formed to explore optimised descent profiles (ODP) from upper airspace to terminal manoeuvring areas. The goal is to improve vertical flight efficiency and environmental sustainability while also considering capacity aspects.

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*Figure 167: ODP article on CANSO website*

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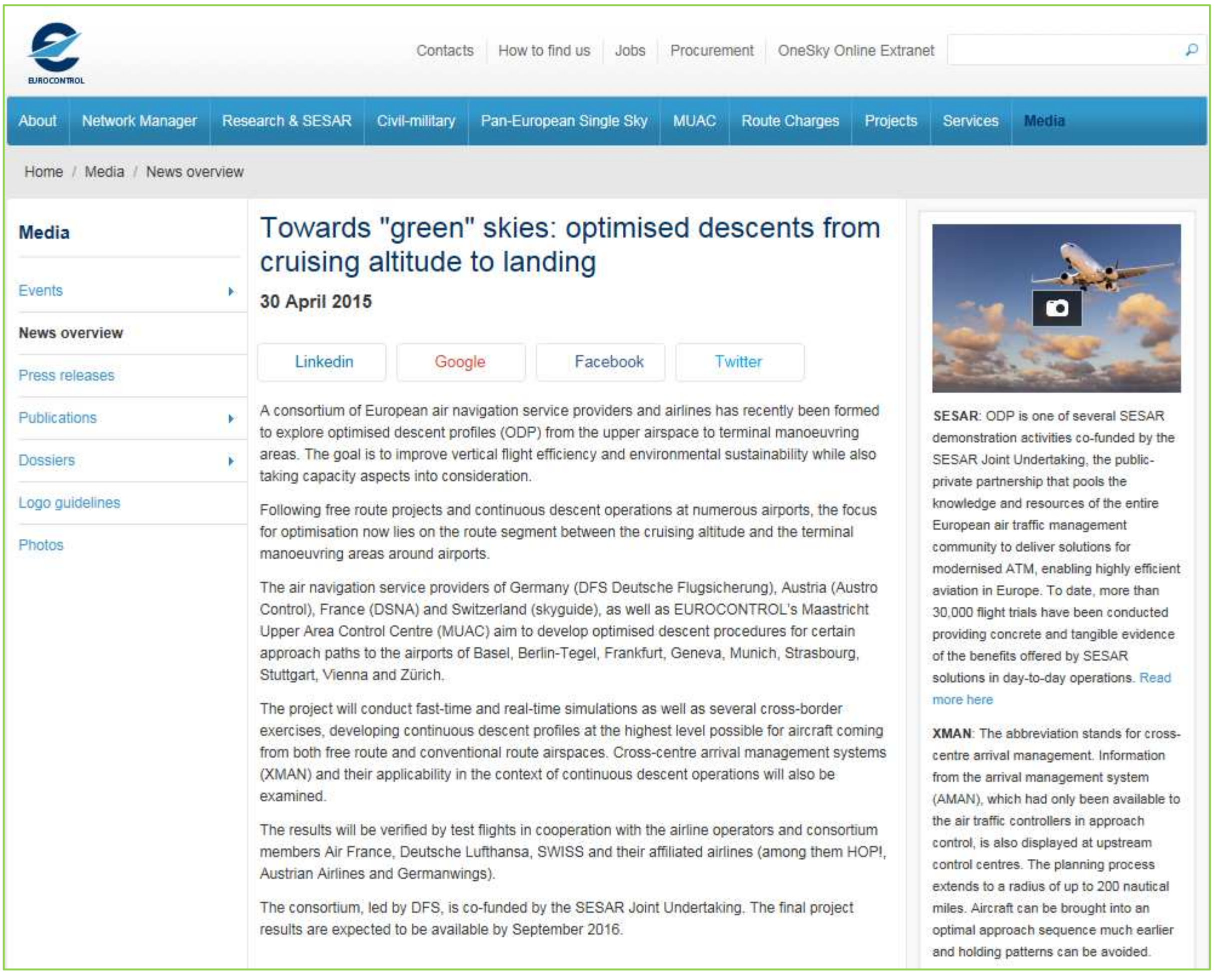

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## Towards "green" skies: optimised descents from cruising altitude to landing

**30 April 2015**

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**XMAN**: The abbreviation stands for cross-centre arrival management. Information from the arrival management system (AMAN), which had only been available to the air traffic controllers in approach control, is also displayed at upstream control centres. The planning process extends to a radius of up to 200 nautical miles. Aircraft can be brought into an optimal approach sequence much earlier and holding patterns can be avoided.

*Figure 168: ODP article on ECTL website*

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Press » Press releases » 2015 » 30.04.2015.- Optimised descents

## Optimised descents from cruising altitude until landing

Towards "green" skies

30.04.2015.- A consortium of European air navigation service providers and airlines has recently been formed to explore optimised descent profiles (ODP) from upper airspace to terminal manoeuvring areas. The goal is to improve vertical flight efficiency and environmental sustainability while also considering capacity aspects.

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Note to the editors
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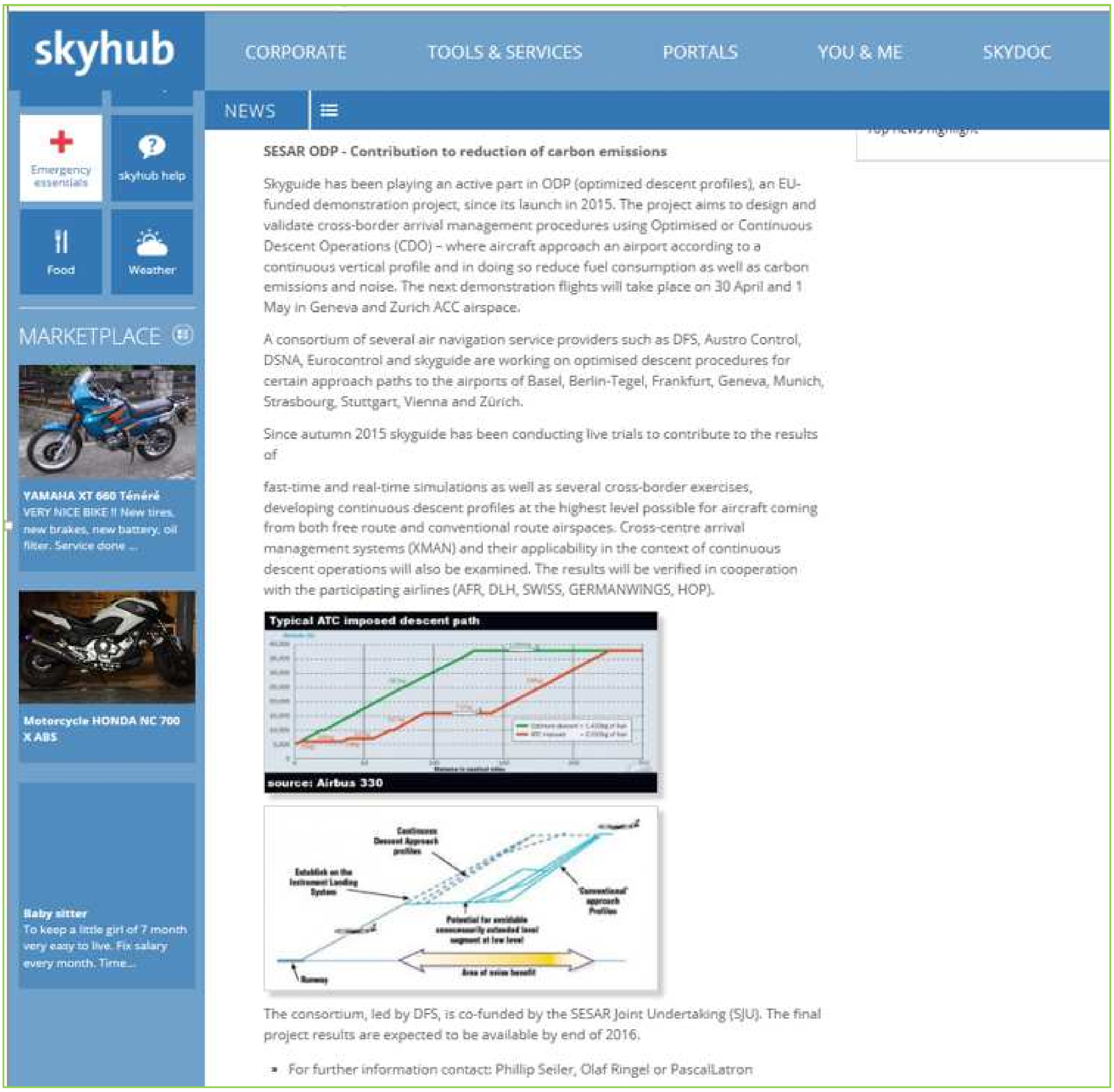
http://www.sesarju.eu/

XMAN: The abbreviation stands for cross-centre arrival management. Information from the arrival management system (AMAN), which had only been available to the air traffic controllers in approach control, is displayed at upstream control centres. The planning process extends to a radius of up to 200 nautical miles. Aircraft can be brought into an optimal approach sequence much earlier and holdings can be avoided.

**DFS Deutsche Flugsicherung GmbH**, the German air navigation service provider, is a State-owned company under private law with 5,881 employees as at 31 December 2014. DFS ensures the safe and punctual flow of air traffic over Germany. Around 2,000 air traffic controllers guide up to 10,000 flights in German airspace every day, and about three million movements every year. This makes Germany the country with the highest traffic volume in Europe. The company operates control centres in Langen, Bremen, Karlsruhe and Munich as well as 16 control towers at international airports in Germany. In addition, DFS is represented at the EUROCONTROL Control Centre in Maastricht, the Netherlands. Additional areas of activity include consulting, provided by the Aeronautical Solutions Division, and aeronautical data, grouped in the Aeronautical Information Management Division.

*Figure 169: ODP article on DFS website*

Intranet Newsflash skyguide (18.04.2016):




**SESAR ODP - Contribution to reduction of carbon emissions**

Skyguide has been playing an active part in ODP (optimized descent profiles), an EU-funded demonstration project, since its launch in 2015. The project aims to design and validate cross-border arrival management procedures using Optimised or Continuous Descent Operations (CDO) – where aircraft approach an airport according to a continuous vertical profile and in doing so reduce fuel consumption as well as carbon emissions and noise. The next demonstration flights will take place on 30 April and 1 May in Geneva and Zurich ACC airspace.

A consortium of several air navigation service providers such as DFS, Austro Control, DSNA, Eurocontrol and skyguide are working on optimised descent procedures for certain approach paths to the airports of Basel, Berlin-Tegel, Frankfurt, Geneva, Munich, Strasbourg, Stuttgart, Vienna and Zürich.

Since autumn 2015 skyguide has been conducting live trials to contribute to the results of

fast-time and real-time simulations as well as several cross-border exercises, developing continuous descent profiles at the highest level possible for aircraft coming from both free route and conventional route airspaces. Cross-centre arrival management systems (XMAN) and their applicability in the context of continuous descent operations will also be examined. The results will be verified in cooperation with the participating airlines (AFR, DLH, SWISS, GERMANWINGS, HOP).

The consortium, led by DFS, is co-funded by the SESAR Joint Undertaking (SJU). The final project results are expected to be available by end of 2016.

- For further information contact: Phillip Seiler, Olaf Ringel or PascalLatron

*Figure 170: iSTREAM, ODP, PEGASE and AAL: News from SESAR projects with skyguide participation*

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Thursday, April 30, 2015

European ANSP, Airlines Form ODP Consortium

Veronica Magan

A consortium of European air navigation service providers and airlines has recently been formed to explore optimized descent profiles (ODP) from the upper airspace to terminal maneuvering areas. Photo: Eurocontrol

[Avionics Today 04-30-2015] European Air Navigation Service Providers (ANSPs) and airlines have formed a consortium to explore Optimized Descent Profiles (ODP) from the upper airspace to terminal maneuvering areas. The goal is to improve vertical flight efficiency and environmental sustainability while also taking capacity aspects into consideration.

The ANSPs of Germany (DFS Deutsche Flugsicherung), Austria (Austro Control), France (DSNA), and Switzerland (Skyguide), as well as Eurocontrol's Maastricht Upper Area Control Centre (MUAC) aim to develop optimized descent procedures for certain approach paths to the airports of Basel, Berlin-Tegel, Frankfurt, Geneva, Munich, Strasbourg, Stuttgart, Vienna and Zürich.

The project will conduct fast-time and real-time simulations as well as several cross-border exercises, developing continuous descent profiles at the highest level possible for aircraft coming from both free route and conventional route airspaces. Researchers will also examine Cross-center Arrival Management Systems (XMAN) and their applicability in the context of continuous descent operations.

The results will be verified by test flights in cooperation with the airline operators and consortium members Air France, Deutsche Lufthansa, Swiss and their affiliated airlines (among them HOP!, Austrian Airlines and Germanwings).

The consortium, led by DFS, is co-funded by the SESAR Joint Undertaking. The final project results are expected to be available by September 2016.

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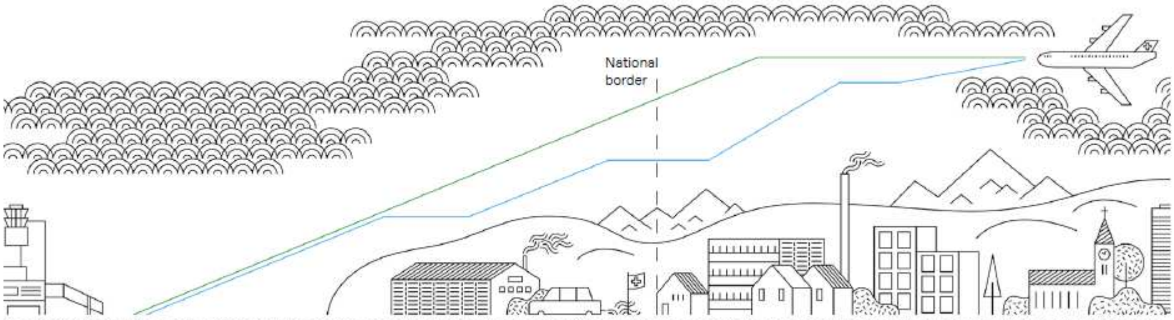
*Figure 171: ODP article on Avionics website*

*Swiss staff magazine “Airmail”:*




The ODP project is intended to optimize flight descents and thereby reduce fuel consumption. The green line shows the ideal descent profile. The blue line shows the current descent procedure, using the example of Zurich Airport. Illustration: Raffinerie AG

SESAR

# Objective: better descents!

**SWISS is playing an active part in Optimised Descent Profiles (ODP), an EU research project that is designed to enhance the descents of flights to airports.**

— Thomas Hirt

Aircraft today have both high-performance wings with outstanding glide characteristics and on-board computers that can constantly calculate the flight's optimum descent profile based on the current wind conditions. Ideally, after it has completed its climb, a flight will remain at its cruising altitude for as long as possible, since this is where it will consume the least fuel. Once the flight has started its descent, the engines' thrust should be reduced all the way to idle, and the aircraft should glide down to the airport with no additional engine power until shortly before landing. It's a procedure that minimizes the flight's fuel consumption and – as a result – its carbon emissions, too.

But… in view of the high traffic volumes they handle, and also of their differing technical control centre capabilities, the air navigation services providers (ANSPs) of some European countries have concluded agreements that lay down clearly what altitude restrictions must be observed at what points. These agreements specify the flight level at which a flight should be handed over from one air traffic controller to another, and thus also dictate a flight's descent profile. As a result, the ideal flight profile calculated by the on-board computer – the profile that the flight's pilots would prefer to follow – is all too rarely flown.

The ANSPs of some European nations are striving under the Single European Sky (SES) project to find ways to bring more flexibility into these traffic handovers. This could be done by providing more separation between the airways currently used, and/or by replacing the present fixed handover levels with so-called "altitude windows" that the on-board computer would be aware of. This in turn would allow the pilots to calculate adjusted flight profiles. At the same time, air traffic controllers should make greater use of new conflict detection tools.

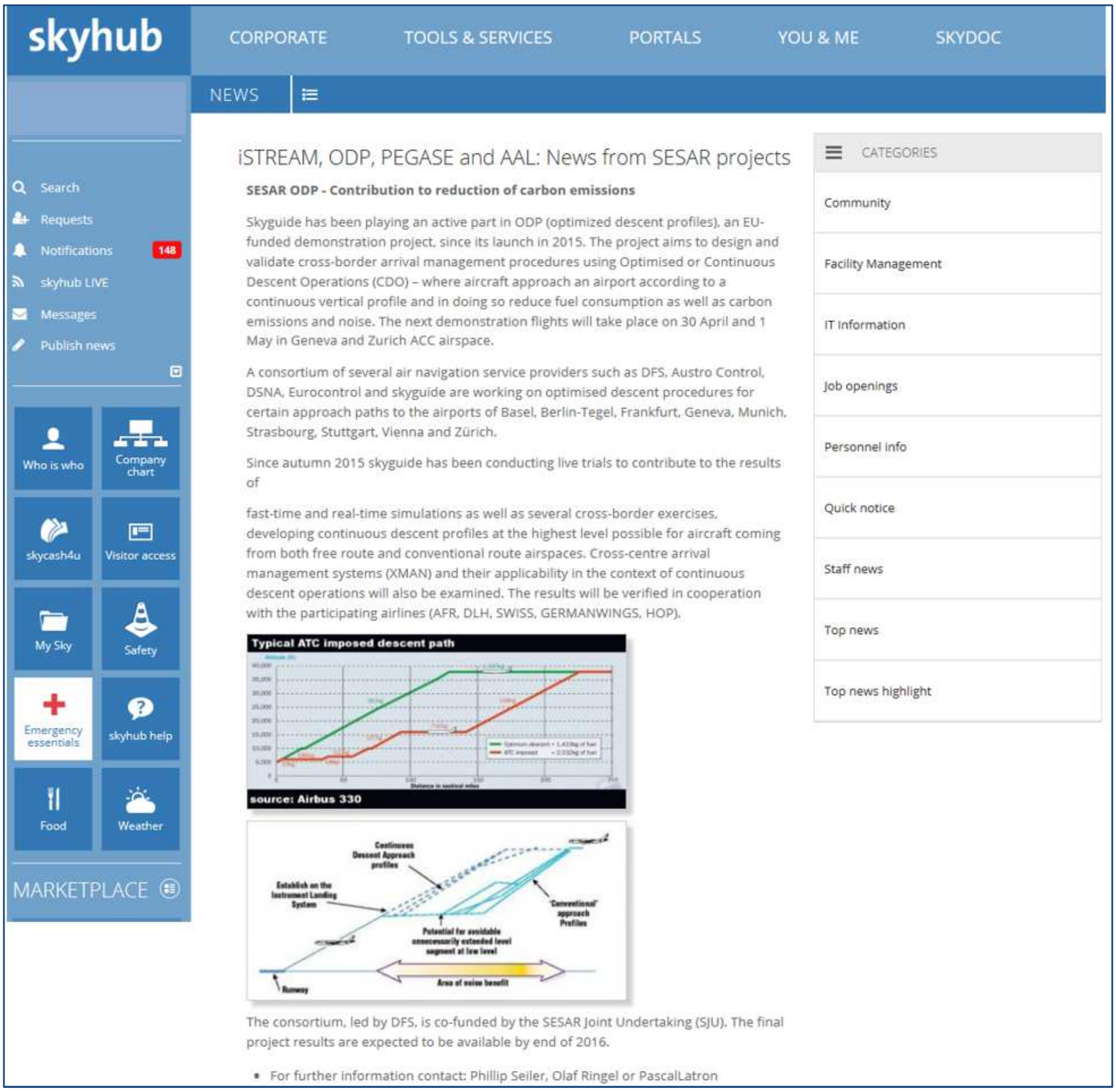
It was to ensure that the research and development of new concepts of this kind are pursued in a coordinated manner that Europe's Optimised Descent Profiles or ODP project was launched. The project, in which our own Operations Research team is substantially involved, seeks to determine how more flexible approaches could be adopted without reducing the capacity of the airspace concerned. To this end, the project partners are currently optimizing descents to Frankfurt, Munich, Vienna, Stuttgart, Berlin, Geneva and Zurich airports.

**SESAR projects at SWISS**

SESAR stands for Single European Sky Air Traffic Management Research. This joint initiative by the European Commission and Eurocontrol is intended to make Europe's air traffic management safer, more efficient and more sustainable.

In addition to ODP, SWISS is involved in two further SESAR projects: Free Solutions, which is meant to develop more direct routings for flights within Europe, and Enhanced Arrival Management (iStream), a continuation of the Strategic & Tactical Steering project that is designed to reduce the number of holding patterns flown by aircraft in our first Zurich morning arrival wave by optimizing the approach sequence.

*Figure 172: ODP article in Swiss staff magazine 04/2016*



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MARKETPLACE

iSTREAM, ODP, PEGASE and AAL: News from SESAR projects

**SESAR ODP - Contribution to reduction of carbon emissions**

Skyguide has been playing an active part in ODP (optimized descent profiles), an EU-funded demonstration project, since its launch in 2015. The project aims to design and validate cross-border arrival management procedures using Optimised or Continuous Descent Operations (CDO) – where aircraft approach an airport according to a continuous vertical profile and in doing so reduce fuel consumption as well as carbon emissions and noise. The next demonstration flights will take place on 30 April and 1 May in Geneva and Zurich ACC airspace.

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Since autumn 2015 skyguide has been conducting live trials to contribute to the results of

fast-time and real-time simulations as well as several cross-border exercises, developing continuous descent profiles at the highest level possible for aircraft coming from both free route and conventional route airspaces. Cross-centre arrival management systems (XMAN) and their applicability in the context of continuous descent operations will also be examined. The results will be verified in cooperation with the participating airlines (AFR, DLH, SWISS, GERMANWINGS, HOP).



The consortium, led by DFS, is co-funded by the SESAR Joint Undertaking (SJU). The final project results are expected to be available by end of 2016.

- For further information contact: Phillip Seiler, Olaf Ringel or PascalLatron

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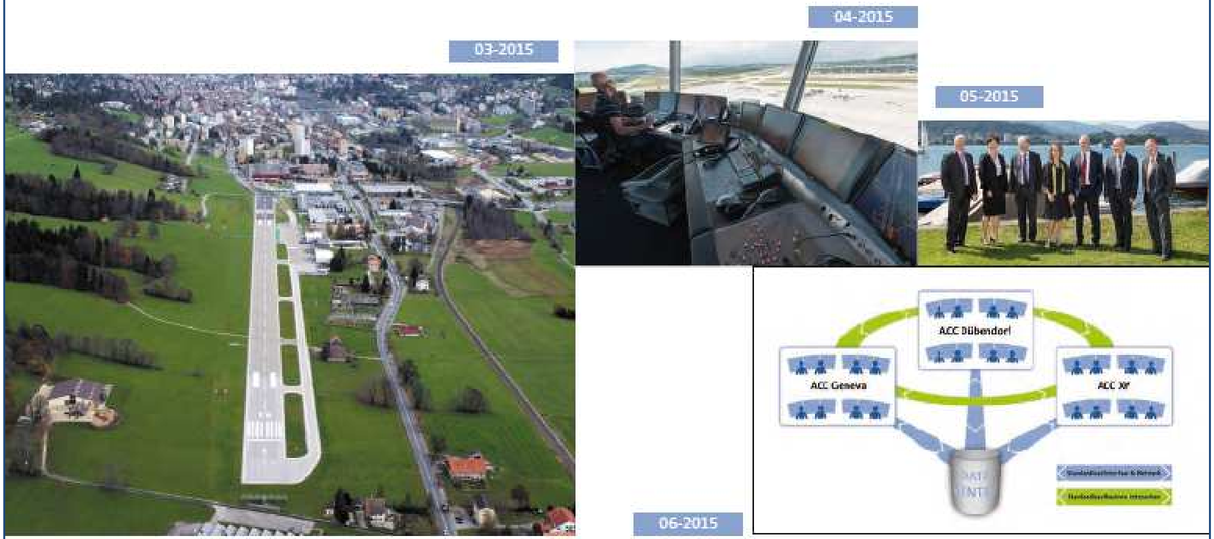
*Figure 173: Extract of publication on the skyguide intranet*




## 1.2 Highlights of 2015

**JANUARY**

**BMS transformation programme successfully concluded**

Thanks to the results achieved and the experiences gained, the "Business Model Skyguide" (BMS) programme is brought to an end earlier than envisaged. The BMS has enabled the company to position itself better in terms of its four performance dimensions of Safety, Capacity, Financial Efficiency and Sustainability, within an operating environment of constantly growing challenges.

**FEBRUARY**

**Stripless Switzerland Step 3 adopted at Geneva and Zurich**

The successful adoption of this subproject of the Virtual Centre programme helps further harmonize the technical infrastructures and the operating procedures at skyguide's Geneva and Zurich control centres. With its harmonized route management, its lateral route monitoring support and its new ability to pre-calculate flight tracks, the new system also helps further enhance both safety and capacity.

**MARCH**

**Satellite-based approach procedure for Les Eplatures Airport**

The satellite-based approach procedure for Les Eplatures Airport in Northwest Switzerland which has been jointly developed by skyguide, the Swiss Air Force, the airport operator and the Federal Office of Civil Aviation is trialled live during the STABANTE 15 armed and air force's exercise and validated for military air traffic. The system will subsequently be extended to civil air traffic in 2016 and highlights the innovative collaboration between Air Force and civil aviation.

**APRIL**

**New flight plan data system for Zurich Tower**

The new TRACE electronic flight plan data and coordination system is introduced to Zurich's tower operations. TRACE raises the efficiency of air traffic services and is a key element in airport operations. Various processes such as gate management, aircraft fuelling and apron services depend directly or indirectly on the new flight plan data system.

**SESAR live trial for ecofriendly descents**

As part of a consortium of European air navigation service providers and airlines, skyguide conducts trials to optimize the descents to Basel, Geneva and Zurich airports involving both Swiss and non-Swiss airspace. The research project, which is part of the overall SESAR programme, is intended to lessen the environmental impact of air transport operations without reducing capacity.

**MAY**

**New-look Board of Directors**

The Skyguide Board of Directors sees Walter T. Vogel take over as Chairman of the Board and Cristina Feistmann and Dominik Hänggi elected to its ranks. Previous Chairman Guy Emmenegger and further Board members Urs Sieber and Reto Hunger, who have all stepped down having reached the statutory term-of-office limit, are all thanked for their service at the General Meeting in Bern.

**JUNE**

**Copflex1: an operating concept for Virtual Centre Switzerland**

The leaders of the Virtual Centre programme present the operating concept for Phase 1 of its operation. Under the concept, the uppermost sectors of all skyguide airspace should be managed either separately or combined from either the Geneva or the Zurich centre. The approach should ensure the creation of two equally valid operating locations and also promote maximum harmonization of Switzerland's air traffic management services.

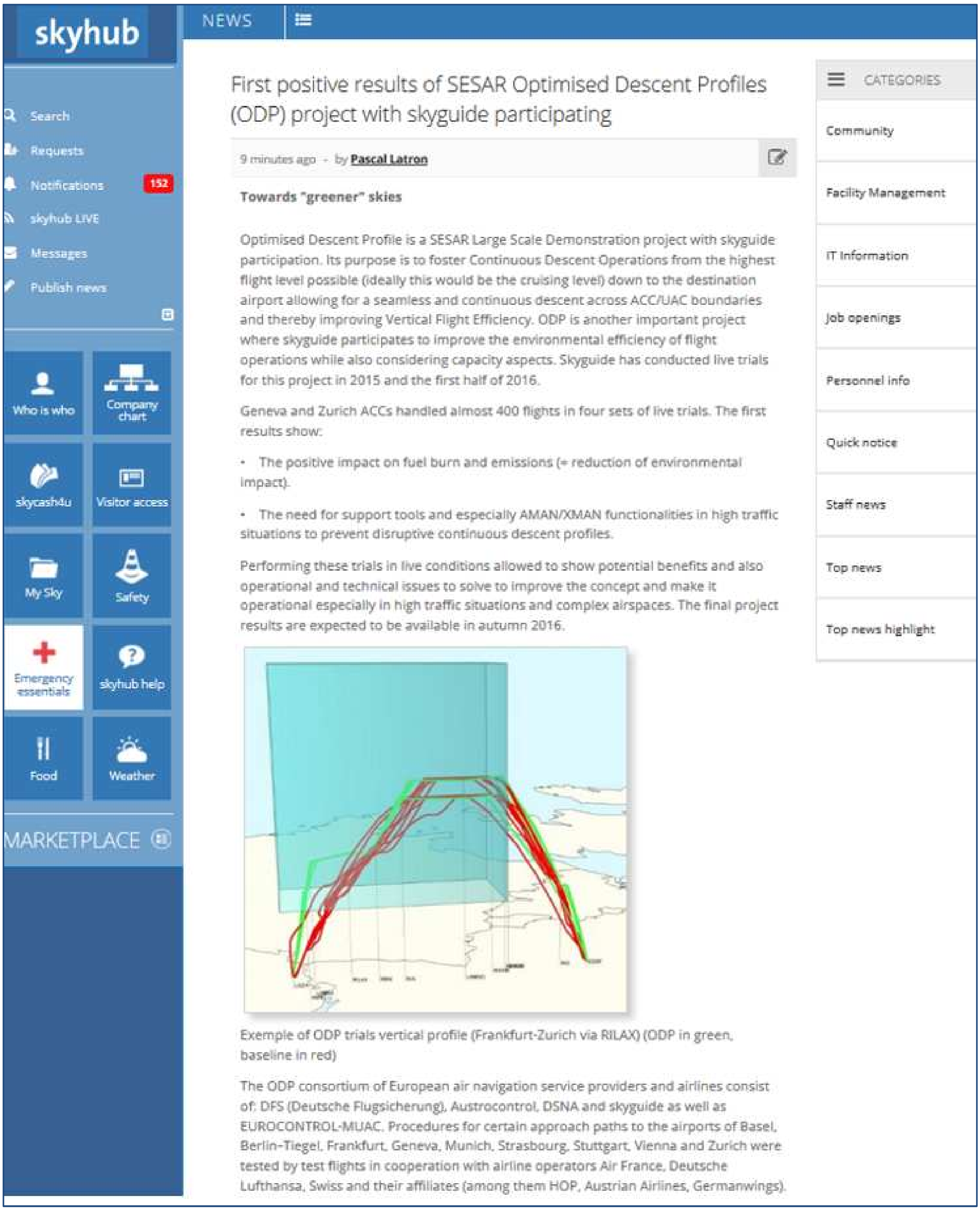
**JULY**

**Collaboration in a consortium for innovative ATM solutions**

Skyguide takes part in the "PEGASE" SESAR consortium, which is developing real-time projection capabilities through live trials. Providing a constant flow of information between flights and ATM on an aircraft's speed, weight and 4D trajectory will help enhance the accuracy of flight planning.

6

*Figure 174: Extract of publication in the skyguide Annual report 2015*



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MARKETPLACE

## First positive results of SESAR Optimised Descent Profiles (ODP) project with skyguide participating

9 minutes ago - by Pascal Latron

**Towards "greener" skies**

Optimised Descent Profile is a SESAR Large Scale Demonstration project with skyguide participation. Its purpose is to foster Continuous Descent Operations from the highest flight level possible (ideally this would be the cruising level) down to the destination airport allowing for a seamless and continuous descent across ACC/UAC boundaries and thereby improving Vertical Flight Efficiency. ODP is another important project where skyguide participates to improve the environmental efficiency of flight operations while also considering capacity aspects. Skyguide has conducted live trials for this project in 2015 and the first half of 2016.

Geneva and Zurich ACCs handled almost 400 flights in four sets of live trials. The first results show:

- The positive impact on fuel burn and emissions (= reduction of environmental impact).
- The need for support tools and especially AMAN/XMAN functionalities in high traffic situations to prevent disruptive continuous descent profiles.

Performing these trials in live conditions allowed to show potential benefits and also operational and technical issues to solve to improve the concept and make it operational especially in high traffic situations and complex airspaces. The final project results are expected to be available in autumn 2016.

Exemple of ODP trials vertical profile (Frankfurt-Zurich via RILAX) (ODP in green, baseline in red)

The ODP consortium of European air navigation service providers and airlines consist of: DFS (Deutsche Flugsicherung), Austrocontrol, DSNA and skyguide as well as EUROCONTROL-MUAC. Procedures for certain approach paths to the airports of Basel, Berlin-Tiegel, Frankfurt, Geneva, Munich, Strasbourg, Stuttgart, Vienna and Zurich were tested by test flights in cooperation with airline operators Air France, Deutsche Lufthansa, Swiss and their affiliates (among them HOP, Austrian Airlines, Germanwings).

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*Figure 175: Extract of publication on the skyguide intranet after trials*

# KEROZEN!

LA NEWSLETTER DU PLAN CARBURANT HOP!

#3 Juillet 2015

## ÉDITO

Le groupe KéroZen est en place depuis maintenant 6 mois. Il est constitué d'une petite équipe extrêmement motivée, réactive et à votre écoute (Courriels, Yammer...). Au cours de ces premiers mois, nous avons d'abord cherché à relancer les démarches existantes, notamment en communiquant largement, et, nous l'espérons, efficacement sur les « bons réflexes ». En parallèle nous avons lancé une démarche structurée et exhaustive de benchmark (AF, KLc, TO) et d'analyse des améliorations possibles. Certaines donnent déjà des résultats comme les améliorations de RPL (routes, niveaux) ou la possibilité de faire des NPA décélérées en bonnes conditions météo, d'autres seront rapidement visibles (Profils Cost Index CRJ, NADP ERJ, roulage monomoteur ATR). Quelques démarches nécessitent quant à elles plus de temps: indicateurs, améliorations des routes et des PVE, formation, modifications de procédures...

*« Le plus important, c'est vous car les principaux outils d'éco-pilotage existent déjà ! ».*

La création d'outils d'éco-pilotage et l'exploration de nouvelles pistes d'amélioration est un travail d'équipe, entre l'équipe KéroZen et vous. Utilisez-les chaque fois que cela est possible: de la préparation du vol à l'arrivée au parking, en passant par toutes les phases de sol et de vol. Bonne lecture.

L'équipe KéroZen /
kerozen@hop.fr

## LE SAVIEZ-VOUS ?

**CONSOMMATION MOYENNE DE LA FLOTTE HOP!**
(2014-2015)

**5,3 L / 100 KM**
Par passager transporté*
(contre 5.6 L en 2013-2014)
*Une amélioration liée à un meilleur remplissage et une baisse de la part des Jets 50 sièges

**COEFFICIENT DE TRANSPORT**
**2,5 % / HEURE DE VOL** pour les jets
**1,5 % / HEURE DE VOL** pour les ATR

**TAUX DE DÉGAGEMENT NON PRÉVU À DESTINATION**
= 0,007 %
moins de 10/an pour tout HOP!

## L'ACTU DU MOIS

FABEC dgac DSNA SESAR DEPLOYMENT MANAGER

# HOP! ET L'ATC UNE COLLABORATION EFFICACE

La bonne collaboration avec les différents contrôles aériens est un atout essentiel pour permettre d'améliorer l'efficacité de nos 150 000 vols annuels. De nombreux contacts avec les centres de navigation aérienne ou avec les différents programmes dont HOP! est partenaire (le projet européen SESAR...) ont été entrepris. Souvent méconnu, ce travail de collaboration est essentiel pour obtenir des résultats concrets. Prenons l'exemple de la ligne Nantes-Amsterdam où l'ATC impose des restrictions de niveaux en été. Après intervention auprès de la Direction des Services de la Navigation Aérienne (DSNA), nous avons finalement pu obtenir le FL340 (vs FL300) en programmé (avec possibilité de monter plus haut en tactique). D'autres exemples existent. Entre Paris-CDG et Stuttgart, les contrôleurs aériens français et allemands nous ont proposé une nouvelle trajectoire plus courte de 66 Nm. Sans la forte implication des contrôleurs qui essayent d'optimiser les vols, (parfois suite à la pression des demandes PNT!), nous n'aurions pas pu constater ces économies concrètes et immédiates de plus de 30 kg de fuel et 100 kg de $CO_2$ non émis dans l'atmosphère sur chacun de ces vols.

Nous ne pouvons que nous réjouir du résultat de cette étroite collaboration entre les services de la DSNA et HOP! Les mesures prises aujourd'hui sont le fruit d'une coopération efficace, permettant de parvenir à un compromis satisfaisant pour HOP! en matière de consommation carburant, tout en permettant aux centres de contrôle d'assurer pleinement leur mission de sécurité.

Figure 176: Publication of HOP! in July 2015

**The Good Life**

PAYS : France
PAGE(S) : 152;154
SURFACE : 142 %
PERIODICITE : Trimestriel
DIFFUSION : 50265

► 1 février 2016 - N°22

THE GOOD SPEED

Europe

## Prêts pour le « vrai » décollage du ciel unique ?

Vingt ans déjà que la construction du ciel unique – un vaste territoire aérien de 1,7 million de kilomètres carrés – promet de prendre son envol... pour tomber finalement en panne sur la piste des belles idées non applicables. Mais cette fois, le temps presse pour faire de l'aviation un puissant moteur de croissance économique, et la Commission européenne annonce le déploiement d'un arsenal réglementaire et technologique propre à venir à bout – au mieux dès 2025 – des divers obstacles et réticences.

*Par Laura Cordin*
ILLUSTRATIONS : *Ariel Martín Pérez*

**A peine venait-elle d'apprendre** sa nomination, en octobre 2014, que la commissaire européenne slovène Violeta Bulc usait de son franc-parler pour réactiver le processus en panne : *« Il faut en faire plus pour mener à bien cette réforme du ciel unique ! »* En faire plus pour imposer les « FAB », ces blocs d'espaces aériens fonctionnels restés plus ou moins en friche depuis leur création, en 2004. Leur mission est de fusionner les couloirs aériens nationaux des Etats membres, afin de raccourcir les itinéraires de vol par le choix de trajectoires plus directes (ignorant les frontières géographiques des pays traversés) et donc moins polluantes et moins coûteuses. En faire plus, pour mettre fin aux pratiques déloyales des compagnies du Golfe, perfusées par des subventions étatiques – 42 milliards de dollars, de source américaine –, dont ne peuvent bénéficier leurs rivales européennes. En faire plus en matière de sécurité et de contrôle aériens, rétif à la complexité d'un défi technologique dont il ne pourra sans doute plus se détourner dans les années à venir, tant la pression est forte pour mutualiser les divers systèmes nationaux, afin d'optimiser la gestion de cette fourmilière d'avions toujours plus grouillante dans les airs comme au sol. En faire plus, surtout, pour qu'on en finisse avec les concepts et passer à l'acte. Cela est d'autant plus urgent que le secteur aérien est un formidable pôle de croissance, avec près de 2 millions d'employés dans l'Union européenne et une contribution à son économie à hauteur de 110 milliards d'euros. Des chiffres cependant atrophiés par l'actuelle gestion éclatée de ce secteur. *« La productivité du contrôle aérien est deux fois supérieure aux Etats-Unis qu'en Europe,* observe Laurent Renou, responsable « Air Trafic Management », en charge du projet Sesar (Single European Sky Air traffic management Research) à la direction générale des opérations aériennes d'Air France. A l'origine de ce *gap*, identifié dès les années 90 : le morcellement de l'espace européen en 35 Etats... et autant d'organismes nationaux agissant indépendamment les uns des autres, quand une seule et même Administration fédérale de l'aviation (FAA) coiffe l'ensemble du trafic aérien américain de son unique autorité régulatrice. Une telle fragmentation de l'espace entraîne chaque année un surcoût d'environ 5 milliards d'euros. *« Les zigzags dans le ciel allongent les vols de 50 km en moyenne ! »* rappelle Violeta Bulc.

### Faire bloc et parler d'une seule voix

L'absence de fusion des systèmes nationaux s'enracine dans la vraie difficulté, pour la Commission européenne, d'imposer ses règles supranationales en les substituant à celle des Etats, qui ne sont pour l'instant pas prêts à abandonner leur souveraineté et encore moins à se passer des redevances qu'ils perçoivent à chaque survol de leur territoire. Pas plus qu'ils ne sont enclins, pour nombre d'entre eux, à tirer un trait sur des accords bilatéraux ou à faire taire leurs différends, à l'instar de cette querelle territoriale à propos de Gibraltar, qui oppose l'Espagne au Royaume-Uni, et qui, de l'avis des députés ▪

**La révolution du contôle aérien**

Quatre compagnies aériennes, 25 exploitants d'aéroports et 11 contrôleurs aériens sont unis au cœur de Sesar (Single European Sky Air traffic management Research), l'entreprise commune de recherche dédiée à la modernisation et à la fusion des 28 systèmes de contrôle aérien nationaux. Mission : faire basculer le trafic aérien dans l'ère numérique pour rentabiliser les nouvelles routes aériennes et optimiser la gestion du trafic au sol. *« Aujourd'hui, les échanges de données entre les avions et les systèmes de contrôle aérien sont limités,* explique Laurent Renou, responsable du projet Sesar au sein d'Air France. *Demain, ces échanges seront enrichis de la prédiction de la trajectoire afin d'optimiser le vol en lui offrant des routes plus directes et d'améliorer la connaissance de la trajectoire de chaque vol pour que le contrôle aérien puisse anticiper les conflits éventuels. »* Un vrai séisme pour le milieu ultraconservateur des contrôleurs aériens.

- **Investissement** : de 10 à 30 Mds € d'ici à 2030, tant ce grand chantier repose sur un arsenal de routeurs, logiciels et systèmes embarqués.
- **Impacts dans le viseur de Sesar** : 419 Mds € supplémentaires pour le PIB de l'UE ; 328 000 emplois créés ; 50 M de tonnes de CO2 en moins.

*Figure 177: Article in 'The Good Life'*

# Appendix C ODP Questionnaires

The following Questionnaires have been used during or after the ODP trials in order to document the results and feedback of the operational personnel.

# Questionnaire Austrocontrol

## SJU ODP ZZZZ - ATCO Feedback

This questionnaire is aimed at assessing the effects of CDO procedures on ATCOs´ workload in live traffic.
All your answers will be treated strictly confidentially.

Please answer the following questions with reference to your last run working with CDO, your sector and your working position!
Please tick only one answer per question!

Thank you very much for your contribution!

*Sector:* ____________________

*Working Position:* O EC O PLC

*Time in Position from - to (UTC):* ____________________

*Date:* ____________________

| 1 | Traffic Density | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.1 | Please rate the traffic density in your sector: | very low O | O | O | O | O | very high O |

| 2 | Traffic Complexity | | | | | | |
|---|---|---|---|---|---|---|---|
| 2.1 | Please rate the traffic complexity in your sector: | very low O | O | O | O | O | very high O |
| 2.2 | Which effect did the execution of CDO have on the traffic complexity? | high decrease O | O | O | O | O | high increase O |

| 3 | Workload | | | | | | |
|---|---|---|---|---|---|---|---|
| 3.1 | Please rate the overall workload at your working position: | very low O | O | O | O | O | very high O |
| 3.2 | Which effect did the execution of CDO have on the workload? | high decrease O | O | O | O | O | high increase O |

| 4 | Situational Awareness | | | | | | |
|---|---|---|---|---|---|---|---|
| 4.1 | Which effect did the execution of CDO have on your situational awareness? | high decrease O | O | O | O | O | high increase O |
| 4.2 | Was there any risk of losing your situational awareness at any time? | O yes | | O no | | | |

| 5 | Mental Demand | | | | | | |
|---|---|---|---|---|---|---|---|
| 5.1 | How mentally demanding were your ATCO tasks? | very little O | O | O | O | O | very much O |

WORKLOAD EVALUATION ATCO SJU ODP ZZZZ FO ATM ENRO XYZ V1.0

# Questionnaire Swiss

# ODP - PILOT QUESTIONNAIRE

The objectives of this questionnaire: -learn about your experience with regards to the descent trial via RILAX
-collect opinions to help us develop new descent profiles & policies

After EVERY descent via RILAX the pilot flying (PF) is kindly asked to fill in the questionnaire (2pages!)
Please send it back to Operations Research (ZRHLX/OER/HITH) or leave it at dispatch.

Note: All feedback will be treated confidentially!

The PF on this flight was: ☐ PiC / ☐ Co-Pilot

| | |
|---|---|
| Date: | Type of aircraft: |
| Routing via: ☐IBINI – RILAX / ☐EMKIL – RILAX | Last Cruise-Flight Level before TOD: |

☐ This was my 1st descent via RILAX during the trial week acting as PF
☐ This was my 2nd, 3rd, 4th, ....time

## ALL pilots (AVRO & AIRBUS):

| | | |
|---|---|---|
| 1 | Who initiated descent to leave cruise-flight level? | ☐ ATC ("descend to").<br>☐ Pilot ("requesting descent") |
| 1a | If ATC initiated descent:<br>How much "too early" compared to your own descent planning were you asked to leave cruise-FL?<br>(approximate answer) | ☐ less than 2minutes prior Pilot's TOD (<15nm)<br>☐ 2 to 5minutes prior Pilot's TOD (~15 – 35nm)<br>☐ more than 5minutes prior Pilot's TOD (>35nm) |
| 1b | If Pilots initiated the request for descent: | ☐ it was according to the FMS calculated TOD<br>☐ it was before the FMS calculated TOD<br>☐ it was after the FMS calculated TOD |
| 2 | If descent was NOT requested according FMS TOD: | ☐ descent was initiated earlier for smoother transition to descent phase (less initial ROD)<br>☐ descent was initiated earlier/later because of unreliable FMS predictions<br>☐ no FMS TOD calculation available |
| 3 | How did you deal with "Descent Planning Information" (e.g. 20NM to SUL expect FL250): | ☐ I put it in the FMS as constraint to optimise FMS descent profile calculation<br>☐ I considered it for my own descent planning without putting it in the FMS<br>☐ I disregarded it |
| 4 | "Descent Planning Information" is: | ☐ generally useful information improving profile anticipation because it is based on standard ATC procedures and experience<br>☐ superfluous information because it doesn't constitute restrictions I have to comply with |

1/2 -turn page-

## AIRBUS –pilots only:

| | | |
|---|---|---|
| 5 | On this descent I was able to use "Managed Descent Mode" | ☐ YES, for the whole descent from TOD to RILAX<br>☐ partially, for some segments of the profile<br>☐ NO |
| 5a | If "Managed Descent Mode" was NOT used for the whole descent between TOD and RILAX, it was | ☐ because ATC assigned speed (speed intervention)<br>☐ because ATC didn't provide continuous descent (intermediate level-off for separation or handover)<br>☐ because I was navigating in HDG-mode (ATC/WX)<br>☐ because I preferred to use conventional modes (V/S, Open Descent)<br>☐ other: |
| 6 | When all expected ATC-restrictions are in the FMS, it calculates an optimised and realistic descent profile? | ☐ YES, I agree<br>☐ NO, I disagree |
| 7 | "Managed Descent Mode" | ☐ is a good tool if all restrictions are known to the FMS before TOD<br>☐ is too much of a "black-box" to be trusted / used<br>☐ other: |
| 8 | If a full CDO (continuous descent operations)-profile was coded in the FMS and ATC cleared me for it | ☐ I would use "managed descent mode" to follow the profile<br>☐ I would use conventional descent modes (V/S, Open Descent) to follow the profile |
| 9 | If ATC would clear my flight on a lateral & vertical profile to the final level of a STAR (e.g. "descend via BLM 2G-arrival to 7'000ft") | ☐ I would like to set ATC-cleared altitude on the FCU and comply with intermediate constraints by monitoring descent (OMA change required)<br>☐ I would still prefer to set every intermediate constraint altitude on the FCU during descent |
| 10 | The use of ALT CSTR mode (ALT CSTR magenta) | ☐ is useful as long as the FCU-altitude is set above safe altitude (MGA, MSA)<br>☐ is difficult to monitor and shall therefore not be used<br>☐ other: |

### ADDITIONAL REMARKS

| |
|---|
| |

***Thanks for your help!***

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The ODP project addressed this issue at manufacturer level for future solutions.

# Appendix D Not covered but worth "looking into-flows"

Within the ODP project, the partners found several other cross-border flows which are worthwhile for further investigation outside of the ODP project. Details can be found in Table 12: Overview of complete ODP Demonstration activities.

Specific leads for new study and improvement have been identified per flow. Promising flows are summed up in the following table. If the flow was or will be implemented than the column "promising flow" is filled in as n/a.

| Exercise Title / Airport | Demonstration ID | Permanent implementation | Promising flow |
|---|---|---|---|
| Bale-Mulhouse (LFSB/BSL) | DEM-001-01 | Y | n/a |
| Frankfurt (EDDF/FRA) | DEM-002-01 | N | Yes, see DEM-02-02 |
| | DEM-002-02 | Y | After Demo Trails in DEM-002-01 this flow will be implemented WEF 13OCT16 |
| | DEM-002-03 | Y | n/a |
| | DEM-002-04 | Y | n/a |
| | DEM-002-05 | Y | Will be implemented at a later stage, planned 5JAN17 |
| | DEM-002-06 | N | Not promising in this constellation of airspace |
| | DEM-002-07 | Y | On weekends, it is already without level cap. Further improvement possible. |
| | DEM-002-08 | Y | n/a |
| | DEM-002-09 | N | n/a, FTS only |
| | DEM-002-10 | N | Not promising in short term |
| Geneva (LSGG/GVA) | DEM-003-01 | N | CDO is not possible for the time being but an optimised profile according EFL desirable and should be subject to future agreements with adjacent units |
| Munich (EDDM/MUC) | DEM-004-01 | Y | n/a |
| | DEM-004-02 | Y | Will come WEG 2FEB17 |
| | DEM-004-03 | Y | n/a |
| | DEM-004-04 | Y | n/a |

| Exercise Title / Airport | Demonstration ID | Permanent implementation | Promising flow |
|---|---|---|---|
| | DEM-004-05 | N | Negotiations after cross-border free route airspace initiative between Slovenia Control and Austro Control (ACG) WEF AIRAC 10 NOV 2016 can start between DFS and ACG |
| | DEM-004-06 | Y | n/a |
| Strasbourg (LFST/SXB) | DEM-005-01 | N | Does not make sense because this “small” frequented flow (4 flights) would affect “big” flows. |
| | DEM-005-02 | N | To be further investigated by DSNA and Strasbourg APP |
| Stuttgart (EDDS/STR) | DEM-006-01 | N | Must be further investigated by skyguide |
| | DEM-006-02 | N | Must be further investigated by skyguide, e.g. possible improvements during MIL OFF |
| | DEM-006-03 | N | Is already implemented by LoA. ODP project does not count it because DSNA sees this flow as a FABEC VFE improvement. |
| Vienna (LOWW/VIE | DEM-007-01 | Y | n/a |
| | DEM-007-02 | Y | n/a |
| Zurich (LSZH/ZRH) | DEM-008-01 | Y | n/a |
| | DEM-008-02 | N | • During MIL OFF the ODP trial procedure (GUDAX FL260-280) is possible and desirable for AO's (an adaption of the LoA is recommended/required concerning LSGG departures via KORED)<br>• A "silent handover at EFL250" to ZRH WEST should be possible as flights are laterally separated from LSGG departures inbound KORED (subject to further investigation) |
| | DEM-008-03 | Y | n/a |
| | DEM-008-04 | N | AMAN/XMAN should prevent additional speed request and |

| Exercise Title / Airport | Demonstration ID | Permanent implementation | Promising flow |
|---|---|---|---|
| | | | unnecessary holding instructions.<br>A descent window (constraint e.g. FL130-150) overhead IBINI/EMKIL (LoR) and a speed constraint would be helpful to "smoothen" the descent profile (change of LoA between LANGEN/LANGEN LOW and ZRH) |
| Berlin-Tegel (EDDT/TXL) | DEM-009-01 | Y | n/a |
| | DEM-009-02 | Y | n/a |
| | DEM-009-03 | Y | n/a |
| | DEM-009-04 | Y | n/a |
| **Total numbers** | **33** | **17** | **8** |

*Table 41: Promising flows*

## Not part of ODP but a promising Cross-border CDO for LSZH via AMIKI

The ODP project identified a possible improvement which was not part of the Demonstration Plan for arrivals to Zurich via AMIKI which can be further investigated after the project. The following information will show the content and benefits of this profile.


*Figure 178: promising cross-border CDO for LSZH via AMIKI*


*Figure 179: Content of the possible CDO for LSZH via AMIKI*

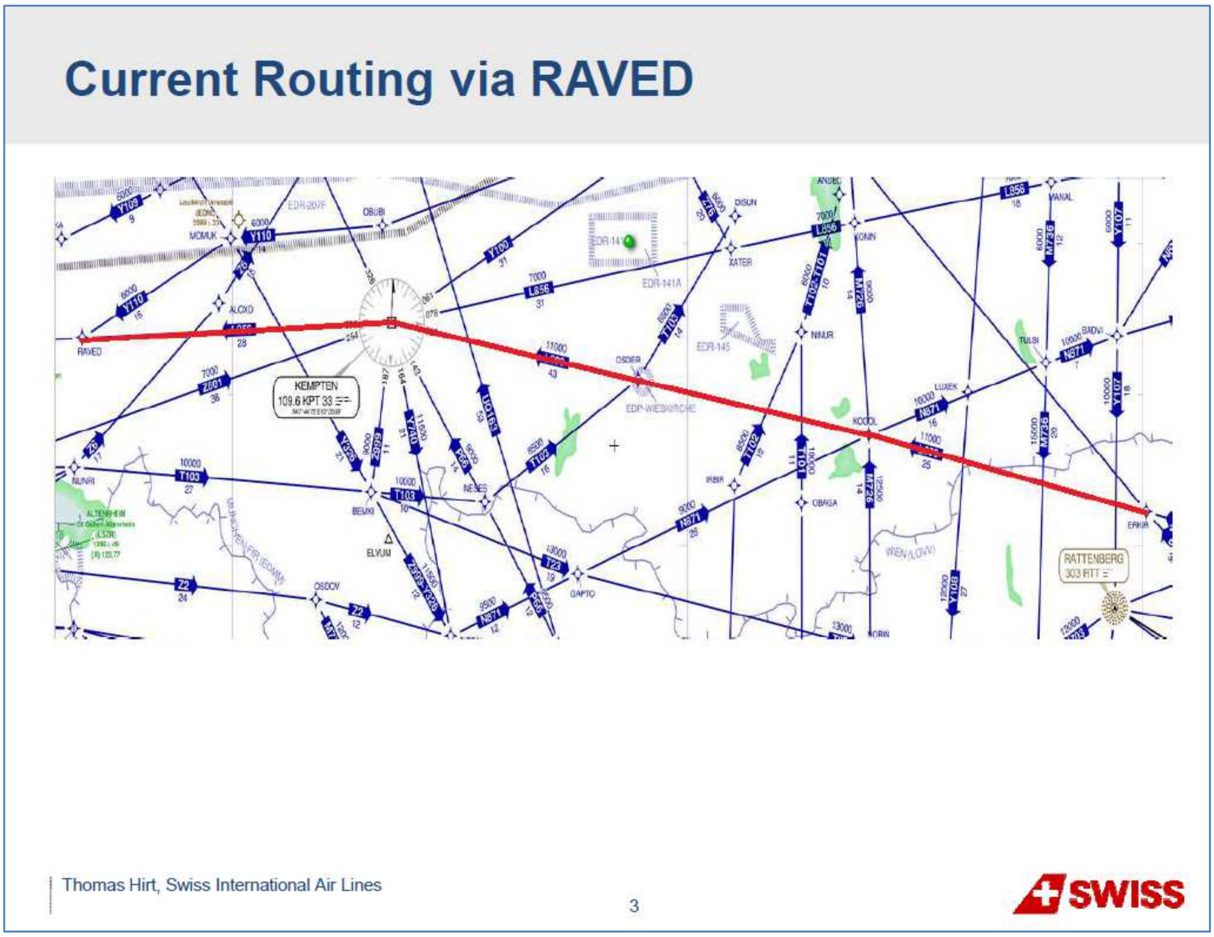


*Figure 180: routing via RAVED for CDO LSZH via AMIKI*

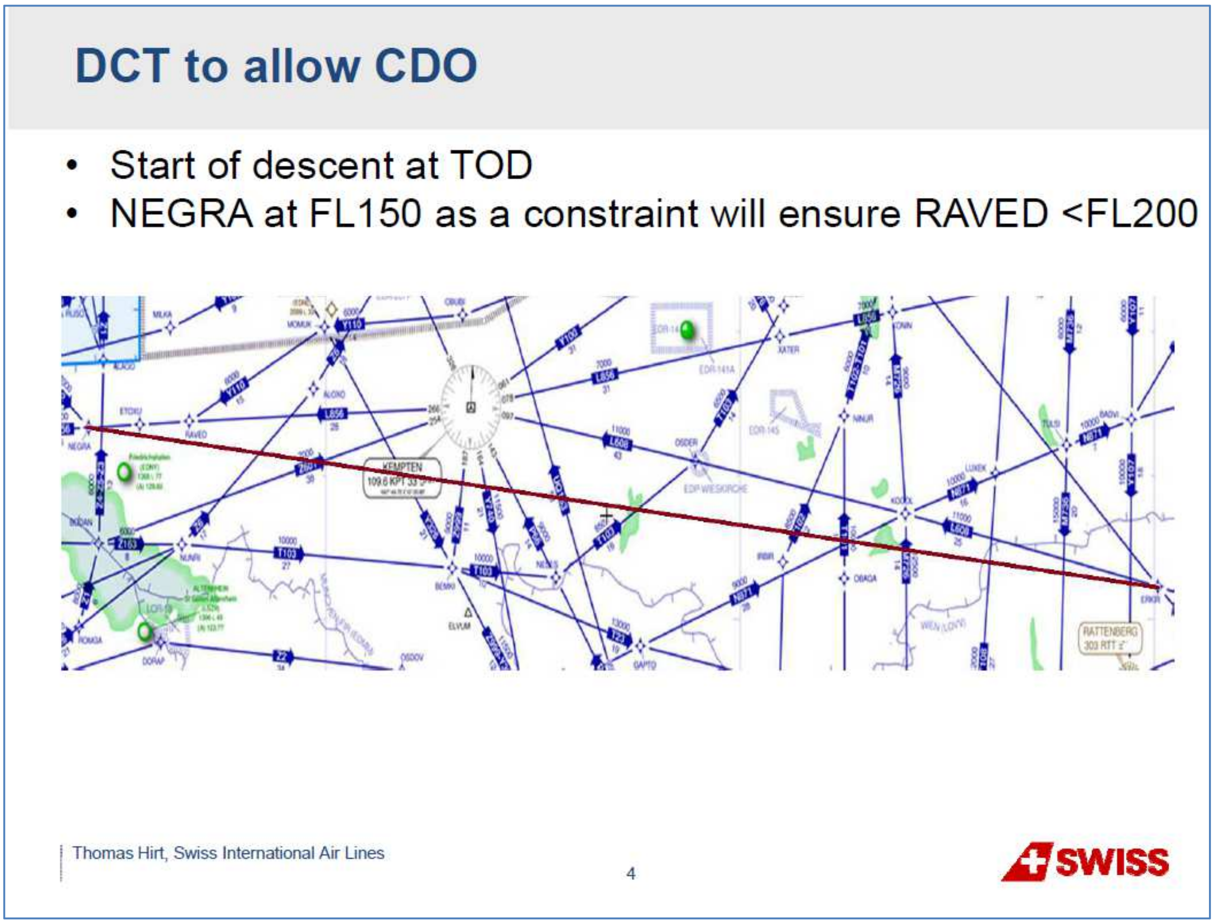


*Figure 181: DCT in CDO for CDO LSZH via AMIKI*

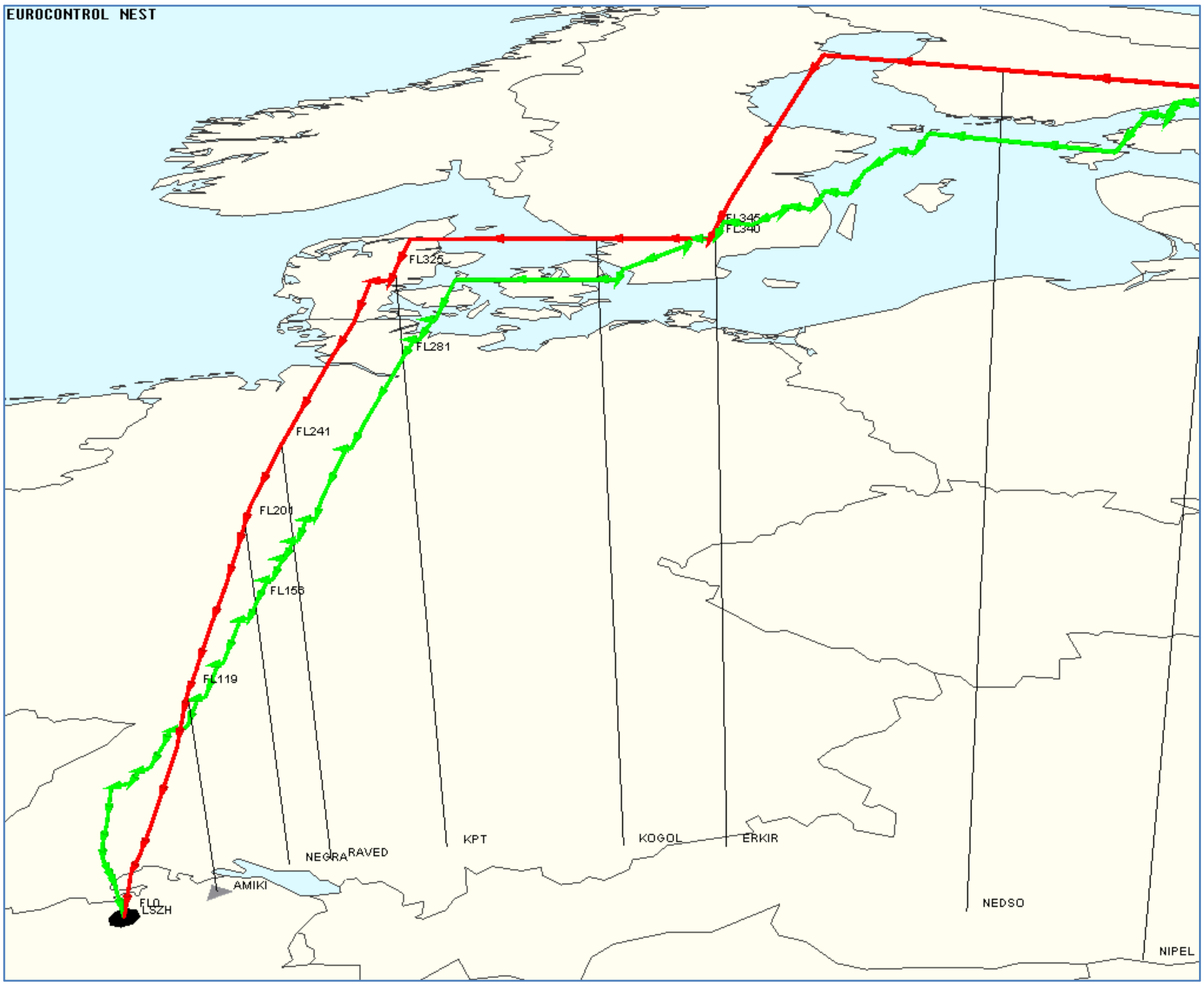


*Figure 182: 3D view of LSZH ARR via KPT – AMIKI (red = initial, green = actual track), Source: SAAM NEST*

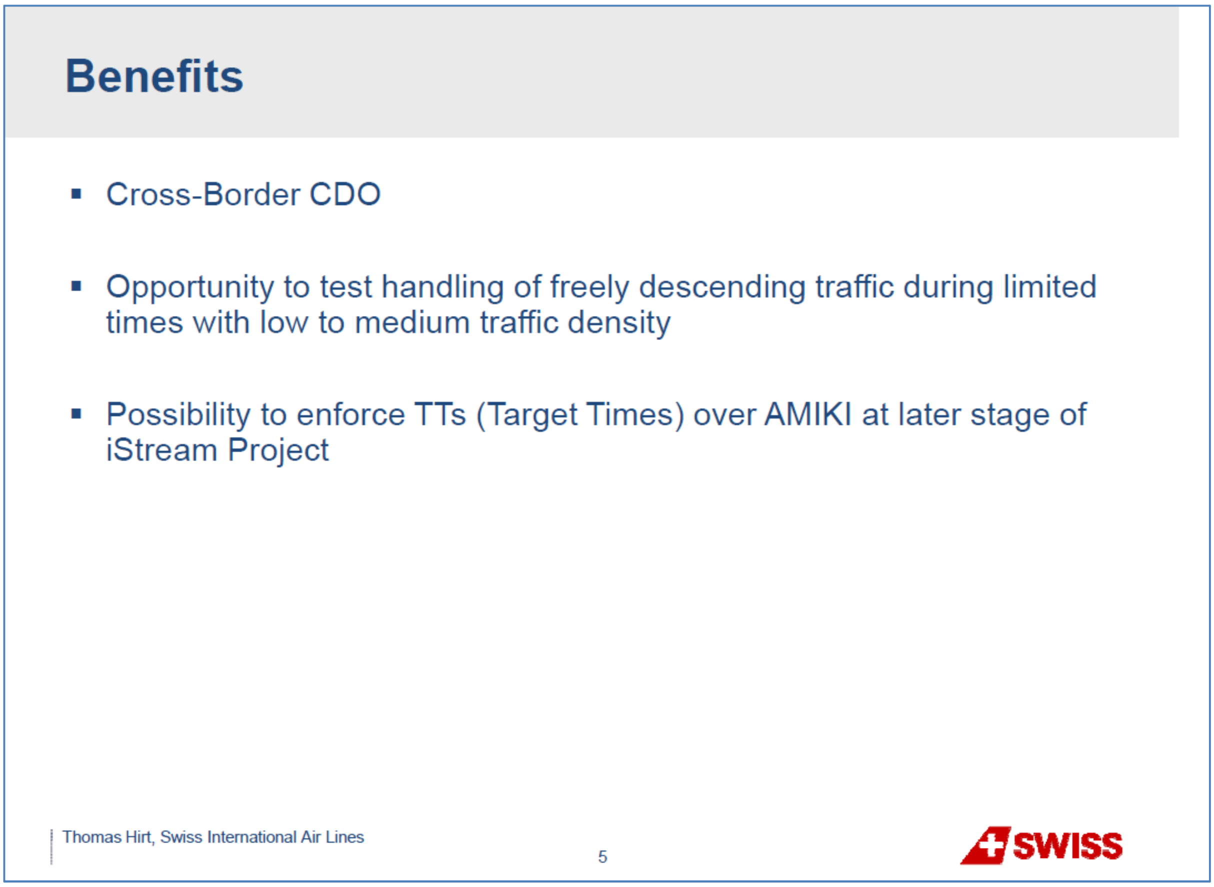


*Figure 183: Benefits of LSZH CDO via AMIKI*

Of course, there is no guarantee to implement such a flow via AMIKI since there are good reasons supporting the system as it is today. Nevertheless it is worthwhile for further investigation. Since the target aerodrome is in Switzerland, skyguide should take further actions on this flow. Concerned ANSPs are Austro Control, DFS and skyguide.

**-END OF DOCUMENT-**