Demonstration Report

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Abstract

BUDAPEST 2.0 project aimed at showing that SESAR solutions can improve operational efficiency at small and medium-sized airports. The solutions include Remote Tower Services (which aims at increasing ATCO's situational awareness, improving capacity and cost effectiveness), Required Navigation Performance (RNP), use of on-board systems to define automated flight paths, and aiming to an enhanced performance in terms of environment, safety and costs; and CDO Enhancement Tool, which helps air traffic controllers to better sequence arrivals and departures, particularly for continuous descent operations, which will lower the costs related to fuel and, thus, an environmental impact.

This document presents the results of the demonstrations performed in the framework of BUDAPEST 2.0.

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Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

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Executive summary

This document is the deliverable D3: Demonstration Report of the Project BUDAPEST2.0 (LSD 02.10). It contains information on the execution of the exercises planned on the document D2: Demonstration Plan (2nd Release). The information provided in this document includes:

- Overview of the management organisation
- Exercise preparation information
- Exercise execution detail, including deviations from the demonstration plan
- Summary of communication activities
- Conclusions and recommendations

BUDAPEST2.0 aims at demonstrating a set of solutions and concepts of operations for Small/Medium Size Airport users and stakeholders such as:

- **CDO enhancement tool** that supports ATCO on the sequencing of arrivals and departures, in particular for handling the implementation of Continuous Descend Operations (CDO) in Terminal Manoeuvring Area (TMA). The tool builds on, and can be considered as an extension of Point Merge concept developed by EUROCONTROL, providing simple and intuitive Distance-To-Go (DTG) information and separation alerts between arriving aircrafts to controllers.
- **Required Navigation Performance (RNP)** is a type of Performance Based Navigation (PBN) that allows an aircraft to fly a specific path between two 3D-defined points in space. RNP operations are defined based on the existence of an on-board performance monitoring and alerting system, and can contribute mainly to Enhanced Terminal Airspace operations.
- **Remote Tower** is a new concept where the air traffic service (ATS) at an airport is performed somewhere else than in the local control tower. As such, the Air Traffic Control Officer (ATCO) will be re-located to a Remote Concept Centre from where they will provide the ATS.

In order to demonstrate the aforementioned solutions, BUDAPEST2.0 consortium is formed by the following companies:

- **Pildo Labs**: leader of the project, responsible for the project management, analysis of the data recorded during the implementation of the CDO Enhancement Tool and design and validation of the RNP APCH procedures to Budapest Airport.
- **HungaroControl**: responsible for the design and implementation of the T-bar procedures and Remote Tower concept.
- **WizzAir**: responsible for flying the CDO operations in Budapest and for providing the corresponding data.
- **JetStream**: responsible for performing the validation flights of the RNP APCH procedures in Budapest Airport.
- **Slot Consulting**: responsible for analysing the data from the implementation of the Remote Tower solution and the CDO Enhancement Tool.
- **UPC**: support to the assessment of the FDR data provided by WizzAir and to the generation of the showroom in cooperation with Pildo Labs.

The project has been successfully executed and the main conclusions of the exercises are the following:

- CDO operations can be effectively supported with the appropriate procedural and software tools. Positive impacts were observed both on safety, environment and even cost-efficiency related aspects of CDO.
- For a significant improvement in CDO performance, full airspace and procedure reconfiguration, proper training for pilots and ATCOS are inevitable, and suitable software is a great advantage.

- The RNP APCH procedures to the four runway ends of Budapest Airport have been successfully designed, validated and implemented.
- Regarding Remote Tower, the current level of technology is generally capable of providing the background for safe ATS service provision. However, to secure the continuous and safe operation from a remote tower facility, the visualization needs to be carefully fine tuned to the local environment and to the well-defined concept of operations.
- The importance of human factor aspects of the Remote Tower solution has been confirmed. The change of visualisation is big enough on its own to put the focus on the human factors in the system, but in an operational environment where several ATCOs work together as a team and rely on the video images, it gains special importance.
- The implementation of the Remote Tower concept in medium size airports has other motivations than that of small airports which shifts emphasis from pure cost-efficiency motives to capacity considerations.

1 Introduction

1.1 Purpose of the document

This document is the **deliverable D3: Demonstration Report.**

This document provides the Demonstration report for BUDAPEST 2.0 project. It describes the results of demonstration exercises defined in **Deliverables D1 and D2** and how they have been conducted.

1.2 Intended readership

The SESAR Joint Undertaking (SJU) and, particularly the SJU's points of contact and SESAR Large Scale Demonstrations leaders and reviewers assigned to BUDAPEST 2.0 project shall find this document particularly interesting as it provides an accurate description of the demonstration exercises execution.

Secondly, this document could be used by all members of the project as it contains clear description of all the technical and operational concepts, details and tools used during the project.

The results presented in this document might be of particular interest for Budapest Airport managers in order to see the benefits of implementing SESAR solutions, as well as other Hungarian Airports managers, and it might be the reference material for those airports interested in the implementation of any of the proposed solutions addressed in BUDAPEST2.0 Project.

In addition to that, OFA [6] leaders, especially those from the OFAs addressed during the Project (02.01.02, 02.02.01, 02.01.01, 02.02.04, 06.03.01) should be particularly interested in the results presented in this document. They might be an useful input for the abovementioned OFAs meetings.

Finally, the document might provide remarkable inputs to other projects dealing with CDOs Implementation, PBN Implementation or Remote Towers Implementation.

1.3 Structure of the document

The document is organised as follows:

- Section 1 is the introduction to the document;
- Section 2 presents how this project and the demonstrations are related to the SESAR programme and the near-future objectives of different stakeholders;
- Section 3 explains the programme management;
- Section 4 provides general information regarding the execution of the exercises;
- Section 5 contains an overview of the most relevant results regarding the execution of all the exercises;
- Section 6 includes all the demonstration exercises reports, mostly referencing each exercise end report;
- Section 7 is the summary of the project's communication activities carried out in the frame of the project:
- Section 8 provides the conclusions and recommendations based on the obtained results;
- Section 9 includes the applicable and reference documents;

1.4 Glossary of terms

APV – Approach Procedure with Vertical guidance. This term is used for RNP APCH Operations that include vertical guidance. That is, those flown to LNAV/VNAV or LPV minima. It does not meet the requirements established for precision approach and landing operations.

Official description extracted from ICAO (2005), Annex 2, Rules of the Air.

CDO – Continuous Descent Operation: An operation, enabled by airspace design, procedure design and ATC facilitation, in which an arriving aircraft descends continuously, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the final approach fix/final approach point.

Note 1 – An optimum CDO starts from the top of descent and uses descent profiles that reduce segments of level flight, noise, fuel burn, emissions and controller/pilot communications, while increasing predictability to pilots and controllers and flight stability.

Note 2 – CDO initiated from the highest possible level in the en-route or arrival phases of flight will achieve the maximum reduction in fuel burn, noise and emissions.
Definition extracted from ICAO (2010) Doc 9931, Continuous Descent Operations (CDO) Manual

LNAV – Lateral Navigation; the minima line to be flown on aircraft with no VNAV approach. LNAV approval is according to AMC 20-27.

Official definition extracted from ICAO AC No: 008A-APV

LNAV/VNAV – The minima line to be flown if the aircraft has an approved Baro/VNAV system, approved according to AMC 20-27.

Official definition extracted from ICAO AC No: 008A-APV

LPV – Localizer Performance with Vertical guidance. The minima line to be flown if the aircraft has SBAS capability approved according to AMC 20-28.

Official definition extracted from ICAO (2006), PANS-OPS, Procedures for Air Navigation Services – Aircraft Operations – Flight Procedures [Doc 8168]

Point merge sequencing method – With this technique, aircraft follow a RNAV routing, which generally includes a level flight arc segment until receiving a "direct to" routing to a merge point.

Definition extracted from ICAO (2012) Doc 9931, Continuous Descent Operations (CDO)

1.5 Acronyms and Terminology

Term	Definition
ATM	Air Traffic Management
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
EAVD	Enhanced Airport Vision Display
E-OCVM	European Operational Concept Validation Methodology
OFA	Operational Focus Areas
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint

Term	Definition
	Undertaking Agency.
Term	Definition
ACC	Area Control Centre
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
BATCC	Budapest Air Traffic Control Centre
CAT	Category
CDA	Continuous Descent Approach
CDO	Continuous Descent Operation
CFP	Call For Proposals
CTR	Control Zone
DFDR	Digital Flight Data Recorder
DMU	Data Management Unit
DOG	Detailed Operational Description
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology
ESSIP	European Single Sky Implementation Plan
FIR	Flight Information Region
FL	Flight Level
FMS	Flight Management System
ILS	Instrument Landing System
KPA	Key Performance Area
KPI	Key Performance Indicator

Term	Definition
LNAV	Lateral Navigation
LoA	Letter of Agreement
LPV	Localizer Performance with Vertical guidance
LSSIP	Local Single Sky Implementation Plan
MDA/H	Minimum Descent Altitude/Height
MSL	Mean Sea Level
NPA	Non Precision Approach
OFA	Operational Focus Areas
P-RNAV	Precision RNAV
QAR	Quick Access Recorder
RNAV	Area Navigation
RNP	Required Navigation Performance
RWY	Runway
SBAS	Satellite Based Augmentation System
SESAR	Single European Sky ATM Research Programme
SID	Standard Instrument Departure
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency
SW	Software
TMA	Terminal Area
ToD	Top of Descent
TWR	Tower
VNAV	Vertical Navigation
WP	Work Package

2 Context of the Demonstrations

2.1 Scope of the demonstration and complementarity with the SESAR Programme

Within the Single European Sky (SES) initiative, the European ATM Master Plan [2] is the agreed roadmap driving the modernization of the Air Traffic Management system and connecting SESAR research and development with deployment. The ATM Master Plan is the key tool for SESAR deployment, providing the basis for timely, coordinated and efficient deployment of new technologies and procedures within 2030 timeframe. Its content has been aligned with International Civil Aviation Organisation's Aviation System Block Upgrades (ASBU), in order to secure global interoperability and synchronisation.

The Master Plan is performance-driven, responding to the four Key Performance Areas (KPAs) of environment, cost-efficiency, safety and capacity. These criteria, set by the European Commission, form part of the wider set of ICAO KPAs and have been adopted to fulfil the high level goals of Single European Sky (SES).

SESAR programme comprises three phases:

- Definition Phase (2005-2008) has produced the ATM master plan, identifies technological steps and priorities
- Development phase (2008-2013) managed by the SESAR Joint Undertaking to develop the equipment and standards to ensure replacement of existing ground and airborne systems and interoperability outside Europe
- Deployment phase (2014-2020) large-scale production, procurement and implementation of new ATM ground and aircraft equipment

Deployment of ATM system changes shall cover both, operational and technological changes, and be performance-driven and substantiated by robust Cost-Benefit Analysis. In other words, ATM system changes shall be deployed only if and when they bring demonstrated benefits substantially exceeding their implementation costs.

Large-scale demonstrations framework, on which BUDAPEST 2.0 activities are proposed, shall contribute to the operational exposure of a series of SESAR solutions towards its implementation and adoption.

The SESAR concept steps are the phases through which the SESAR target concept is realized. Step 1, "Time-based operations" is the building block for the implementation of the SESAR concept and is focused on flight efficiency, predictability and the environment. The goal is a synchronized European ATM System where partners are aware of the business, operational situations, and collaborate to optimize the network. BUDAPEST 2.0 demonstrations contribute to operational and technological changes for Step 1, related to the operating environment, as per highlighted in the figure below.

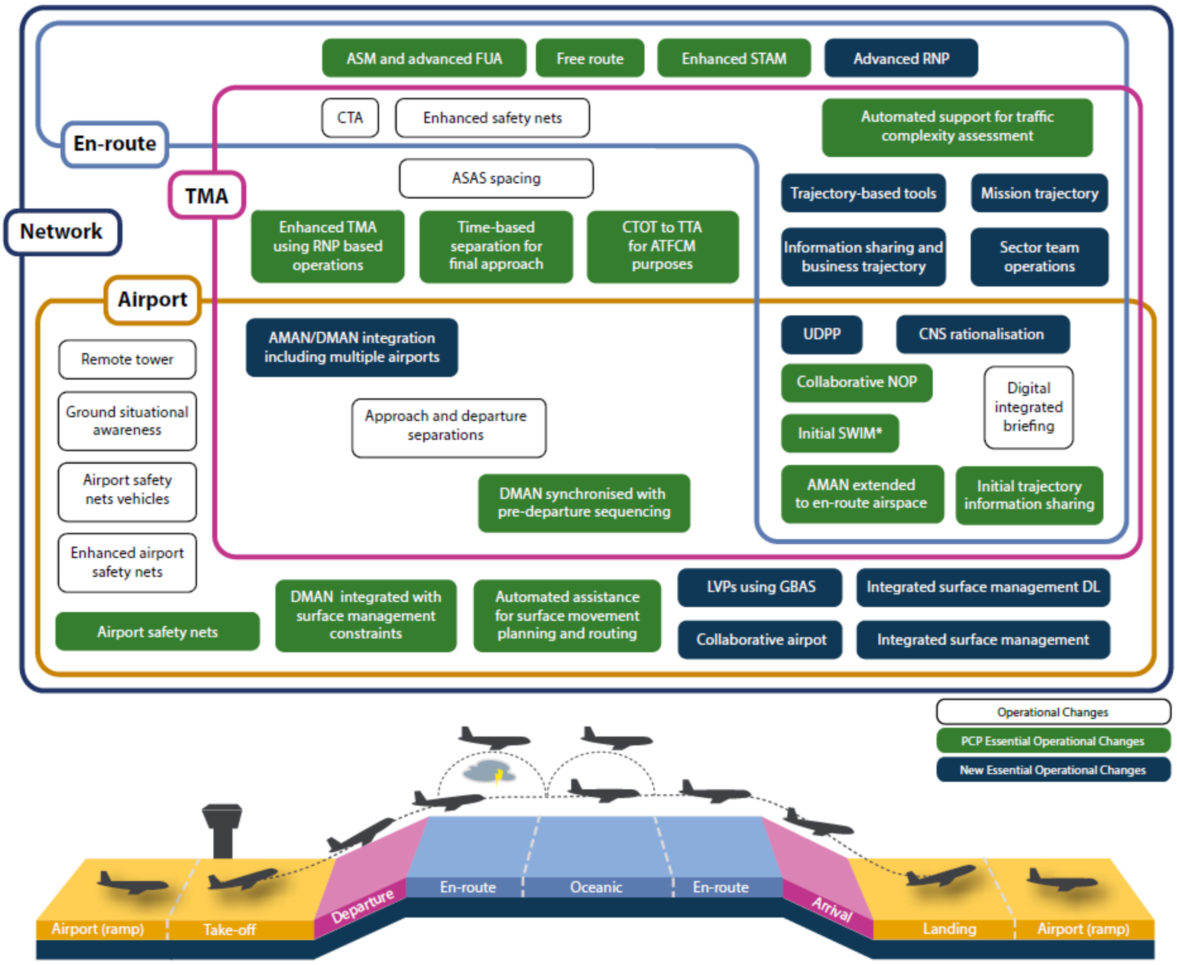


Figure 2-1: Operating Environment [2]

Operational changes provide performance benefits to one or more of the four types of Operating Environment, i.e. Airport, En-route, TMA and Network. The full scope of the Operational Changes to be deployed in Step 1 is shown in the above figure, allocated to the respective Operating Environment(s) where they bring the most benefit.

BUDAPEST 2.0 is also well aligned with the different work packages defined within the SESAR Programme. In particular:

- WP 5 focuses on TMA operations and covers all phases of planning and execution of flight/trajectories and the identification of supporting technical systems necessary for TMA Operations. TMA Operations are considered as those from “top-of-descent” until landing and from take-off until “top-of-climb”. BUDAPEST 2.0 will optimize farther CDO operations implemented at Budapest Airport throughout SESART REACT-Plus project based in CDO Enhancement tool concept. In the meantime will contribute to coordinated actions for optimal arrival sequencing in surrounding TMAs. The activity will also promote the implementation of RNP procedures within the TMA, in particular for the departure and the final approach phase of flight.
- WP6 focuses on the new operational concepts of airport operations. The main concepts to be studied include improving the provision of aerodrome control services at remote or small airports through the development of concepts of “remote and virtual towers”. BUDAPEST 2.0 will promote further the remote tower concept for middle size airports even controlled from a smaller/regional distance. Reference WP 06.09.02 (Advanced integrated CWP (A-lcwp)) and WP 06.09.03 (Remote & Virtual TWR)

- WP12 focuses on technical developments and validation/verification, providing the ground-based system support to the new concepts, procedures and practices described by WP6. In particular, remote tower activities are linked with SESAR WP12.4.6, WP12.4.7, WP12.4.8, WP12.4.9 and WP12.4.10.

2.1.1 Link with SESAR SOLUTIONS

The CDO Enhancement tool links with the Advanced Air Traffic Services SESAR solution [5] by enabling the merging of traffic into a single entry point which facilitates a more efficient and simplified traffic synchronisation mechanism that reduces communication workload and increases collective traffic predictability. This allows efficient integration and sequencing of inbound traffic thus facilitating more CDO's to be flown, with the commencement of these CDOs facilitated from a higher level and from more optimum levels.

In addition, the CDO enhancement tool will enable controllers to extend the borders of the TMA into the upstream airspace sectors. In this work package, an LNAV, LNAV/VNAV and LPV approach procedures have been designed for the 4 runway ends of Budapest Airport. Furthermore, RNP-1 SID has been designed for 2 runway ends of Budapest airport, thus evaluating the feasibility of landing operations in bad weather conditions and at other airports that are not equipped with ILS. It will also evaluate whether there is any reduction in radar vectoring activities by air traffic controllers.

Finally, the Remote Tower demonstration is totally aligned with (and the operational solution formulated upon) the SESAR High-performing airport operations solution and will enable ATS to be provided at Budapest from a remote location (the ACC). The objectives and the content of the demonstration exercises are elaborated based on the solution #12 described in SESAR Release 5.

2.1.2 Link with related projects

The most important projects at European level and their synergies with BUDAPEST 2.0 are the following:

- Remote Tower implementation at Budapest Liszt Ferenc International Airport: HungaroControl has decided to install and implement remote tower infrastructure at its control centre in Budapest, for the control of the Budapest CTR aerodrome airspace. This is for the improvement of the quality of air traffic services, in particular for increasing the safety level of operations, and creating economic benefits as well. The remote tower concept to be implemented at Budapest is fully in line with the SESAR Solution package, and it is considered complementary to projects currently underway in SESAR. The cornerstone of the concept is to integrate the A-SMGCS with a camera system, and to create an enhanced Controller Working Position that supports the controllers in exploiting all the benefits of this technology. In the frame of BUDAPEST 2.0, the consortium wants to demonstrate that ICAO standard ATS/ATC services can be provided for the aerodrome, from a site not located in the airport, and with all service levels at least equal to services provided from conventional towers.
- SAERCO Remote Tower: SAERCO is a Spanish company designated by the Spanish DGAC to provide Air Traffic Services at some Canary Island airports. Pildo Labs has developed a Concept of Operations for the provision of Remote Tower ATS within SAERCO Canary Islands Tower Network. A preliminary Safety Assessment was performed in order to assess the most critical elements at System level and consolidate technical requirements. The work was financed by the Madrid Community, and inputs from this work will be provided to BUDAPEST 2.0 project.
- Development of the CDO Enhancement Tool and its validation with CRDS: HungaroControl, based on its experience and the conclusions drawn from the EUROCONTROL CDO workshops, developed a new ATC support tool for enhancing CDO operations and sequencing traffic onto a time or distance based scale, which allows the controller to create the sequence in earlier phase of the flight, provide accurate distance to arrival, and thus, enable the aircraft to fly its optimum trajectory (through a given set of waypoints). In addition to this, this tool also visualizes traffic in reference to the optimum glideslope, supporting continuous descent operations. The CDO Enhancement Tool was developed entirely inside

HungaroControl, and was thoroughly tested and validated in the Centre of Research, Development and Simulation (CRDS) of HungaroControl. It is currently operational at Budapest ATCC. The consortium is planning to demonstrate the extended use of the tool for supporting the sequencing of traffic arriving at Vienna at the handover point.

- REACT-Plus (Reduction of Emissions using CDOs and CCDs in TMA): this project aimed to optimize terminal operations with the introduction of more efficient flight profiles at Budapest airport, and involving HungaroControl, WizzAir and Pildo Labs. The implementation of the CDOs and CCDs was based on the operational introduction of a new ATM CDO Enhancement Tool. This tool is nowadays deployed at HugaroControl Budapest ATCC. As mentioned before, with BUDAPEST 2.0, the consortium wants to move a step forward and enhance the use of the CDO Enhancement Tool concept in the TMA at Budapest and if possible, for sequencing arrivals into Vienna.
- NASCIO (Navigation SESAR Concepts Involving Operators) RNP APCH) aims to demonstrate new Navigation Specifications described in the new PBN Manual, through 8 scenarios involving all the stakeholders' chain. In particular, NASCIO is focused on PBN/RNP and APV SBAS. NASCIO includes activities in Switzerland, Spain, Poland, Slovakia, Bulgaria, Turkey and Morocco. Hungary was not involved in NASCIO, and has no RNP Approaches implemented yet. BUDAPEST 2.0 aims to introduce HungaroControl and its national operators to this new kind of approaches that will serve as a back-up for the current ILS installed at Budapest airport, and will also demonstrate the business jet operator about the potential of this type of approaches for other regional airports. Furthermore, the tool developed and used in NASCIO by Pildo to validate the procedures will be reused in Budapest 2.0.

2.1.3 Scope of the demonstrations

Budapest 2.0 aimed at demonstrating a set of solutions and concepts of operations for Small/Medium Size Airport users and stakeholders such as:

- CDO Enhanced Operations
- RNP Based Operations
- Remote Tower

New concepts of operations proposed are of particular interest for medium size airports like Budapest Liszt Ferenc International Airport. Although the applicability of SESAR concepts demonstrated is not limited to small/medium size airports, the activity scope is limited to those, and in particular for Budapest Liszt Ferenc International Airport.

As such, the operational and safety material (including human factors analysis if relevant) developed for each solution or operational concept demonstrated, although based as much as possible on generic material, has been limited in scope to similar operational conditions as per Budapest Liszt Ferenc International Airport. That is of particular importance at the level of test and validation exercises throughout the use of CDRS (Centre of Research, Development and Simulation) facilities.

The provision of ground infrastructure as in support to the implementation of the SESAR solutions was out of the demonstration activity scope (namely: Remote Tower system or the equipment installation of CDO Enhancement Tool system in the ATS Approach Centre).

HungaroControl as Air Navigation Service Provider at Budapest Liszt Ferenc International Airport ensured the necessary equipment as in support to the activity.

Table 2-1, Table 2-2 and Table 2-3 show a summary of the scope of the demonstrations performed in the framework of BUDAPEST2.0 Project.

Demonstration Exercise ID and Title	EXE-02.10-D-001.1 : CDO Enhancement Tool
Leading organization	HungaroControl
Demonstration exercise objectives	Take CDO operations to the next level by demonstrating the benefits of enhancing the procedures in the Budapest TMA by means of implementing T-Bar Procedures in LHBP TMA and the CDO Enhancement Tool in LHBP.
OFA addressed	02.01.02 Point Merge in Complex TMA 02.02.01 CDA
Applicable Operational Context	Budapest TMA
Demonstration Technique	Live trial
Number of trials	For the LHBP TMA T-bar procedure the data of 3432 flights have been collected

Demonstration Exercise ID and Title	EXE-02.10-D-001.2 : CDO Enhancement Tool in ACC
Leading organization	HungaroControl
Demonstration exercise objectives	Demonstrate the potential benefits of the CDO Enhancement tool in the en-route environment. The tool will be used to help ATCOs at sequencing the arriving traffic to Vienna, merging at a single boundary point. The exercise assessed the potential of the software to support ATCO decision-making in en-route sequencing tasks, and provides insight on how the software supports CDO operations in earlier phases of flight.
OFA addressed	02.02.01 CDA
Applicable Operational Context	Budapest ACC
Demonstration Technique	Live trial
Number of trials	For the Vienna arrival sequencing exercise, data will be collected for 40 hours over a 4 week period.

Table 2-1: Summary of the scope for CDO Enhancement Tool Implementation

Demonstration Exercise ID and Title	EXE-02.10-D-002.1 : RNP Based Operations
Leading organization	Pildo Labs in collaboration with HungaroControl
Demonstration exercise objectives	Design and validate RNP SIDs at Budapest TMA for two runway ends.
OFA addressed	02.01.01 Optimised RNP Structures 02.02.04 Approach Procedures with Vertical guidance
Applicable Operational Context	Budapest TMA Budapest TWR
Demonstration Technique	Flight Trials on GNSS equipped aircraft with additional flight validation platform installed inside
Number of trials	2 Flight Trials has tested the SID procedure

Demonstration Exercise ID and Title	EXE-02.10-D-002.2 : RNP Based Operations
Leading organization	Pildo Labs in collaboration with HungaroControl
Demonstration exercise objectives	Design, validate and implement RNP APCH (LNAV, LNAV/VNAV and LPV) at Budapest TMA for the four runway ends. Integrate RNP APCH with T-bar based procedures designed in EXE-00.10-D-001 CDO Enhancement Tool
OFA addressed	02.01.01 Optimised RNP Structures 02.02.04 Approach Procedures with Vertical guidance
Applicable Operational Context	Budapest TMA Budapest TWR
Demonstration Technique	Flight Trials on GNSS equipped aircraft with additional flight validation platform installed inside
Number of trials	10 Flight Trials have validated the procedures

Table 2-2: Summary of the scope for RNP Based Operations

Demonstration Exercise ID and Title	EXE-02.10-D-003.1 : Single RWY Remote Tower operation
Leading organization	HungaroControl
Demonstration exercise objectives	Demonstrating technical capabilities and boundaries of using camera technologies for visual observation of medium traffic volume on a single runway
OFA addressed	06.03.01 Remote Tower
Applicable Operational Context	Budapest TMA Budapest Airport
Demonstration Technique	Passive shadow operation Active shadow operation (live trial)
Number of trials	Data for 62 flights was collected. Shadow operations lasted for 93 hours in aggregate.

Demonstration Exercise ID and Title	EXE-02.10-D-003.2 : Dual RWY Remote Tower – operations
Leading organization	HungaroControl
Demonstration exercise objectives	Demonstrating technical possibilities and limitations of enhancing visual observation by camera technologies on two runways at a medium-sizes airport environment.
OFA addressed	06.03.01 Remote Tower
Applicable Operational Context	Budapest TMA Budapest Airport
Demonstration Technique	Passive shadow operation Active shadow operation (live trial)
Number of trials	Data for 524 flights was collected. Shadow operations lasted 27 hours in aggregate

Table 2-3: Summary of the scope for Remote Tower Implementation

3 Programme management

3.1 Organisation

The project consortium is composed by six partners: Pildo Labs, HungaroControl, Wizzair, JetStream, Slot Consulting and UPC.

Pildo Labs has been acting as "Project Coordinator" until the end of the Project, while HungaroControl, WizzAir, JetStream, Slot Consulting and UPC have been "Consortium Members".

Under such organisation, Pildo has been responsible for dealing with most project management tasks, and in particular of those related with interfacing with the SJU. This includes submission of deliverables, quarterly progress reporting, and notification of significant project achievements and organisation of project meetings, among others.

The following table provides information on Point of Contacts for each BUDAPEST 2.0 project consortium member:

	Main Responsible	Coordination Contact	Financial Contact
Pildo Labs	Mr Brent Day	Ms Luján Corte	Ms Zugeila Gascón
HungaroControl	Mr József Bakos	Ms Eszter Füredi	Ms Zsófia Lukovich
WizzAir	Mr David Morgan	Mr Fényes Attila	Mr Zoltan Simandi
JetStream	Mr Varga Tibor	Mr Laza Máté	Mr Mosolygó Miklós
Slot Consulting	Mr Roland Gurály	Mr Andrej Kocsis	Mr Roland Gurály
UPC	Mr Xavier Prats	Mr Xavier Prats	Mr Xavier Prats

Table 3-1: BUDAPEST 2.0 points of contact

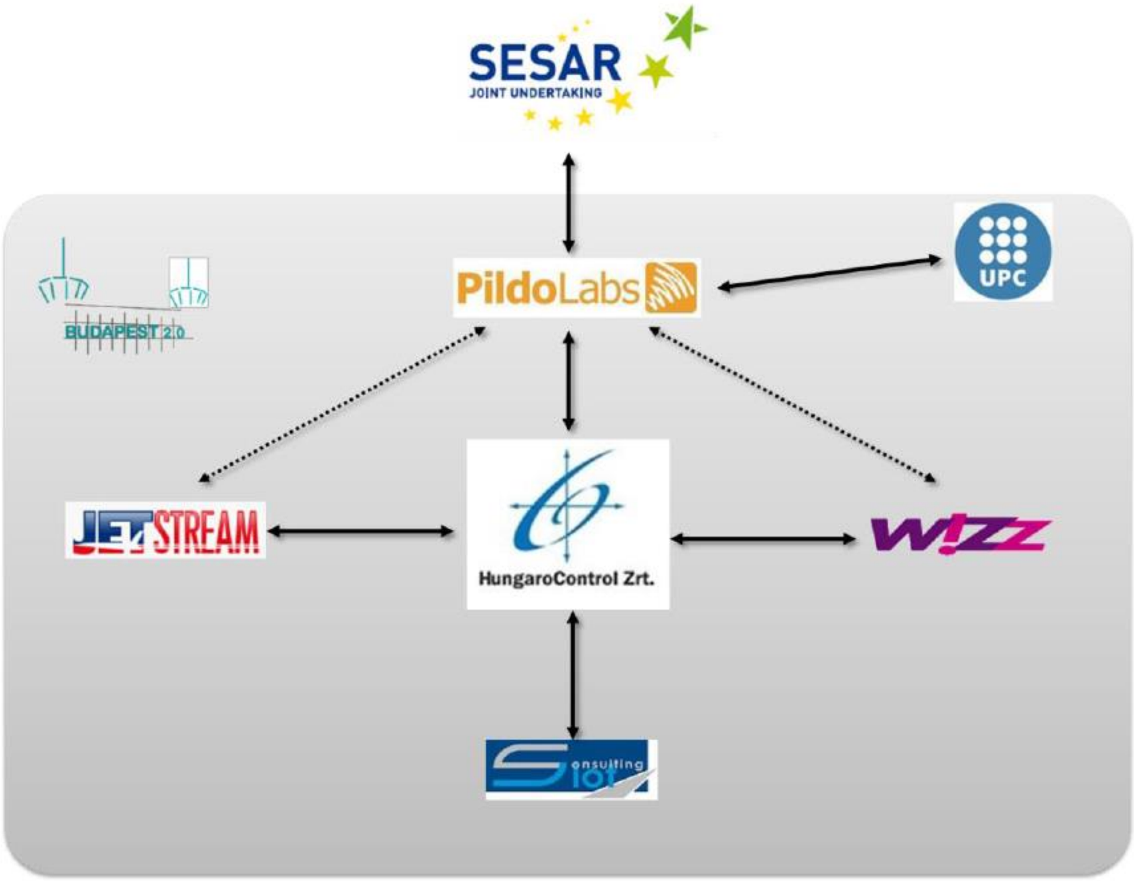


Table 3-2: Consortium Organisation

3.2 Work Breakdown Structure

BUDAPEST 2.0 Project is divided into 5 different work packages, as presented in the following figure:

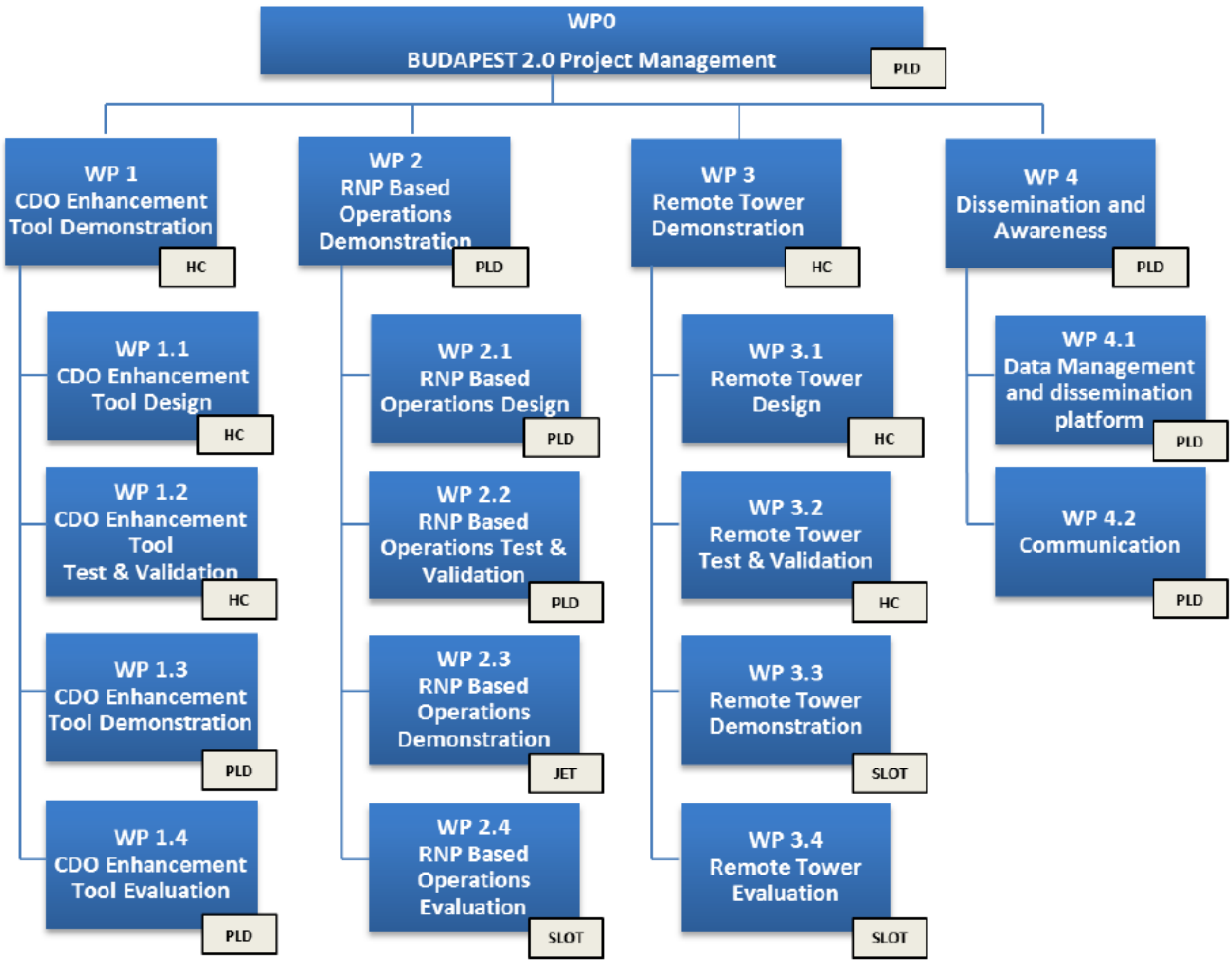


Table 3-3: Work breakdown structure for BUDAPEST 2.0

WP0 encompasses the management and coordination activities, taking on the interface with the SJU. Control of the project deadlines, milestones accomplishment and deliverables submission is included as part of this WP. Pildo Labs, as project coordinator, led WP0.

All the demonstration activities proposed in BUDAPEST 2.0 (WP1 to WP3) have been structured in the same way, in order to follow the same coherence: Design, Test & Validation, Demonstration and Evaluation.

WPs1, 2 and 3 have been subject to a continuous Management Process throughout the whole life-cycle of each WP.

WP1 aims to demonstrate the use of CDO Enhancement Tool. HungaroControl lead WP1, with the contribution of WizzAir and Pildo.

WP2 scoped the design, validation and publication of RNP APCH procedures and design and validation of a SID procedure. It has been led by Pildo Labs, with the contribution of JetStream and Slot Consulting.

WP3 has been devoted to implement Remote Tower. HungaroControl led WP3, with the contribution of Slot Consulting.

WP4 gathered all data from previous WPs. All these WPs' data have been evaluated, and inputs have been provided to WP4. This Work package contains all the activities aimed at raising awareness on the project activities and enhancing the dissemination of the results. In particular, it contains the development, set up and run of the data management and dissemination platform. Pildo Labs led WP4, with the support of UPC.

3.3 Deliverables

The BUDAPEST 2.0 Kick Off meeting took place on the 16th October 2014. Based in this date, and taking into account that the project activities had to be performed in a maximum period of 24 months; the deliverables were provided to SESAR SJU in the following dates:

Deliverable name	Date
Demonstration Plan 1st Release (D1)	Final version approved on the 26th March 2015
Demonstration Plan 2nd Release (D2)	Final version delivered on the 26th April 2016
Demonstration Report (D3)	Current document

Table 3-4: Formal deliverables' submission dates

D1 – Demonstration Plan 1st Release, following SJU Demonstration Plan Template

D2 – Demonstration Plan 2nd Release, following SJU Demonstration Plan Template

D3 – Demonstration Report, current document (describing the results of the demonstration exercises, following SESAR Demonstration Report Template)

3.4 Risk Management

A risk is any foreseeable circumstance that might affect the project in a negative way. A responsible entity is assigned to each risk to assure that the necessary mitigation actions are undertaken.

A continuous monitoring of the risks identified below has been set, as well as those arose during the project.

Risk Description	Probability assessment (Low/Medium/ High/Very High)	Severity Assessment (Low/Medium/High/Very High)	Mitigation Actions	Owner
ATCOs overwhelmed with changes – Demonstration activities impose major changes to the working environment of ATCOs, which could have a negative effect performance.	High	Low	Demonstration activities and changes to ATCO working environment are distributed across the demonstration timeframe, thus keeping the ATCO workload steady and below critical levels	HungaroControl
Changing ATCO paradigm – The so called change of paradigm (ATCO’s basic assumptions and attitude towards the aerodrome controller’s work) could cause psychological discomfort and cultural challenges for the ATCOs, so the project has to	Medium	Low	Providing the ATCOs all information transparently and on-time. Continuous dialogue with the TWR ATCOs about what are the differences between the past, the OTW and the future, the rTWR and what do you need to make the	HungaroControl

cope with the related questions, problems and risks.			necessary change happened. Monitoring every single ATCOs' commitment	
ATM-System issues – Malfunctioning one or more part of ATM-System	Medium	Low	Planning unique mitigation plan for all of ATM-system, performing Hazard Functional Analysis (FHA), Preliminary System Safety Assessment (PSSA) and SSA regarding all specific risks of given ATM-system	HungaroControl
Information collected during the recording campaign is not sufficient to compute fuel savings	Low	High	Assure data format and parameters before demonstration	WizzAir/HGC/Pildo
Fuel flow data not available	Low	Very High	Assure data format and parameters before demonstration	WizzAir/JetStream
Lack of human resources, personnel becomes unavailable during the project	Low	Low	Ensure transparency of the project management and agreement with reporting and quality procedures. Provide the project with other staff with similar or higher skills	All
Account should be taken of variability in descent/climb paths and speed management depending on aircraft weight, the type of FMS and pilot training	Medium	Medium	Position will be tracked on-real time. Pilots will abort the CDO if necessary	WizzAir/JetStream
Interaction between traffic following different vertical paths	Medium	Medium	It will be allowed to all aircrafts to perform CDO. ATC will manage abnormal situations establishing the adequate priorities always keeping the highest safety levels	HungaroControl
Under bad weather conditions, pilots might decide not to conduct a CDO	Medium	Low	Define a timeframe for conducting the trials as much extended as possible	HungaroControl
In radar vectored CDO it is necessary that pilots have accurate information of DTG	Medium	High	Close tracking about "CDO enhancement tool" implementation shall be followed to be sure it is available for ATCOs by the time the demonstration starts	HungaroControl

Lack of coordination with Wien FIR, to guarantee Budapest CCDs and future CDO implementation at Wien	Low	Medium	Involvement of Austrocontrol achieved since the very first day of the project	HungaroControl
Lack of authority approval or appropriate certification by the Hungarian CAA for testing remote tower ops room	Low	High	Continuous commutation about authority expectations and requirements, direct involvement of the authorities in elaborating the safety case	HungaroControl
Lack of available ATCO for live trials	Low	Medium	Detailed planning of ATCO resources, reducing ATCO intensive tasks	HungaroControl
Delay in remote tower demonstrations due to delay of deploying infrastructure or ATM-system as a result of the dependency on the rTWR deployment project	Medium	Medium	Integrated planning with technology projects and planning alternative solutions	HungaroControl
Delay of procedure design due to lack of consensus between the actors – ops personnel, procedure designers, managers and airport	Medium	High	Continuous involvement and communication with ops personnel during design phase	HungaroControl
EGNOS coverage is not available or the accuracy is not adequate for the SBAS approach procedures in Budapest TMA	Low	High	Direct contact with EGNOS from design phase and signing a LoA	HungaroControl

Table 3-5: Identified risks

4 Execution of Demonstration Exercises

4.1 Exercises Preparation

CDO Enhancement Tool Demonstration

In Work Package 1 T-bar procedures and a set of waypoints has been designed in Budapest TMA for all runway ends, and combined with the use of the CDO Enhancement Tool, and the benefits of Continuous Descent Operations will be demonstrated in the Flight Trials Campaign.

In part two of WP1, the use of the CDO Enhancement Tool will be extended to Budapest ACC sectors, for the sequencing of traffic arriving at Vienna Airport, demonstrating the benefits of extending sequencing to en-route phases of flights and continuous descent operations from top of descent until FL140.

All new procedures and new instances of the CDO Enhancement Tool have been tested and validated in a simulated environment, before validating them by flights. Following the successful validation phase, procedures and waypoints concerning the LHBP TMA has been duly published in the Hungarian AIP, and 3432 live flights have been flown by WizzAir (as part of every-day scheduled flights).

After the demonstration phase, data provided by WizzAir from on-board devices and data recorded and extracted from HungaroControl's ATM systems have been analysed and evaluated. This has been accompanied by a set of interviews to ATCOs and questionnaires to pilots prepared by Slot Consulting in order to record qualitative experiences as well. Since WizzAir does not fly to Vienna, for Vienna arrivals only data from questionnaires have been completed by the ATCOs involved in the demonstrations.

Based on all the data and information acquired, this demonstration report has been developed and delivered to the SJU at the end of the project.

RNP Based Operations Demonstration

LNAV, LNAV/VNAV and LPV approach procedures have been designed for the four runway ends and RNP1-SID has been designed for one runway configuration of Budapest Airport and validated using a flight simulator at Pildo offices in a first step, and special flight trials with JetStream and Pildo Flight Validation Platform in a second step.

This flight validation served as demonstration towards the business operator, JetStream, to see the benefits of flying an RNP APCH and SID procedures. It is important to highlight that the demonstration of the SID has been valuable especially from the point of view of local communities around Budapest Airport, since this exercise has provided these stakeholders with tangible benefits of flying a new SID procedure based on advanced noise abatement possibilities.

After the procedure design process, the approval from the Hungarian Civil Aviation Authority has been obtained, so the RNP APCH procedures to four runway ends of Budapest Airport have been published in the AIP of HungaroControl. RNP-1 SID was not devoted to be implemented, just tested.

The performances have been evaluated, pilots feedback collected and inputs have been provided to WP4 for dissemination purposes.

Remote Tower Demonstration

As a prerequisite condition of this Demonstration, a fully capable Remote Tower prototype has been set at HungaroControl's Air Traffic Control Centre, with every ATM system and functionality necessary for active shadow operation.

In this work package, the remote ops room has been used to demonstrate the capability of providing ATC services with such technology. There are two runways at LHBP (13L/31R and 13R/31L) and two aprons. The demonstration covers all the runways and aprons with deploying fixed and PTZ cameras close to these areas. This work package was devoted to assess the control capability of CTR traffic of complex situations including even coexistent movements on runways and aprons.

Besides the technical point of view, controlling airport traffic outside of the airport has other operational and human factors aspects as well. The demonstration contains activities aiming to describe in detail the differences between the out-of-the-window view and the visualization of TV-monitors in the remote tower.

The performance has been evaluated; ATCO's feedback has been collected.

4.2 Exercises Execution

All the demonstration exercises took place at Budapest (HungaroControl HQ and Liszt Ferenc International Airport). The execution of the exercises concerned all three units of Budapest FIR (ACC, APP and TWR), but not simultaneously, in order to keep the necessary coordination between the units to a minimum for a single exercise.

As some of the exercises required extra ATCO working hours, ATCO roster meant the most significant constraint for the timing of the demonstration exercises. Other influencing factors were also taken into account for each exercise, as stated below:

EXE-02.10-D-001.1: The new arrival procedures for the TMA were effective from the AIRAC date 26th May. By that time all the other requirements (equipment, ATCO training etc.) were ready for the demonstration, however the actual exercise started only a week later. The reason behind this decision is to omit the initial learning period from the measurement, therefore to focus on the potential long term benefits.

The exercise was running for almost two month continuously, during this period a predefined group of ATCOs (12 people) were involved in the measurements and analysis.

EXE-02.10-D-001.2: The CDO enhancement tool was installed at only one CWP in the West Lower ACC sector and only for demonstration purposes; therefore ATCOs were not expected to use it continuously during the demonstration period. A group of 9 ATCOs were involved in this exercise, who used the tool in traffic volumes when they felt comfortable with it (dominantly lower to medium traffic) for a maximum period of 90 minutes during a shift.

EXE-02.10-D-002.1 and **EXE-02.10-D-002.2:** RNP APCH procedures have been designed and validated for the four runway ends of Budapest Airport. The Procedure Design process took place during most of the duration of the Project, since close cooperation with the National Authorities and stakeholders needed to be established. The final result had to be agreed with all the interested parties. Once the Procedures were designed and ground validated, the flight validation campaign took place in Budapest with a local Aircraft Operator. The RNP APCH procedures have been published in the Hungarian AIP and are effective from 15th September 2016.

An RNP-1 SID procedure was designed and flight tested. However, the main objective of this exercise was not to implement the procedure but prove the benefits of this kind of departure procedures to the local stakeholders.

EXE-02.10-D-003.1 Due to the scheduled update of the ILS equipment for runway 31L/13R at LHBP, only single runway operations were performed during a three-week period. During this timeframe only passive shadow mode operations were conducted as part of the demonstration. The passive shadow mode ran for 5 hours on each weekday during the exercise.

EXE-02.10-D-003.2 Live trial (active shadow mode) exercises were performed during dual runway operation circumstances. Live trials ran on 9 days and for several (typically 90 minutes) periods during those days.

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-02.10-D-001.1	CDO Enhancement Tool	06/06/2016	29/07/2016	12/07/2016	25/08/2016
EXE-02.10-D-001.2	CDO Enhancement Tool in ACC	02/06/2016	20/07/2016	01/07/2016	17/08/2016
EXE-02.10-D-002.1	RNP Based Operations	17/12/2014	05/07/2016	06/07/2016	06/08/2016
EXE-02.10-D-002.2	RNP Based Operations	17/12/2014	05/07/2016	06/07/2016	06/08/2016
EXE-02.10-D-003.1	Single RWY Remote Tower operation	25/07/2016	19/08/2016	01/08/2016	19/07/2016
EXE-02.10-D-003.2	Dual RWY Remote Tower - Operations	22/08/2016	09/09/2016	29/08/2016	09/09/2016

Table 4-1: Exercises execution/analysis dates

4.3 Deviations from the planned activities

This section summarizes the changes with respect to the content within the Demonstration Plan. The following table lists a brief description of the deviations found in each scenario:

Exercise ID	Deviations description
EXE-02.10-D-001.1	More flights than expected have been analysed. In the Demonstration Plan [1], 50 CDOs and 50 non-CDOs were planned to be analysed and finally data from 3432 flights have been collected and assessed.
EXE-02.10-D-001.2	More hours of demonstration than planned – 58 hours instead of 40.
EXE-02.10-D-002.1	No deviations have been detected during the execution of EXE-02.10-D-002.1 with respect to the 2nd Release of the Demonstration Plan.
EXE-02.10-D-002.2	Two flight trials have been performed for the RNP SID procedure instead of four as planned in the 2nd Release of the Demonstration Plan.
EXE-02.10-D-003.1	Demonstration covered more operational hours (93 hours) and more aircrafts controlled (62 movements) than it was planned.
EXE-02.10-D-003.2	Demonstration covered significantly more aircrafts controlled (524 movements) (93 hours), but less operational hours (27 movements) than it was planned.

Table 4-2: Deviations from planned activities

5 Exercises Results

5.1 Summary of Exercises Results

This section lists the objectives set in the demonstration plan together with information of the status reached.

Exercise ID	EXE-02.10-001.1, EXE-02.10-001.2
Demonstration objective Tittle	Deployment of T-bar Procedures and CDO Enhancement Tool for full CDO implementation in LHBP
Demonstration Objective ID	OBJ-02.10-01
Success Criterion	The objective shall be reached upon: • Restructuring TMA routes for optimal CDO • Introduction and usage of T-bar based procedures for all four runway ends after AIP publication • All APP CWPs equipped with CDO tool and ATCO decision making is continuously supported by the tool
Exercise Results	T-bar procedures are designed for the TMA and published in the AIP (effective of 26th May). An updated version of the CDO support tool is available at APP working positions.
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-001.1, EXE-02.10-001.2
Demonstration objective Tittle	Demonstrating capabilities and limitations of restructured TMA routes and the application of T-bar procedures together with CDO enhancement tool. Demonstrating the benefits of the tool in supporting CDOs.
Demonstration Objective ID	OBJ-02.10-02
Success Criterion	The objective shall be reached upon: • Restructuring routes, T-bar application and use of CDO enhancement tool confirmed being able to provide accurate DTG information to pilots • Analysing flight path and confirming fuel saving potential for AUs comparing CDO routes and earlier arrival routes • Identifying the effects of working with these procedures and the tool on ATCO workload and situational awareness
Exercise Results	T-bar procedures are designed for the TMA and published in the AIP (effective of 26th May). QAR data collected from 3432 WizzAir flights and analysed to identify flight path characteristics and fuel saving potential. Data collected via ATCO questionnaires and interviews regarding workload and situational awareness.
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-001.1, EXE-02.10-001.2
Demonstration objective Tittle	Demonstrate the potential in efficiently substituting current separation tools with CDO enhancement tool in the en-route phase in order to achieve benefits on workload.
Demonstration Objective ID	OBJ-02.10-03
Success Criterion	Report based on direct ATCO feedback reinforcing positive workload effects
Exercise Results	Data collected via ATCO questionnaires and interviews regarding workload and situational awareness.
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-002.1, EXE-02.10-002.2
Demonstration objective Tittle	Integrate RNP-1 SIDs with RF legs into B-RNAV/Conventional routes at Budapest TMA by designing and validating the procedures to avoid noise sensitive areas mainly in initial climb phase
Demonstration Objective ID	OBJ-02.10-04
Success Criterion	Flight tests and feedback from the pilots
Exercise Results	RNP-1 SIDs successfully designed and tested at Budapest Airport
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-002.1, EXE-02.10-002.2
Demonstration objective Tittle	Integrate RNP APCH into conventional routes at Budapest TMA by designing and validating the procedures at least for two runway ends
Demonstration Objective ID	OBJ-02.10-05
Success Criterion	Report based on PLATERO platform generated after the validation flights performed by JetStream
Exercise Results	RNP APCH procedures designed, validated and implemented at the four runway ends Budapest Airport
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-002.1, EXE-02.10-002.2
Demonstration objective Tittle	Integrate RNP APCH with T-bar based procedures designed in EXE-02.10-D.001 – CDO Enhancement Tool
Demonstration Objective ID	OBJ-02.10-06
Success Criterion	Safe reliable and efficient approach procedure regarding the optimal route and glide path in the TMA
Exercise Results	RNP APCH integrated with T-bar procedures
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-002.1, EXE-02.10-002.2
Demonstration objective Tittle	Integrate RNP-1 SID in RNAV SIDs scenario in order to reduce noise pollution and ATCO's workload
Demonstration Objective ID	OBJ-02.10-07
Success Criterion	Report based on PLATERO platform generated after the validation flights performed by JetStream
Exercise Results	RNP-1 SIDs successfully designed and tested in Budapest airport, but they have not been implemented.
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-003.1, EXE-02.10-003.2
Demonstration objective Tittle	Setting up a Remote TWR ops room with all the capabilities needed for live trials (including visualization)
Demonstration Objective ID	OBJ-02.10-08
Success Criterion	Operational approval for testing A-SMGCS integrated with the camera system
Exercise Results	CAA approval obtained for A-SMGCS and camera system, approval for temporary live operation for demonstration purposes.
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-003.1, EXE-02.10-003.2
Demonstration objective Tittle	Demonstrating technical capabilities and boundaries of using camera technologies for visual observation of the airport traffic in order to maintain date ATS provision
Demonstration Objective ID	OBJ-02.10-09
Success Criterion	This objective shall be reached upon (if meteorological conditions permit) providing and analysing the usability and impacts of: • A visual representation enabling the operator to maintain a continuous watch on all flight operations on and in the vicinity of an aerodrome as well as vehicles and personnel on the manoeuvring area

	• Visual surveillance by a videowall as common visual reference for all ATCO positions and in CWP-view corresponding to ATCO position responsibility's needs • Functionality corresponding to the binoculars in the local Tower • Visual reproduction such a visual detail that match OTW direct vision • The operator with warning indicating if a visual reproduction image is corrupt or delayed
Exercise Results	Functionalities of the video system were demonstrated during passive and active shadow mode trials. Samples from demonstration were recorded for further analysis. Feedback was collected from ATCOs via questionnaires and debriefing sessions.
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-003.1, EXE-02.10-003.2
Demonstration objective Tittle	Demonstrating technical possibilities and limitations of enhancing visual observation by camera technologies during limited visibility conditions (occurring within the demonstration time of period) in order to maintain safe ATS provision
Demonstration Objective ID	OBJ-02.10-10
Success Criterion	This objective shall be reached upon • Defining (means choosing) image enhancement techniques which is applicable corresponding to situational awareness • Defining sets of enhancement techniques for a low visibility condition as pre-sets
Exercise Results	Visualization enhancement functionalities were demonstrated during passive and active shadow mode trials. Samples from demonstration were recorded for further analysis. Feedback was collected from ATCOs via questionnaires and debriefing sessions.
Demonstration Objectives Status	OK

Exercise ID	EXE-02.10-003.1, EXE-02.10-003.2
Demonstration objective Tittle	Demonstrating what level of situational awareness can be reached compared to conventional TWR ops room
Demonstration Objective ID	OBJ-02.10-11
Success Criterion	This objective shall be reached upon identifying key elements and determining that situational awareness level of the actual tower • Cannot be reached or • Can be equal or • Might be exceeded
Exercise Results	Level of situational awareness was assessed based on ATCO questionnaires, debriefing sessions and on-the-job observation by human factor experts.
Demonstration Objectives Status	OK

5.2 Choice of metrics and indicators

OBJECTIVE ID	KPA	EXPECTED BENEFIT
OBJ-02.10-01	Capacity	decrease in ATCO workload, capability to support more CDO
OBJ-02.10-02	Environment	less CO2 emission
OBJ-02.10-02	Cost-efficiency	less fuel burnt, less fuel carried
OBJ-02.10-03	Safety	increase ATCO situational awareness, decrease in ATCO workload
OBJ-02.10-04	Environment	to avoid noise sensitive areas mainly in initial climb phase
OBJ-02.10-05	Safety	positive effects due to vertical guidance
OBJ-02.10-06	Cost efficiency	lower Costs (potential dismantle of unnecessary ground-based Navaid equipment)
OBJ-02.10-06	Environment	less go-around due to lower minima
OBJ-02.10-07	Cost efficiency	lower Costs (potential dismantle of unnecessary ground-based Navaid equipment)
OBJ-02.10-07	Safety	less ATCO workload, more precise route
OBJ-02.10-08	Capacity	capacity at a middle-size airport is not reduced due to rTWR operation
OBJ-02.10-08	Cost-efficiency	cost of rTWR operation at a middle-size airport is not higher than cost of conventional tower operation
OBJ-02.10-09	Safety	safety level does not decrease during good visibility conditions
OBJ-02.10-10	Safety	safety level does not decrease during limited visibility conditions
OBJ-02.10-11	Safety	level of situational awareness does not decrease in the rTWR room

Table 5-1: Summary of metrics and indicators

The following KPIs are defined to measure the results of the EXE-02.10-D-001.1 and are calculated accumulating the data collected for all flights:

- Percentage of CDOs
- Mean distance travelled from TOD to ALT = 3500 ft (in NM)
- Mean time spent from TOD to ALT = 3500 ft (in seconds)
- Mean fuel consumption from TOD to ALT = 3500 ft (in kg)

Computed KPIs for EXE-02.10-D-001.1 are presented in Section 6.1.3.1.

For EXE-02.10-D-002, the following KPIs are defined to measure the results of the exercises and are calculated accumulating the data collected for all flights as well as the pilots' opinion:

- Degree of satisfaction of pilots;
- Flyability of introduced procedures, including subjective evaluation from pilots and average deviations during the flight (meters).

The flight data has been collected from PLATERO, the flight validation platform provided by Pildo Labs and installed in the aircraft of each scenario. The collected data has been processed to obtain the deviation values.

6 Demonstration Exercises reports

6.1 Demonstration Exercise EXE-02.10-D-001 Report

The first demonstration covered the concept of CDO Enhanced Operations by means of the use of implemented CDO Enhancement Tool.

EXE-02.10-D-001.1 : CDO Enhancement Tool

EXE-02.10-D-001.2 : CDO Enhancement Tool in ACC

6.1.1 Exercise Scope

Demonstration Exercise ID and Title	EXE-02.10-D-001.1: CDO Enhancement Tool	
Leading organisation	HungaroControl	
Demonstration exercise objectives	Take CDO operations to the next level by demonstrating the benefits of enhancing the procedures in the Budapest TMA by means of implementing T-Bar Procedures in Budapest TMA and the CDO Enhancement Tool at Budapest APP.	
High-level description of the Concept of Operations	CDO Enhancement Tool is a tool that supports ATCO on the sequencing of arrivals in particular for handling the implementation of Continuous Descend Operations (CDO) in Terminal Manoeuvring Area (TMA). The tool builds on, and can be considered as an extension of Point Merge concept developed by EUROCONTROL, providing simple and intuitive Distance-To-Go (DTG) information and separation alerts between arriving aircrafts to controllers.	
Applicable Operational Context	Budapest TMA	
Expected results per KPA	Environment (Fuel Burn per flight)	50-70 kg/arrival
	Cost-efficiency	- Less fuel burnt on CDO routes - Less fuel carried because of expected shorter approach, plus CDO
Number of flight trials	For the LHBP TMA T-bar procedure the data of 3432 flights have been collected	
Related projects in the SESAR Programme	01.02 REACT Plus	
OFA addressed	02.01.02 Point Merge in Complex TMA 02.02.01 CDA	

Demonstration Exercise ID and Title	EXE-02.10-D-001.2: CDO Enhancement Tool in ACC	
Leading organisation	HungaroControl	
Demonstration exercise objectives	Demonstrate the potential benefits of the CDO Enhancement Tool in the en-route environment. The tool will be used to help ATCOs at sequencing the arriving traffic to Vienna, merging at a single boundary point. The exercise will assess the potential of the software to support ATCO decision-making in en-route sequencing tasks, and provides insight on how the software supports CDO operations in earlier phases of a flight.	
High-level description of the Concept of Operations	CDO Enhancement Tool is a tool that supports ATCO on the sequencing of arrivals in particular for handling the implementation of Continuous Descent Operations (CDO). The tool builds on, and can be considered as an extension of Point Merge concept developed by EUROCONTROL, providing simple and intuitive Distance-To-Go (DTG) information and separation alerts between arriving aircrafts to controllers. In the en-route application the focus is not on the CDO support, but on efficient sequencing to a certain exit point. The tool can be a substitute for separate measurement tools in the ATM system, therefore can facilitate efficient decision-making. The horizontal profile information may provide ToD information.	
Applicable Operational Context	Budapest ACC	
Expected results per KPA	Safety	- Increase in situational awareness - Less workload
Number of flight trials	For the Vienna arrival sequencing exercise, data have been collected for 58 hours over a 6 week period	
Related projects in the SESAR Programme	01.02 REACT Plus	
OFA addressed	02.02.01 CDA	

Table 6-1: Summary of the scope for CDO Enhancement Tool

As stated in the Demonstration Plan, this exercise aims to take CDO operations to the next level by demonstrating the benefits of enhancing the arrival procedures in Budapest TMA and also by implementing the CDO Enhancement Tool in an en-route environment. Our complex approach to CDO support intends to cover several elements throughout the system in order to have a considerable effect.

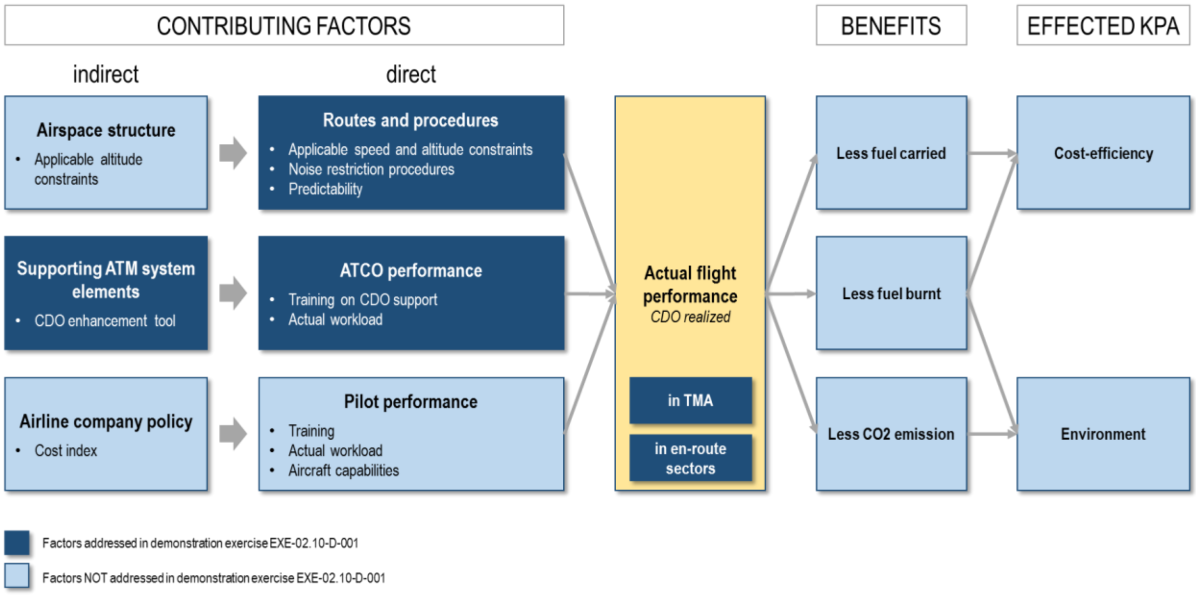


Figure 6-1: CDO supporting factors addressed by EXE-02.10-D-001

As shown on Figure 6-1 demonstration exercise EXE-02.10-D-001.1 is focused mainly on the arrival routes and procedures, the ATCO training elements and the available software support for the enhanced CDO. As part of this demonstration, special T-bar procedures were designed and implemented in Budapest TMA, together with a set of waypoints, which were published for all airspace users from the effective date 26th May. These procedures and the use of the CDO Enhancement Tool were expected to enable aircrafts not only to perform continuous descent approaches via the shortest TMA route, but also to plan for the shortest possible route for the approach phase.

After the validation of the T-bar concept in a simulator, the new approach procedures were implemented for live trials. All airlines that frequent LHBP have access to the new approach procedures during a two-month demonstration period, but data was only collected from WizzAir flights. The usability of the procedures and credibility of the supporting software were measured by ATCO and pilot questionnaires. The actual effectiveness of the CDO was measured based on FDR data from WizzAir. Eventually, six months of live operation and data from 3432 WizzAir flights were assessed.

In demonstration exercise EXE-02.10-D-001.2, the concept of continuous descent operations and the use of the CDO Enhancement Tool were introduced in the upper airspace of Budapest FIR. The aim of this demonstration activity is to demonstrate how conflicts between arriving aircrafts can be efficiently solved early during en-route phase of the flights while the CDO support is taken into consideration. In order to demonstrate this, Budapest ACC will use a duly customized and modified version of the CDO Enhancement Tool, and sequence traffic arriving to Vienna Airport. LOWW arrival traffic was chosen for the sake of demonstration instead of LHBP, because en-route traffic in Budapest FIR with destination LOWW typically has one exit point (PESAT), therefore has a definite traffic flow. This characteristic of the traffic makes it ideal for demonstration unlike the arrival traffic to LHBP that due to the Hungarian Free Route Airspace has very dispersed traffic patterns.

This exercise was running only in live trial mode without preliminary simulator exercises. This solution was the result of the unrealistic pilot performance and the unreliable vertical profile information available in a simulator exercise. By the end of the demonstration period, over 58 hours of operation using the CDO enhancement tool was assessed.

6.1.2 Conduct of Demonstration Exercise EXE-02.10-D-001

6.1.2.1 Exercise Preparation

For *EXE-02.10-D-001.1*, the following major preparatory tasks were undertaken:

1. **Concept design for new TMA arrival routes**

Sequencing of arrivals is made by vectoring in a lot of TMAs, since this is the most efficient method regarding spacing and accuracy. However, from the airlines point of view, the shortest possible route that the traffic allows and the minimization of spacing do not necessarily mean the most efficient method. Fuel consumption and CO_2 emission is getting more and more emphasis so making continuous descent approaches is a matter of utmost importance nowadays. With vectoring, it can be done by ***providing pilots with Distance To Go (DTG) information as early as possible***.

Generally speaking, the closer the aircrafts are to the expected position of their base turn the easier it is for ATCOs to determine DTG value. Unfortunately the later the DTG information is given the less benefit can be brought. But the DTG provided from far away is only a rough estimate so its potential to facilitate CDO is rather limited. This is why vectoring is listed only in second place as a means of CDO implementation in guidance materials.

One of the possible solutions for pilots to get a 100% accurate picture of what can be expected in the TMA is to design, publish and use a closed arrival route. In order to make use of this procedure regarding CDO, the aircraft cannot be vectored off the path which makes the work of the APP ATCOs very difficult, if not impossible. ATCOs can detect sequencing conflicts in a later phase around base turn as mentioned above so even in a low traffic period with 4-5 arrivals at the same time it is very demanding to apply speed control so that aircraft will turn final following the procedure with the necessary spacing.

The other method is to create a quasi-procedure comprising waypoints of the published procedure on a tactical level. This way the FMS can compute the optimal profile with the updated routing but the position of other aircraft has to be taken into account by the ATCO which can overwrite the plan of the FMS.

Since the introduction of the CDO supporting tool, APP ATCOs used this makeshift T-Bar procedure with predefined waypoint (e.g. BP438 – BP531) for Continuous Descend Operation planning and sequencing purposes. This solution is based on the shortening of the transition based Arrival Route. However, this system was not planned for this type of operation, therefore the mentioned waypoints are not placed optimally.

The new concept of operation would still be the same, but instead of the makeshift waypoint based quasi T-Bar procedures proper T-bars are used. In order to further enhance the situational awareness of the pilots, speed and altitude constraints are defined to the respective points of the T-Bar procedure.

2. **Safety assessment**

As the procedures used for demonstration purposes are intended to be used longer after the demonstration period, a required safety assessment process was run to map out and to mitigate to inherent risks.

3. **Designing routes and procedures, AIP publication**

The T-bar approach procedures were designed according to RNAV specifications, therefore connecting arrival routes needed to be aligned properly. After obtaining approval from the Hungarian CAA on the modifications, the following procedures were published on 14th April (effective date 26th May).

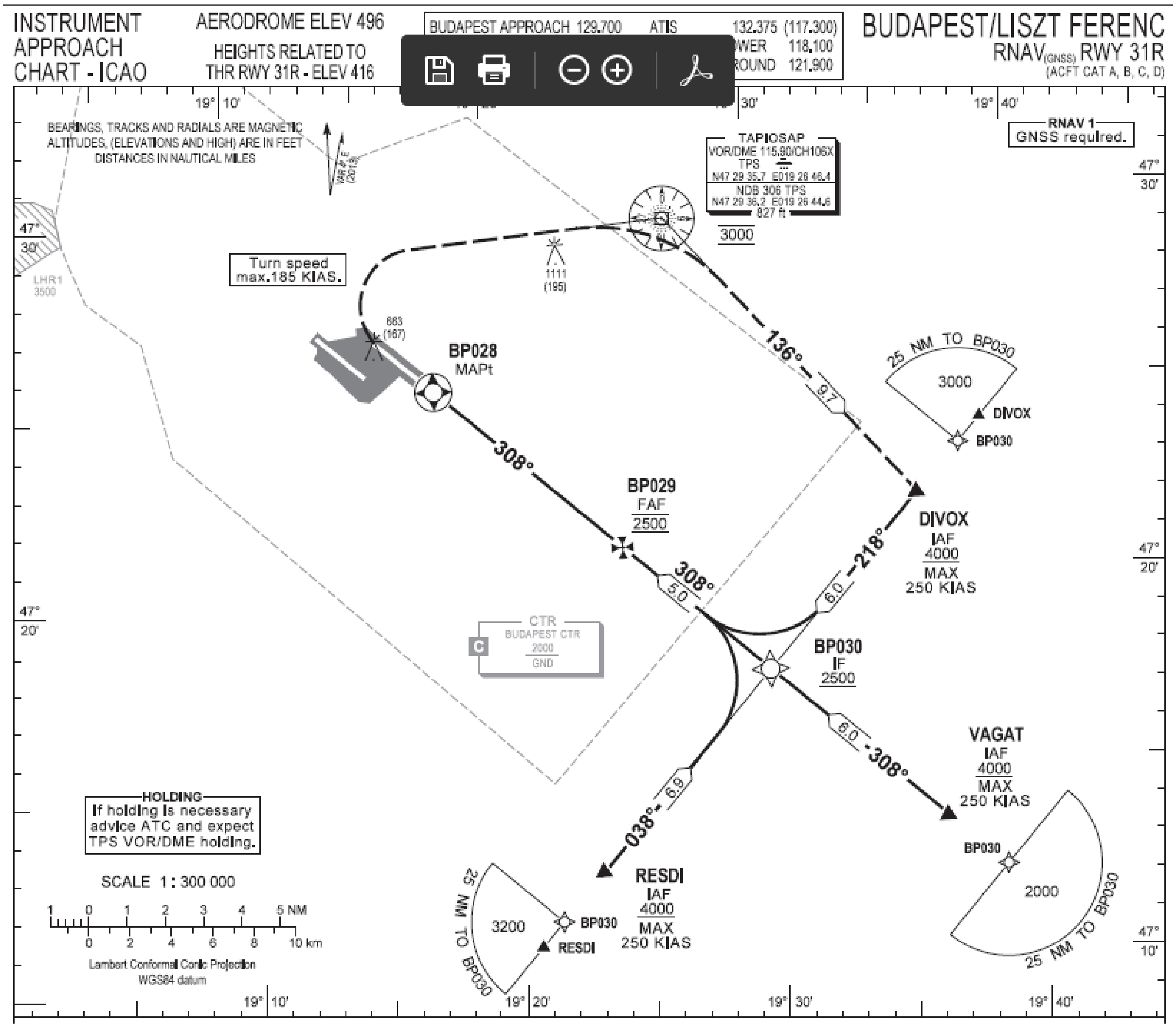


Figure 6-2: RNAV approach chart for LHBP 31R

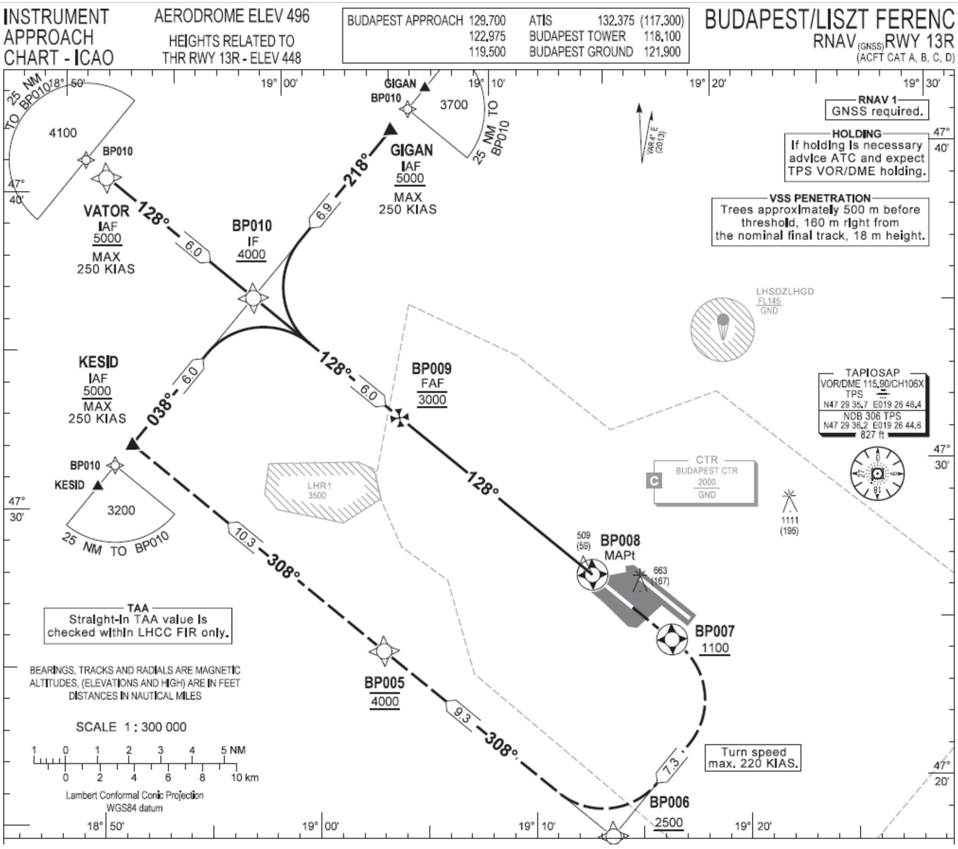


Figure 6-3: RNAV approach chart for LHBP 13R

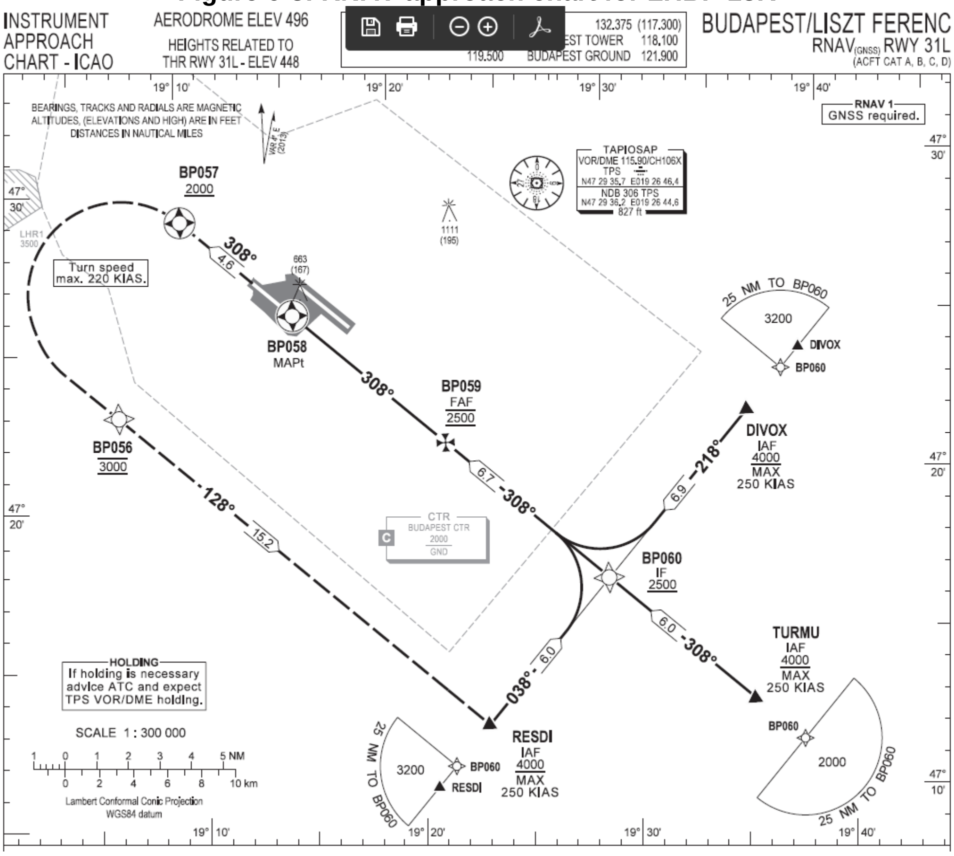


Figure 6-4: RNAV approach chart for LHBP 31L

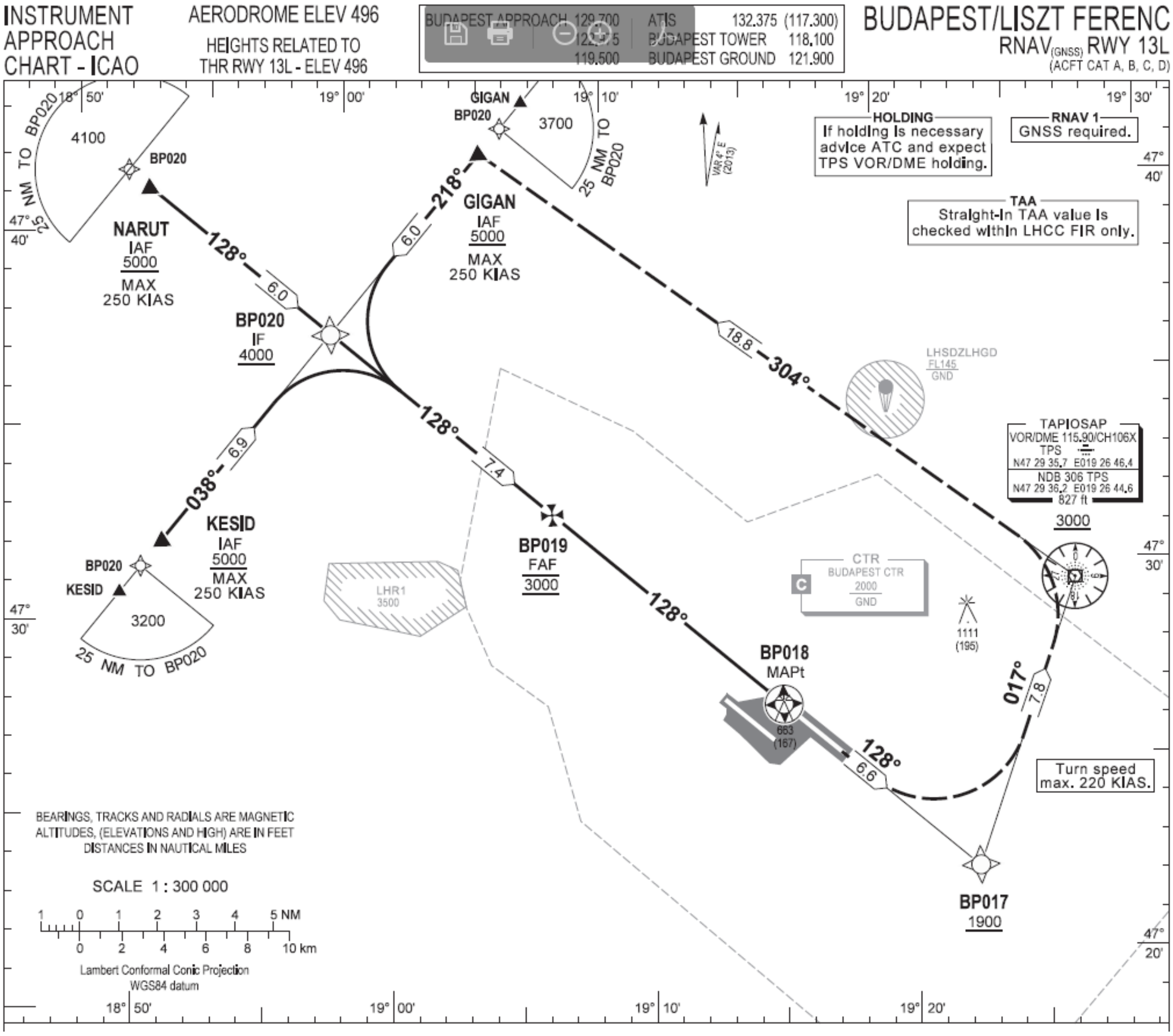


Figure 6-5: RNAV approach chart for LHBP 13L

4. **ATM system modification**.

The CDO support tool that we used for the demonstration can be regarded as an extension of PointMerge. The latter limits the airspace usable for sequencing to the area of a section of a circle. However there is no theoretical obstacle to extend the usable airspace to the full circle. Certainly there is a limit of what turn can be made but with inserting extra base waypoints into the system we can easily overcome this problem.

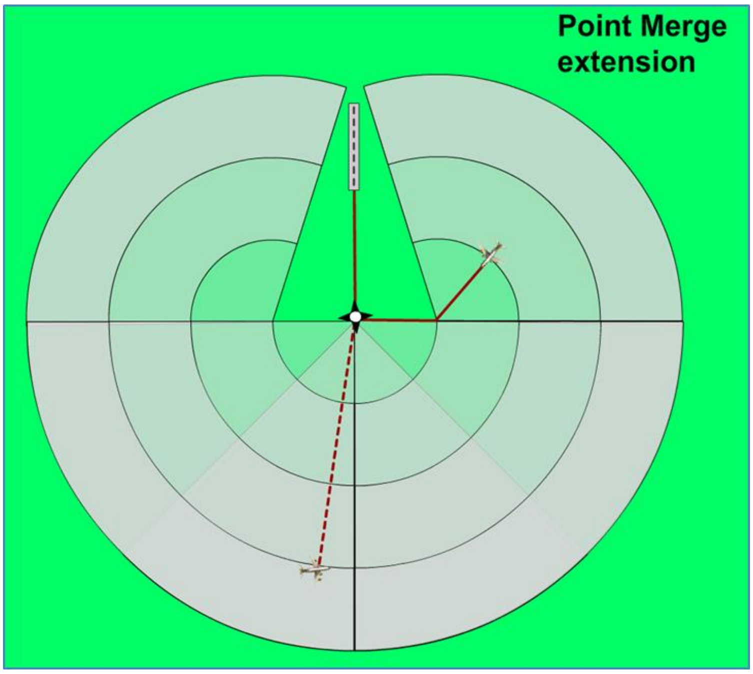


Figure 6-6: Basic concept behind the software used for supporting sequencing and CDO

Using the arcs to measure relative spacing is rather cumbersome even with two aircraft. Fortunately we do not really need the arcs if we can measure the difference between the length of the solid and the broken red line.

The essence of concept is that in an extended environment we use a dynamic system to create relative spacing instead of static map elements. The advantage of this is that an ATCO can check the relative spacing any time, and through a settings menu of the tool the necessary spacing can be modified according to the situation (e.g. wake turbulence, tower request etc.).

With the use of the software, accurate real-time DTG information can be provided to all arriving flights, enabling pilots to use Flight Management System (FMS) capabilities to plan a predictable continuous descent approach.

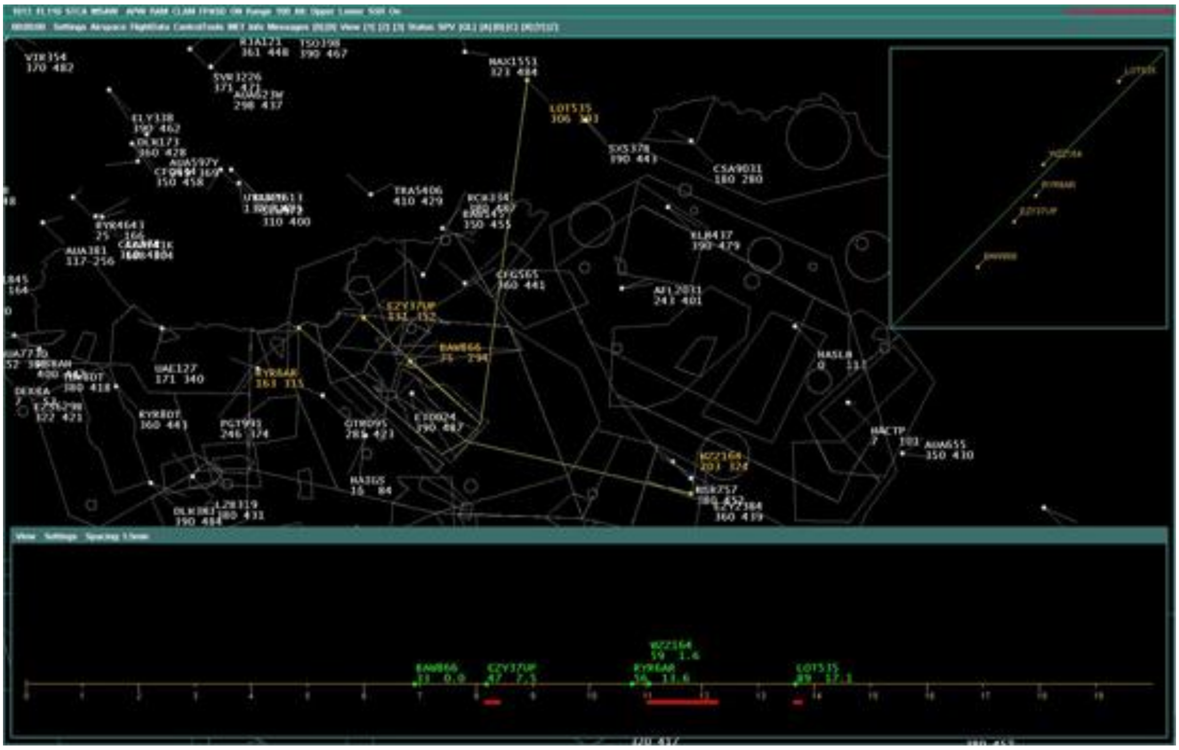


Figure 6-7: Screenshot of the supporting tool

5. **ATCO training:** In order to realize the expected benefits from the implementation, all APP ATCOs were formally trained in the topics of
   - Continuous Descend Operations in general
   - Functions and limitations of the supporting tool
   - New RNAV procedures

A group of ATCOs also took part in the validation simulation of the T-bar procedure in May 2015. That exercise was organized by CRDS in their independent simulator facility.

For *EXE-02.10-D-001.2*, the following major preparatory tasks were undertaken:

1. **Implementation of the CDO enhancement tool:**

The logic of the supporting software can be used in any environment where the traffic is coming from several directions and they need to be merged before reaching a certain point.

In LHCC, this scenario is the so called Vienna arrivals problem. The reference point to merge the traffic is NATEX, from where the aircraft are handled by Vienna APP. The information provided by the tool can help ACC controllers in assessing solutions such as giving direct to the reference point or using the original flight plan route. Moreover, the indication of missing spacing can help determine the optimal speed to be flown in order to merge traffic seamlessly.

During normal operations, en-route controllers use the following tools of the MATIAS system:

- QDM
- Track mile info
- Radar Sep Tool
- FPL Sep Tool
- Speed vector.

The aim of the demonstration is to use the CDO enhancement tool instead of those above and to assess its effects on ATCO workload and the ease of decision-making. As the sequencing of the LOWW arrival traffic is not the main responsibility of this ACC sector, 'the shortest way possible' approach was completed with another function, where the software calculates with FPL route. The following two measuring scenarios are available in the software:

- the CDO enhancement tool will use the FPL route (BALUX, TORNO, NATEX), when the flight is selected to be arrival to Vienna. The ATCO can shorten the route, if applicable.
- the CDO enhancement tool will use a direct route to NATEX point. The ATCO can extend the route, if necessary.

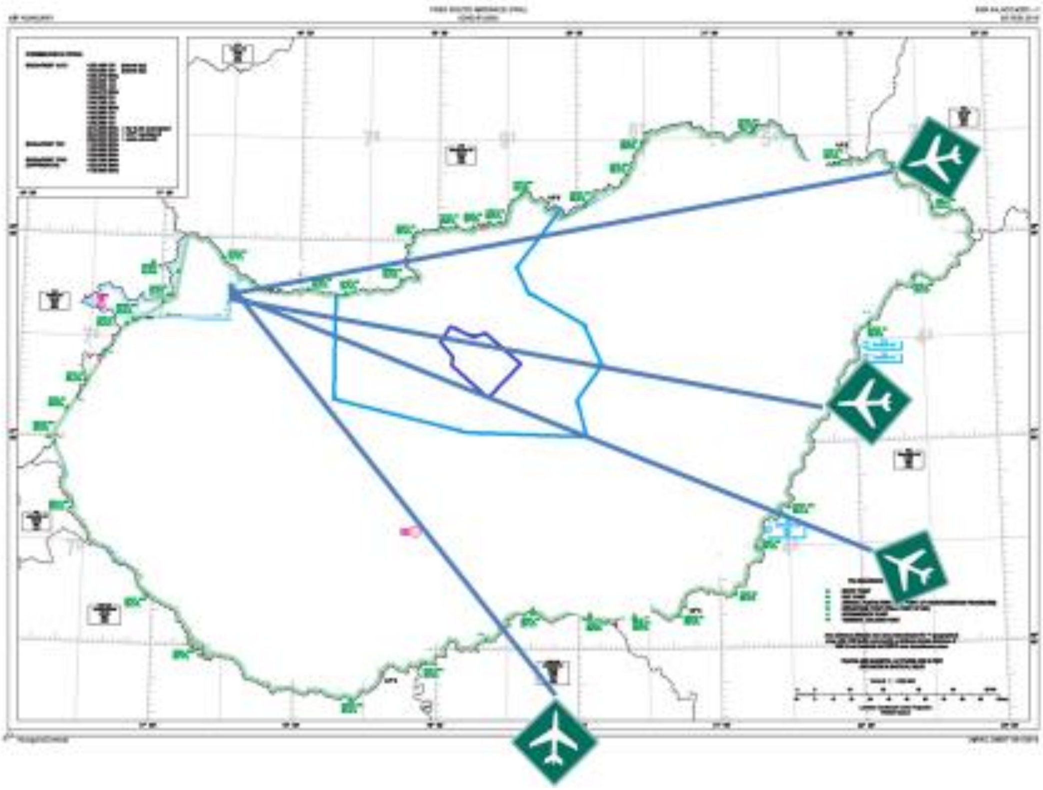


Figure 6-8: Calculation based on direct route

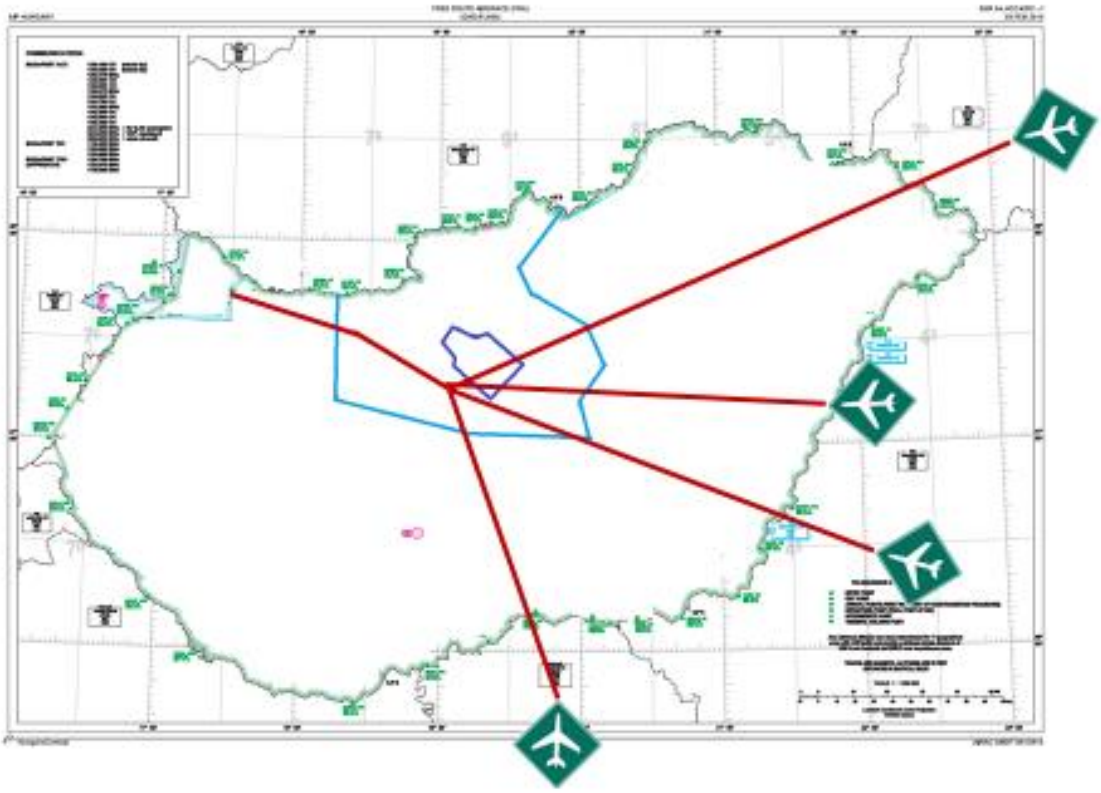


Figure 6-9: Calculation based on FPL route

2. **Safety assessment**

This demonstration exercise does not entail significant risks as it is not integrated in the main ATM system and suspension for safety (or other reasons) is both easy and quick.

3. **ATCO training**

The ATCOs who volunteered to take part in the demonstration received all the necessary information about the software and the data collection method during a briefing session.

6.1.2.2 Exercise execution

For **EXE-02.10-D-001.1** the solution scenario (**SCN-02.10-001**) was tested according to the schedule shown in Table 6-2.The typical traffic load at LHBP is relatively heterogeneous throughout the day, therefore a 24-hour demonstration schedule made it possible to test the solution in low, medium and high traffic intensity. The entire demonstration period was run as in live trial operation.

Demonstration period	06/06/2016-and 29/07/2016	
Daily schedule	low traffic intensity	0000-0800
	medium traffic intensity	1400-1800 2100-2400
	high traffic intensity	0800-1400 1800-2100
No. of ATCOs	2 ATCOs/shift	
Total hours of demonstration	1 344 hours (56 days * 24 hours)	

Table 6-2: EXE-02.10-D-001.1 demonstration schedule

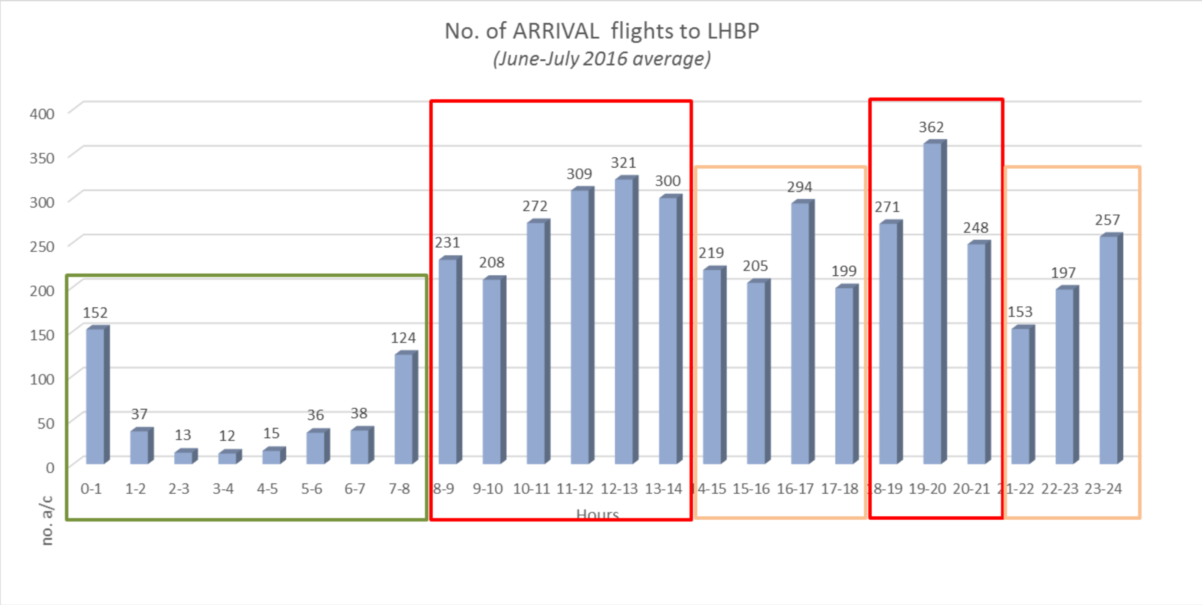


Figure 6-10: Distribution of arrival traffic load during the day

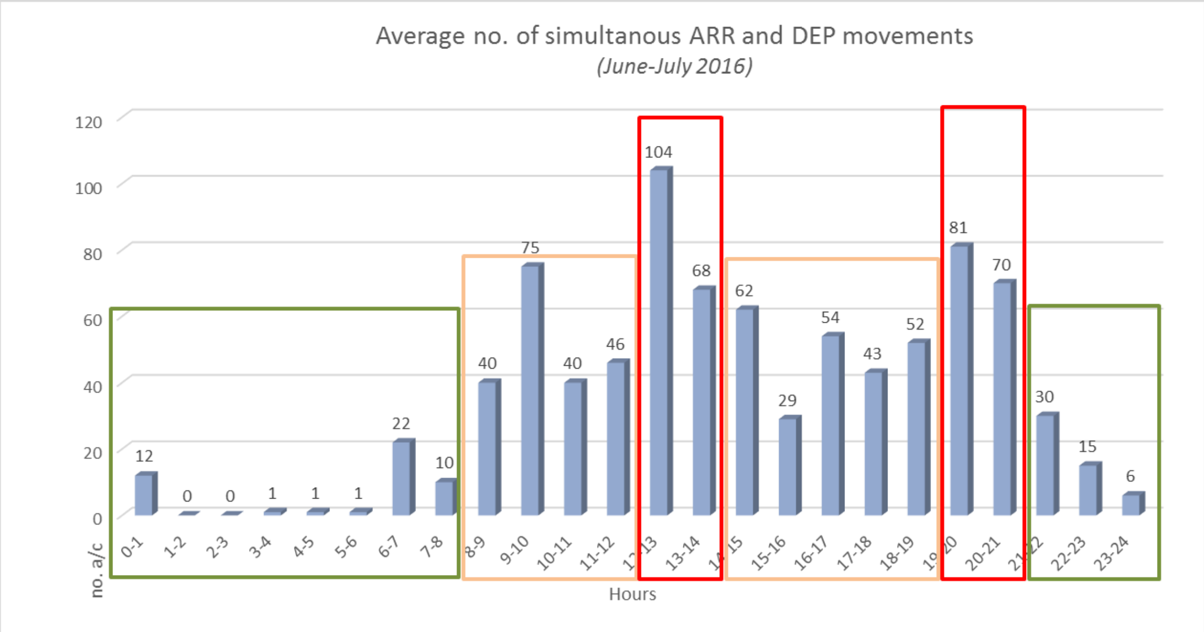


Figure 6-12: Distribution of traffic scenarios most likely to lead to conflict
May 2016.

For **EXE-02.10-D-001.2** the solution scenario (**SCN-02.10-002**) was tested according to the schedule shown in Table 6-3 In case of Vienna arrival traffic, the reference scenario means sequencing without the use of a CDO Enhancement Tool.

All the demonstration periods listed in the table are live trial operations.

Date	ATCO 1	ATCO 2	ATCO 3	ATCO 4	ATCO 5	ATCO 6	ATCO 7	ATCO 8	ATCO 9	Total (minutes)
2 JUN				1015-1145						90
3 JUN		0915-1045						0545-0715		180
4 JUN			0715-0845				0545-0715			180
7 JUN			1315-1445	0745-0830	1145-1315					225
8 JUN	0715-0845	1515-1645								180
9 JUN			0545-0715							90
10 JUN	0300-0330	0530-0700								120
13 JUN	1145-1315									90
14 JUN							0715-0845			90
16 JUN	1400-1530								1900-2030	180
17 JUN			1315-1445							90
18 JUN	0715-0845	0545-0715								180
19 JUN							0545-0715			90
23 JUN	0545-0715	0915-1045								180
26 JUN		1645-1815								90
27 JUN						0545-0715				90
28 JUN	0545-0715	1015-1145								180
29 JUN							0500-0630			90
30 JUN				1445-1615						90
1 JUL									0630-0800	90
3 JUL	0545-0715									90
4 JUL							0545-0715			90
6 JUL								1145-1315		90
8 JUL	0715-0845	0545-0715								180
10 JUL				1315-1445						90
13 JUL	0715-0845	0545-0715						0500-0545		225
18 JUL		1100-1145								45
20 JUL						1015-1145				90
Total										3495 minutes **58,25 hours**

Table 6-3: EXE-02.10-D-001.2 demonstration schedule

The demonstration period started with a briefing session. The ATCOs had the possibility to schedule the demonstration sessions at their convenience taking into considerations some requirements (ie. traffic load, no. of open sectors). As the database consists mainly of ATCO opinion, the participants were asked to fill out a questionnaire after each demo session. After a preliminary analysis of the questionnaires we finished of the demonstration period with a debriefing session.

6.1.2.3 Deviation from the planned activities

According to our Demonstration Plan the full potential of the T-bar procedures were intended to be demonstrated through an extensive restructuring of the TMA where arrival procedures are not mandatory elements anymore. If the transitional arrival routes are omitted, approach can be planned by pilots simply as the shortest route possible from FIR entry point to T-bar base point. This intention was not fully met as transition routes were not omitted just shortened and adjusted due to safety and change management reasons. On Figure 6-13 is an example of the remaining transition routes. The fact that these route sections need to be taken into consideration for fuel planning, the measuring of target KPI – decrease in fuel carried on board – was distorted, With the actual solution an estimation can be made about the potential saving, but we were not able to collect the necessary data evidence for that. The estimation of can be built on the assumption that most arriving aircrafts do not fly the full length of the transition, but in majority of the cases they receive a shortcut (A.2.4.1.)

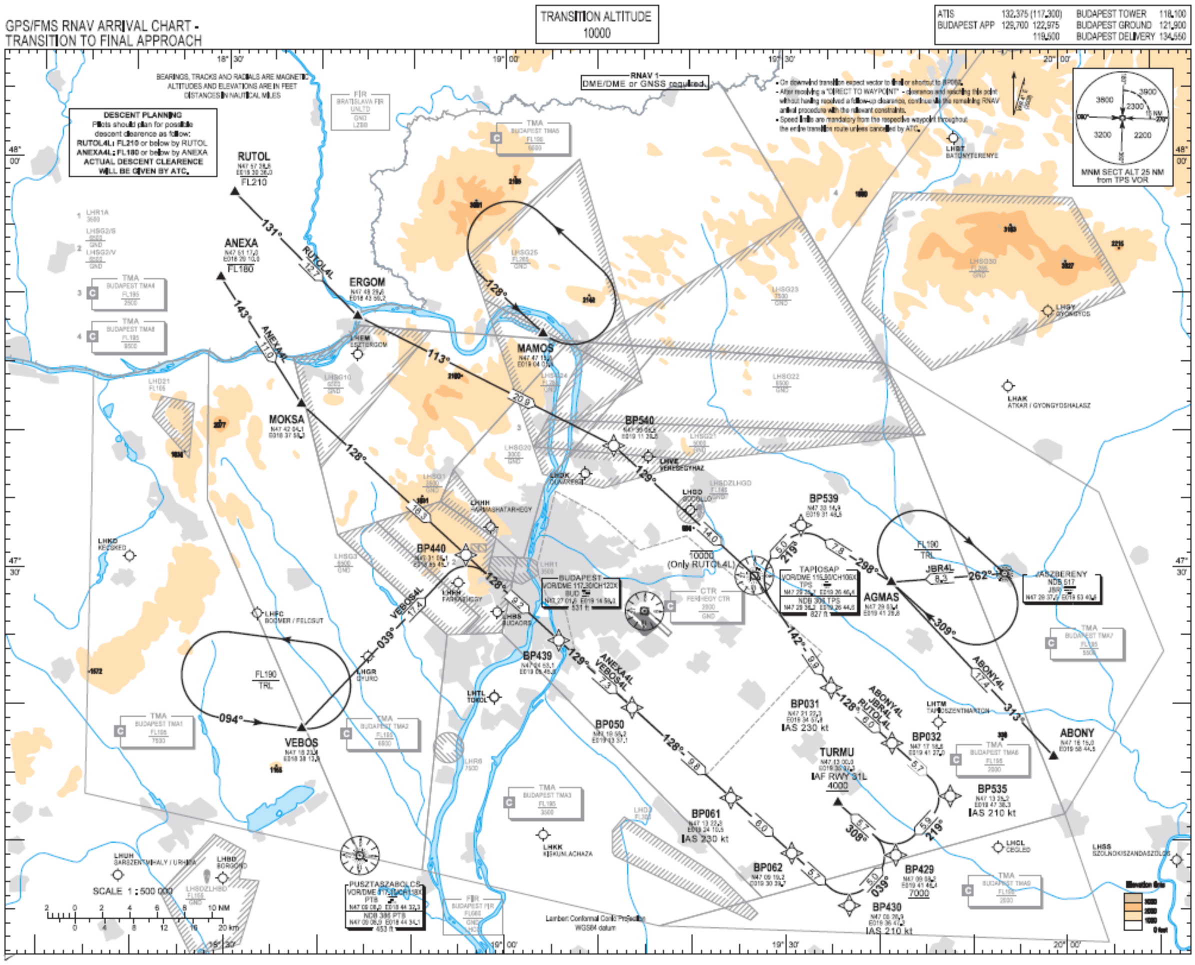


Figure 6-13: Transition to final approach LHBP 31L

A deviation should be noted regarding the data collection method as well. The plan consisted of collecting data for 50 specific WizzAir flights during the solution and the reference scenario. The main data sources are radar data, QAQ data and pilot questionnaires. Finally, we ended up collecting radar data not exclusively to WizzAir flight, but to all arrival traffic. QAR data from WizzAIr was collected not only for 50 flights, but for the 2-month demonstration period. As an auxiliary source of information, we asked pilot about their subjective opinion which gave us insight into about 30 flights during the demonstration period. By collecting more extensive data, we were able to analyse the full scale of the traffic that results in a more realistic assessment of the benefits. However, given the fact that data is not cleared to special demonstration purpose flights, results bear all the implications of the local implementation process and does not show a distilled figure about the solution.

6.1.3 Exercise Results

6.1.3.1 EXE-02.10-D-001.1 Results

6.1.3.1.1 Data

Six months of FDR data provided by WizzAir were assessed:

2015 (T-bar not published) :

- June (711 flights)
- July (731 flights)
- August (754 flights)

2016 (T-bar published):

- June (373 flights)
- July (497 flights)
- August (366 flights)

6.1.3.1.2 Definitions

The following criteria was used to define a **Continuous Descent Operation (CDO)**:

- Throttle differential less than 0.8 during all the descent (timeDiff = 10 seconds)
- Less than 2 minutes with throttle value equal or higher than 64% of the nominal value

The following criteria was used to define the **Top Of Descent (TOD)**:

- Vertical rate equal or less than -800 fpm
- ALT(i) – ALT(i+timeDiff) equal or higher than 10000 ft (timeDiff = 1000 seconds)

6.1.3.1.3 Key Performance Indicators

The following KPIs are calculated accumulating the results per month and per year:

- Percentage of CDOs
- Mean distance travelled from TOD to ALT = 3500 ft (in NM)
- Mean time spent from TOD to ALT = 3500 ft (in seconds)
- Mean fuel consumption from TOD to ALT = 3500 ft (in kg)

6.1.3.1.4 Results

6.1.3.1.4.1 Overall results

	Processed flights [num]	CDOs [%]	Dist. TOD-3500ft [NM]	Time TOD-3500ft [s]	Fuel TOD-3500ft [kg]
June 2015	711	7.74	141.32	1329	381.93
July 2015	731	6.84	140.03	1296	370.09
August 2015	754	8.09	138.75	1307	375.96
TOTAL 2015	**2196**	**7.56**	**140.01**	**1310**	**375.94**
June 2016	373	10.72	132.87	1278	345.42
July 2016	497	9.25	136.68	1286	351.64
August 2016	366	11.48	134.90	1279	346.84
TOTAL 2016	**1236**	**10.36**	**135.01**	**1282**	**348.34**

Table 6-4 Overall results of the FDR data analysis

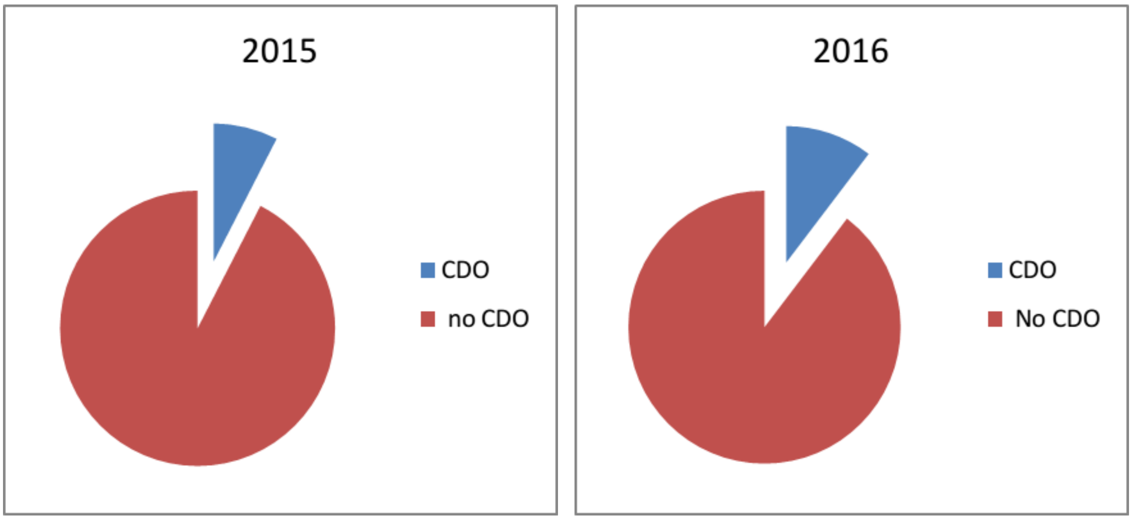


Figure 6-14: Percentage of Continuous Descent Operations

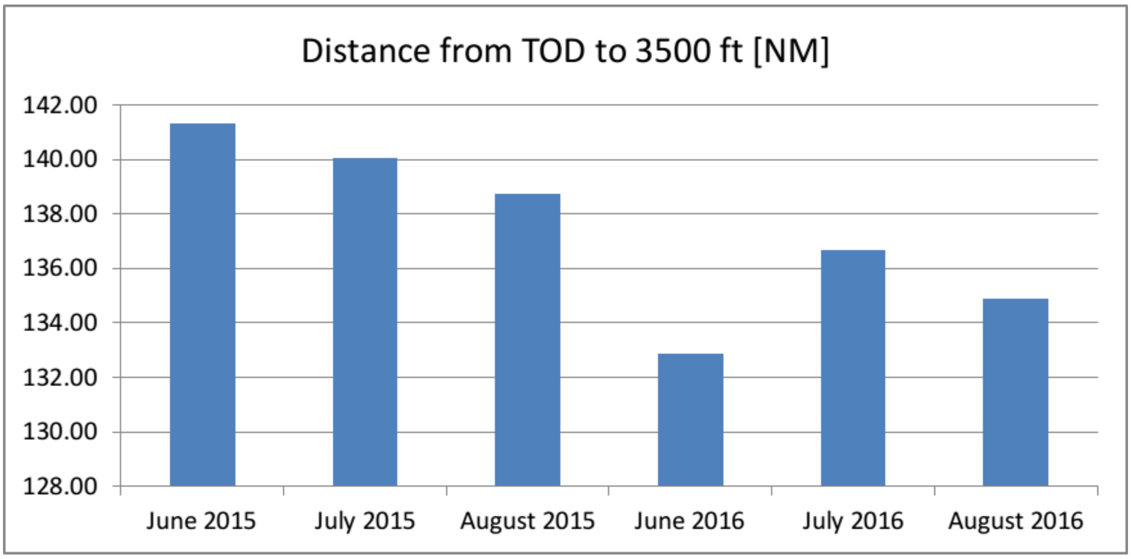


Figure 6-15: Distance travelled from TOD to ALT = 3500 ft

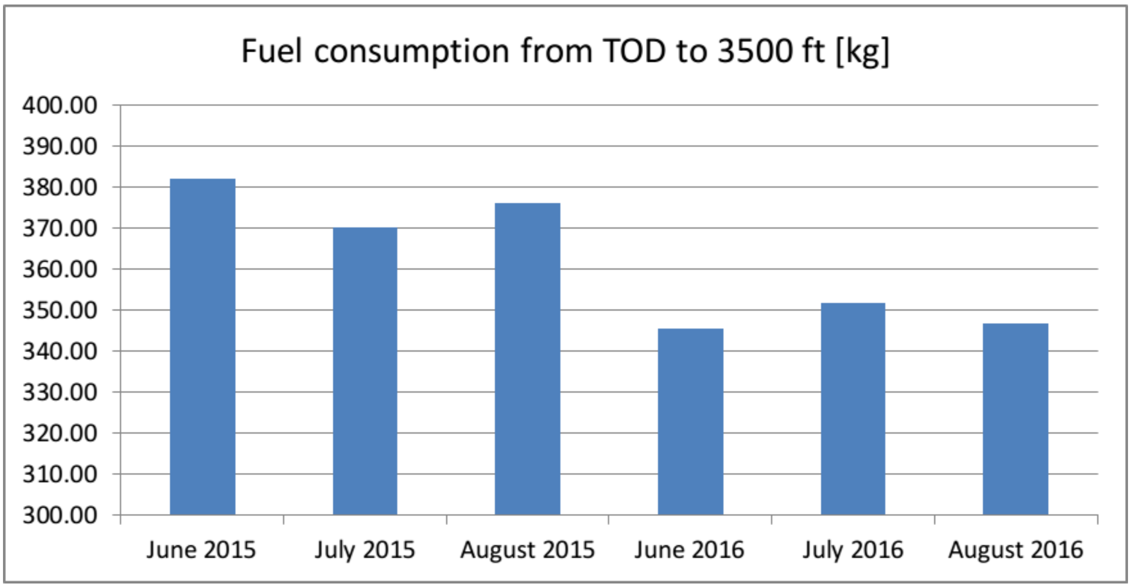


Figure 6-16: Fuel consumption from TOD to ALT = 3500 ft

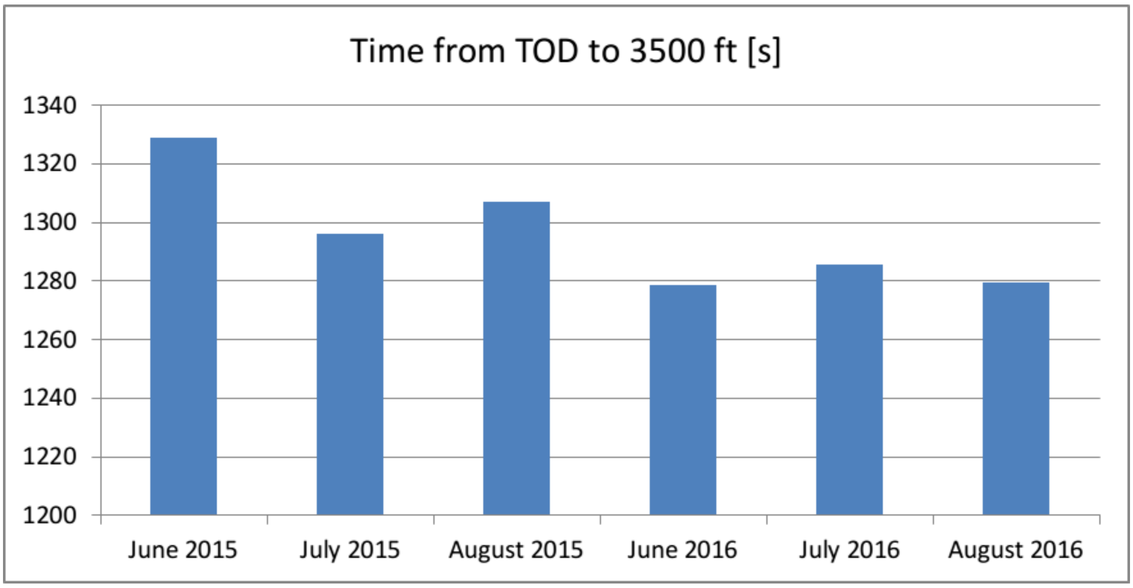


Figure 6-17: Time spent from TOD to ALT = 3500 ft

After publishing the T-bar:

KPI	Effect
Percentage of CDOs	+2.8 percentage points (+37.04 %)
Mean distance from TOD to ALT = 3500 ft	-5 NM (-3.57 %)
Mean time from TOD to ALT = 3500 ft	-28 s (-2.14 %)
Mean fuel consumption from TOD to ALT = 3500 ft	-27.6 kg (-7.34 %)

Table 6-5 T-bar effect on the mean values of all KPIs

6.1.3.1.4.1.1 Conclusions

The improvement in the sequencing of arrivals associated to the new T-bar is observed in terms of fuel consumption (-27.6 kg/descent), due to an increase in the percentage of CDOs and a decrease of both the traveled distance and the time elapsed from TOD to ALT = 3500 ft.

6.1.3.2 EXE-02.10-D-001.2

A summary of EXE-02.10-D-001.2 can be found in section 6.1.3.3 and the corresponding Annexes.

6.1.3.3 Summary of Exercise Results

Table 6-6: Results per KPA for exercise EXE-02.10-D-001

Exe.	Objective	KPA	KPI	Hypothesis		Measurement method	Result		Requirement	Refrence
EXE-02.10-D-001.1	**OBJ-02.10-01** Deployment of T-Bar Procedures and CDO Enhancement Tool for full CDO implementation in LHBP.	**Cost-efficiency**	Amount of fuel carried	HYP-02.10-01	Aircrafts performing CDO via T-bar procedures carry less unnecessary fuel, because their fuel calculation is based on shortest possible arrival routes.	Analythical estimation using IFSET (ICAO Fuel Savings Estimation Tool)	Confirmed	Analysis shows that on average the fuel savings with the shorter arrival routes could be up to 208,7 kg per flight, taken into consideration the typical fleet that frequents LHBP and the typical flight characteristics of those. This sum saving can be broken down to two components. First, 74% of the saving comes directly from planning for the shorter route. The other 25% comes from the fact that less fuel needs to be carried all along the flight due to the calculation.	In order to realize these benefits, the shortest route possible should be published, therefore be the basis for fuel planning. This requirement could work especially well in a free route environment where shortest available route is the general practice.	HungaroControl IFSET study
			Amount of fuel burnt on arrival route	HYP-02.10-02	Aircrafts performing CDO burn less fuel on average than aircrafts on non-CDO routes (regardless of other factors), becasue of shorter and more predictable routes, and the preferable descent characteristics based on early ToD information.	1. Calculation of average fuel consumption from ToD till 3500' based on QAR data. 2. Pilot interviews	Confirmed	It can be concluded from the data that airlines were able to use less fuel between ToD and 3500' in the demonstration period than the reference period (375,94 kg compared to 348,34 kg). In our sample population, majority of pilots claimed that ATC supported CDO effectively.		6.1.3.1.4 A 2.5.1 A 2.5.2
				HYP-02.10-03	Aircrafts on T-bar approach are less likely to go around because of more predictable procedure and longer distance for stabilization.	1. Pilot interviews 2. Statistical data about go-arounds in the demonstration and in the reference period (JUN-JUL2015).	Confirmed	Statistical data and pilots confirmed that as a result of the longer final on the T-bar, less go-around procedures are necessery, which means avoiding some extra fuel burnt.	Long final is preferable for stabilization, but can not be a trade-off for adding otherwise unnecessary extra track miles.	A 2.9.1-2

Exe.	Objective	KPA	KPI	Hypothesis		Measurement method	Result		Requirement	Refrence
EXE-02.10-D-001.1	**OBJ-02.10-01** Deployment of T-Bar Procedures and CDO Enhancement Tool for full CDO implementation in LHBP.	**Environment**	Amount of CO2 emission	HYP-02.10-04	Pilots on the optimal descent profile do not apply extra thrust, therefore fuel consumption and the correlated CO2 emissions decrease compared to previous procedures.	Calculation of CO2 consumption from ToD till 3500' (or less) based on QAR data.	Confirmed	CO2 emmission is calculated based on the fuel consumption described at HYP-02.10-02, so the decrease in fuel used directly implies decrease in CO2 emission.		6.1.3.1.4
			Noise pollution	HYP-02.10-05	When flying an RNAV based approach procedure, (especially when no extra thrust is given during the descent), the noise pollution caused by the aircraft is deminished.	Study on noise impact of new procedures.	Confirmed	Result of the study shows that implementing the T-bar concept will not change the noise pollution in the area significantly. This comes after observing the changes in the dispersion of tracks in the TMA which is expected to be less deviant from the previous routes. However, more concentration along the tracks means larger noise pollution under the affected areas. Together with the implementation of the T-bar, altitude constraints were also put in place at the base points of the T-bar. These constraints are relevant from a noise mitigation point of view as they secure a significant distance between the source of the noise and the immission point. This distance guarantees that noise from the aircraft does not exceed the communal background noise level.	The benefit is realized when the flyability of the routes is validated and a considerable amount of the traffic is capable of flying those procedures.	HungaroControl study about the effect of T-bar concept on the noise pollution
		Safety	Workload	HYP-02.10-06	There is no significant change to pilot workload as a result of the new procedures.	Pilot interviews	Partially confirmed	A significant portion of pilots said that there is no change in the workload. Those pilots who felt otherwise gave reasons for the workload increment that are closely related to the accustomization to the new procedure (learning new waypoint names, expecting to get the old shortcuts etc.)	The learning curve should be taken into account when measuring both ATCO and pilot performance on CDO.	A 2.6.1 A 2.7.3

Exe.	Objective	KPA	KPI	Hypothesis		Measurement method	Result		Requirement	Refrence
EXE-02.10-D-001.1	**OBJ-02.10-02** Demonstrating capabilities and limitations of restructured TMA routes and the application of T-bar procedures together with CDO enhancement tool	Safety	Workload	HYP-02.10-07	Traffic can be conveniently managed based on T-bar concept. CDO support will not create extra workload when promoted in a T-bar environment.	ATCO interviews	Confirmed	Dominant ATCO opinion is that concept behind T-bar is appropriate and is able to serve its purpose.	T-bar implementation needs to take into consideration local airspace characteristics and also airline requirements. In order to guarantee the benefits of a predictable closed route.	A 1.2.1-3
		Safety	Workload	HYP-02.10-08	The CDO enhancement tool is conceptually a usefull tool to help sequencing traffic and support CDO efficiently at the same time.	ATCO interviews	Confirmed	Majority of ATCOs claim that the concept is appropriate.	As a requirement for the implementation of the concept, the tool needs to be integrated into the main radar HMI, and regular update are also necessary.	A 1.3
		Safety	Workload, Stress	HYP-02.10-09	Use of CDO tool reduces ATCO workload and stress that is associated with CDO support, therefore can lead to efficiency gains.	ATCO interviews	Not consistent	ATCO opinion is not consistent. Half of the ATCOs claim that the use of the tool does not effect workload. Another 42% stated that workload can be decreased after proper implementation. Regarding stress, only 25% share the opinion that the tool has potential to reduce stress factor, others does not see any impact.	If the support tool integrated in the main radar HMI, the workload benefits might be realized.	A 1.4.1-2 A 1.5.2

Exe.	Objective	KPA	KPI	Hypothesis		Measurement method	Result		Requirement	Refrence
EXE-02.10-D-001.2	**OBJ-02.10-03** Demonstrate the potential in efficiently substituting current separation tools with CDO enhancement tool in the en-route phase in order to achieve benefits on workload.	Safety	Workload	HYP-02.10-10	Assuming the en-route traffic characteristics, the use of CDO supporting tool is limited to a typical traffic load.	ATCO questionnaires	Confirmed	Majority of the ATCOs have the opinion that the supporting tool can be efficiently used in medium traffic load (generally 4-7 a/c procedding to the same exit point). If the traffic is less, the ATCO can easily do the necessary calculations based on simple measuring tools of the ATM system. If the traffic is greater, the ATCO has other priorities than CDO support. The usability of the tool is correlated not just to the traffic load, but traffic characteristics as well.	Such tool is most likely to bring the expected benefits in en en-route environment, were traffic has a typical direction of flow, with not significant crossing traffic, and the exit point (or other reference point for sequencing) has a fix altitude constraint.	A 3.2.1 A 3.6
		Safety	Workload	HYP-02.10-11	The CDO enhancement tool is easy to use, it gives shows the necessary information to ATCOs in an efficient manner.	ATCO questionnaires	Partially confirmed	Majority of the ATCOs do not consider the use of the tool demanding. However, a group of ATCOs reported that understanding the data shown requires some extra effort.	The data shown on the dashboard should be self-explanatory and intuitive. Different time of data is suggested to have a designated colour (speen info - yellow, distance - blue etc.) FL filter is also recommended in the tool.	A 3.3.1-4 A 3.4.5 A 3.4.6
		Safety	Workload	HYP-02.10-12	The CDO support tool is constantly monitoring a special sequencing situation, therefore it decreases the number of necessary measurements on the main radar screen.	ATCO questionnaires	Not consistent	With the current demonstration setup, most ATCOs did not experience the expected benefit of less measurement on the radar screen (with speed vector, QDM etc.) This result can be a sideeffect of ATCOs constantly making control measurements on the main ATM system to test the capabilities of the tool.	The information shown on the screen should be reliable, frequent adjustments ('jumping plot') should be avoided.	A 3.5.5
		Safety	Situational awareness	HYP-02.10-13	The supporting tool should not drive the attention to that specific problem to an unexpectable extent.	ATCO questionnaires	Confirmed	ATCOs were able to maintain their overall situational awareness, they were not caught up in this particular traffic situation.	Situational awareness can be further improved, if not dislayed on a separate screen, but as a selectable part of the main radar screen.	A 3.4.1-6
		Safety	Confidence in the system	HYP-02.10-14	ATCOs are confident about the validity of the distance and sequence information provided by the tool, therefore willing to use it.	ATCO questionnaires	Partially confirmed	Sequencing information appears to be reliable to the majority of ATCOs. The reliability of the vertical profile information is accepted by only a third of the ATCOs. This reason behind this is that at the demonstration, the tool was not able to calculate with important variables like wind speed and direction.	In order to provide valid vertical profile data, tool should calculate with wind data and aircraft descent characteristics.	A 3.5.1 A 3.5.2 A 3.5.4

6.1.4 Conclusions and recommendations

To sum up the results of these exercises, it can be stated that Continuous Descend Operations can be effectively supported with the procedural and the software tools that were subject of the demonstration. However, the intensity of the benefits realized were somewhat below the expectations. During the solution scenarios positive impacts were observed both on safety, environment and even cost-efficiency related aspects of CDO. The demonstration team concluded that the results can be further improved with considering the following recommendations.

CDO support could bring the most benefits if implemented with a system-wide approach, not simply altering certain elements, like an arrival procedure. Full potential of CDO can only be achieved if all major elements and stakeholders align their operation to the same principles. For a significant improvement in CDO performance, full airspace and route reconfiguration is necessary to find the shortest, most convenient and predictable arrival routes (i.e. T-bars). This must be the foundation of any further tools that are applied to provide ToD information to pilots as early as possible. Usage of a suitable supporting software (like the CDO enhancement tool used in demonstration) is a great advantage, if the way of implementation and the level of integration enables it to reduce CDO support related ATCO workload efficiently. In order to realize the potential benefits of CDO proper training for pilots and ATCOs are also inevitable, Taken into consideration that CDO support is not the only goal of air traffic control, a trade-off between flying the ideal descent profile and sequencing will always be immanent of the operation, although our main objective is the reduce the conflict between these two goals.

6.2 Demonstration Exercise #2 Report

6.2.1 Exercise Scope

Demonstration Exercise ID and Title	EXE-02.10-D-002.1: RNP Based Operations	
Leading organisation	Pildo Labs in collaboration with HungaroControl	
Demonstration exercise objectives	Design and validate RNP SIDs at Budapest TMA for two runway ends	
High-level description of the Concept of Operations	Integrating RNP-based operations into conventional routes at Budapest. Additionally, it would offer a standardized and harmonized approach to CCO implementation and facilitation	
Applicable Operational Context	Budapest TMA Budapest TWR	
Expected results per KPA	Environment	Noise mitigation and CCD operation
	Safety	Positive effects
	Cost-efficiency	Lower Costs (potential dismantle of unnecessary ground-based Navaid equipment)
Number of flight trials	2 flight trials have validated the SID procedure	
Related projects in the SESAR Programme	02.05 NASCIO	
OFA addressed	02.01.01 Optimised RNP Structures 02.02.04 Approach Procedures with Vertical Guidance	

Demonstration Exercise ID and Title	EXE-02.10-D-002.2: RNP Based Operations	
Leading organisation	Pildo Labs in collaboration with HungaroControl	
Demonstration exercise objectives	Design, validate and publish RNP APCH (LNAV, LNAV/VNAV and LPV) at Budapest Airport for the four runway ends. Integrate RNP APCH with T-bar based procedures designed in EXE-02.10-D-001 CDO Enhancement Tool	
High-level description of the Concept of Operations	Integrating RNP-based operations into conventional routes at Budapest. Additionally, it would offer a standardized and harmonized approach to CCO implementation and facilitation	
Applicable Operational Context	Budapest TMA Budapest TWR	
Expected results per KPA	Environment	- Less go-around due to lower minima - Less alternate airport usage
	Safety	Positive effects due to vertical guidance
	Cost-efficiency	Lower Costs (potential dismantle of unnecessary ground-based Navaid equipment)
Number of flight trials	10 flight trials have been performed	
Related projects in the SESAR Programme	02.05 NASCIO	
OFA addressed	02.01.01 Optimised RNP Structures 02.02.04 Approach Procedures with Vertical Guidance	

Table 6-7: Summary of the scope for RNP Based Operations

6.2.2 Conduct of Demonstration Exercise EXE-02.10-D-002

6.2.2.1 Exercise Preparation

The activities carried out to prepare the execution of the demonstration activity are:

6.2.2.1.1 Flight Procedure Design

A set of procedures have been designed at Budapest Airport (LHBP) by Pildo within BUDAPEST 2.0 Project:

- RNP APCH to LNAV, LNAV/VNAV and LPV minima to RWYs 13R/L and 31R/L
- RNP-1 SID from RWYs 31L and 31R

6.2.2.1.2 Ground Validation

A ground validation process has been performed confirming the accuracy of the data used in the procedure design process, the correct procedure design criteria application and the fulfilling of the requirements from the stakeholders.

After a successful stage, the procedure design package was generated (including the charts, coding information and FAS-DB if applicable) and the procedure was coded into the validation platform database in order to perform the demonstration flights.

6.2.2.1.3 Coordination between ATS Units

The coordination tasks between ATS units and airport management was performed by HungaroControl before initiating the flight campaign. Coordination with the Aircraft Operator was established by Pildo Labs with HungaroControl's support.

6.2.2.1.4 Tools and Demonstration techniques

This section describes the tools, equipment and aircraft used to execute the EXE-02.10-D-002 exercise:

- Procedure Design Tools: ProDAN (Procedure Design for Air Navigation), the AutoCAD plugin developed by Pildo, and PDS (Procedure Design Spreadsheets) were used for procedure design tasks.
- Flight Validation equipment: PLATERO, the flight validation platform developed by Pildo was installed inside the aircraft to perform the flights, providing to the pilot in an EFIS look-alike display the deviations from the trajectory of the designed procedures coded in the platform software database. The data collected by PLATERO was post-processed to obtain the deviations during the flight.

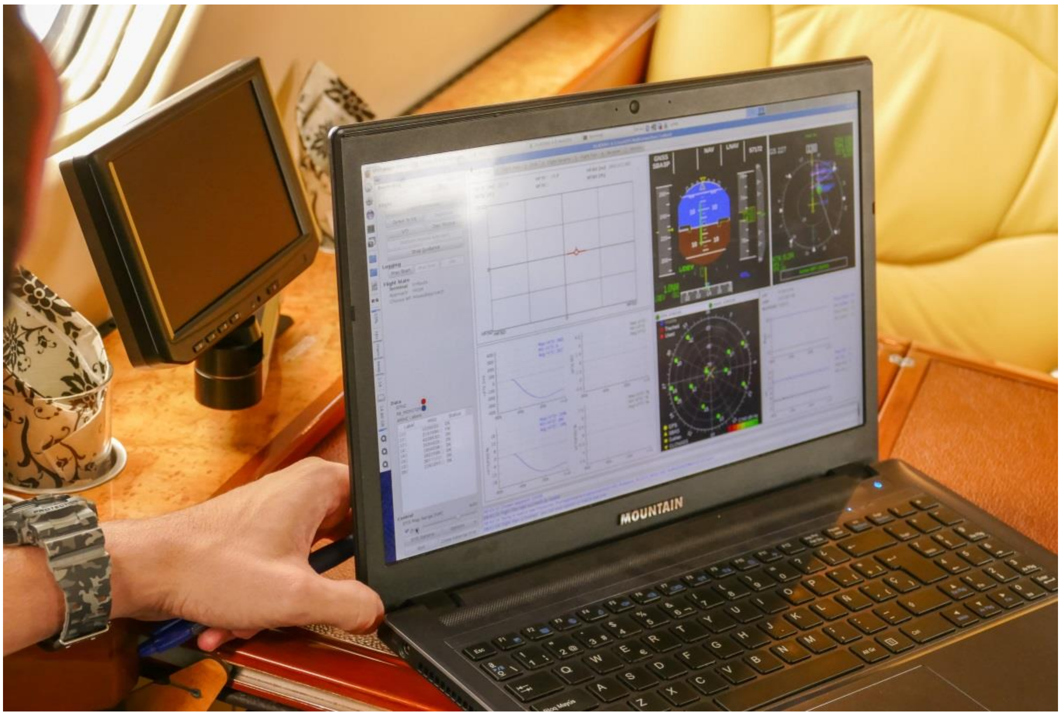


Figure 6-18: Flight engineer laptop during LHBP flight campaign

- Aircraft: a Cessna C-650 Citation III was equipped with Pildo Labs flight validation platform: PLATERO and was used for the flight validation of the procedures designed.

Figure 6-19: JetStream Cessna C-650 Citation III

6.2.2.2 Exercise execution

The activities included in the exercise execution are the pre-flight briefing, the demonstration flight and data collection, and finally, flight data processing and post-flight briefing.

A pre-flight briefing between the pilots and Pildo staff has been done to analyse the procedure design, define a specific flight validation plan and present the flight validation platform. The flight validation presented to the Pilots can be found below:

1 Round – Departure from RWY 13R (06:30 LT)			
Manoeuvre	**Distance (NM)**	**Approx. time (min)**	**Accum. time (min)**
A/C positioning for 13R departure			
• After departure proceed to KESID via BP007 and BP006, climb to 5000’ AMSL	30	(240) 7.5	7.5
• KESID RNAV approach RWY 13R (touch & go) and MA	50	(210) 14.3	36.1
• KESID RNAV approach RWY 13R (1/2 scale down) and full stop landing	20	(210) 5.7	41.8
• taxi to RWY 13L	*(repositioning to holding point K)*		

2 Round – Departure from RWY 13L (07:30 LT)			
Manoeuvre	**Distance (NM)**	**Approx. time (min)**	**Accum. time (min)**
A/C positioning for 13L departure			
• After departure proceed to GIGAN via BP017 and TPS, climb to 5000’ AMSL	30	(240) 7.5	7.5
• GIGAN RNAV approach RWY 13L (touch & go) and MA	50	(210) 14.3	21.8
• GIGAN RNAV approach RWY 13L (1/2 scale down) and full stop landing	20	(210) 5.7	27.5
• taxi to RWY 31L - RWY direction changing	*(repositioning to holding point A2)*		

3 Round – Departure from RWY 31L (08:00 LT)			
Manoeuvre	**Distance (NM)**	**Approx. time (min)**	**Accum. time (min)**
A/C positioning for 31L departure			
• DEMO SID from RWY 31L to KESID, climb to 7000’ AMSL	20	(210) 5.7	5.7
• from KESID proceed to RESDI, descend to 4000’ AMSL	30	(240) 7.5	13.2
• RESDI RNAV approach RWY 31L (DH 200’) and MA	50	(210) 14.3	27.5
• RESDI RNAV approach RWY 31L (touch & go)	50	(210) 14.3	41.8
• RESDI RNAV approach RWY 31L (1/2 scale down) and full stop landing	20	(210) 5.7	47.5
• taxi to RWY 31R	*(repositioning to holding point X)*		

4 Round – Departure from RWY 31R (09:00 LT)			
Manoeuvre	**Distance (NM)**	**Approx. time (min)**	**Accum. time (min)**
A/C positioning for 31R departure			
• DEMO SID from RWY 31R to GIGAN, climb to 7000' AMSL	20	(210) 5.7	5.7
• from GIGAN proceed to DIVOX, descend to 4000' AMSL	30	(240) 7.5	13.2
• DIVOX RNAV approach RWY 31R (DH 200') MA	40	(210) 11.5	24.7
• DIVOX RNAV approach RWY 31R (touch & go)	40	(210) 11.5	36.2
• DIVOX RNAV approach RWY 31R (1/2 scale down) full stop landing	20	(210) 5.7	41.9
• taxi to GAT	*(task completed at 10:00 LT)*		

Manoeuvre	Distance (NM)	Average speed (KIAS)	Accum. time (min)
TOTAL	**570**	**210**	**160**

Table 6-8: Flight Validation Plan

The number of flights performed in this scenario and the date of execution are depicted in the following table:

Procedure	Number of flights	Exercise Execution date
RNP APCH to LHBP RWY 13L	2	05/07/2016
RNP APCH to LHBP RWY 13R	2	05/07/2016
RNP APCH to LHBP RWY 31L	3	05/07/2016
RNP APCH to LHBP RWY 31R	3	05/07/2016
SIDs from LHBP RWY 31L	1	05/07/2016
SIDs from LHBP RWY 31R	1	05/07/2016

Table 6-9: EXE-02.10-D-002 number of flights

Finally, a post-flight briefing between the pilots and Pildo engineers was held to evaluate the flyability and the level of confidence of the tested procedures.

6.2.2.3 Deviation from the planned activities

No major deviations with respect to the panned activities described in the Demonstration Plan [1] have been identified during the execution of EXE-02.10-D-002. However,

6.2.3 Exercise Results

6.2.3.1 Summary of Exercise Results

This section presents the tangible results of the exercise execution: the procedure design package and the demonstration flights processed data, which includes the flight path of each procedure and a graphical representation of the deviations from the designed trajectory.

6.2.3.1.1 Procedure design package

All the information about the procedure design package (charts, coding information and FAS-DB if applicable) can be found in Appendix A.

6.2.3.1.2 Flight trajectory and deviations

This subsection includes the data processed after performing the demonstration flights: the flight trajectory over the terrain and a graphical representation of the horizontal and vertical FTE (pilot deviation) along all the procedure and a zoom into the final approach segment (FAS).

6.2.3.1.2.1 RNP APCH to RWY13L of LHBP airport

6.2.3.1.2.1.1 RNAV (GNSS) RWY13L approach from GIGAN (touch and go and missed approach)

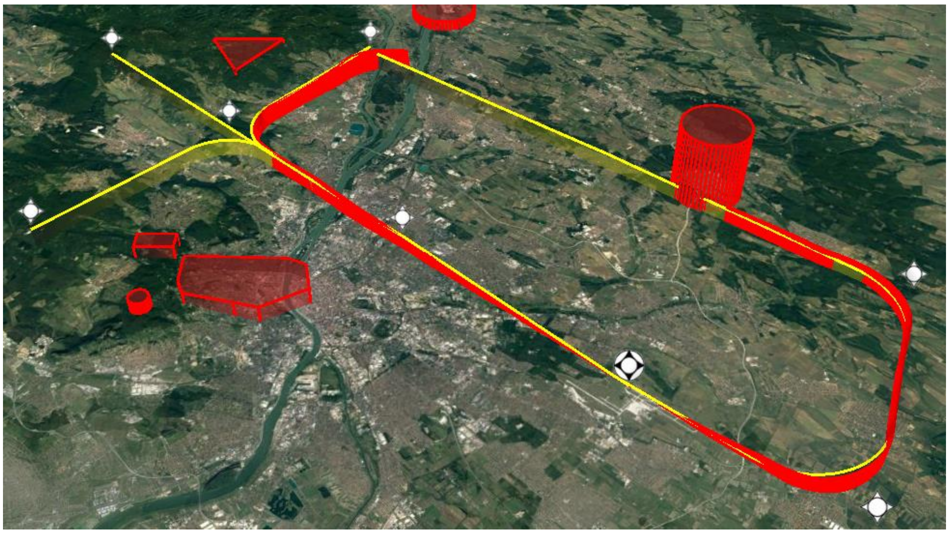


Figure 6-20: RNAV (GNSS) RWY 13L approach from GIGAN (touch and go and MA) trajectory

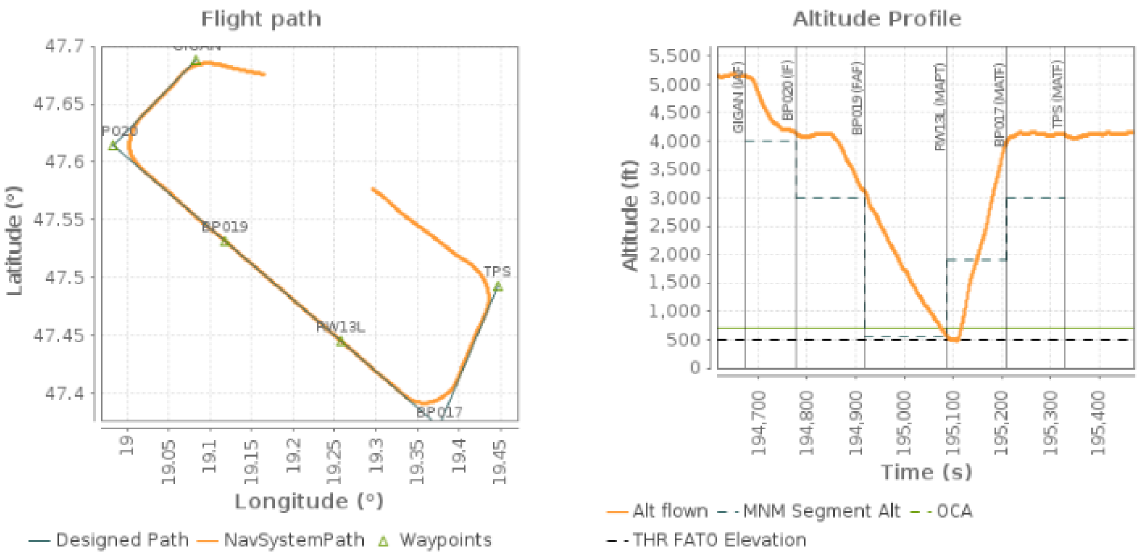


Figure 6-21: RNAV (GNSS) RWY13L approach from GIGAN (touch and go and MA) flight path analysis

6.2.3.1.2.1.2 RNAV (GNSS) RWY13L approach from GIGAN (half scale down)

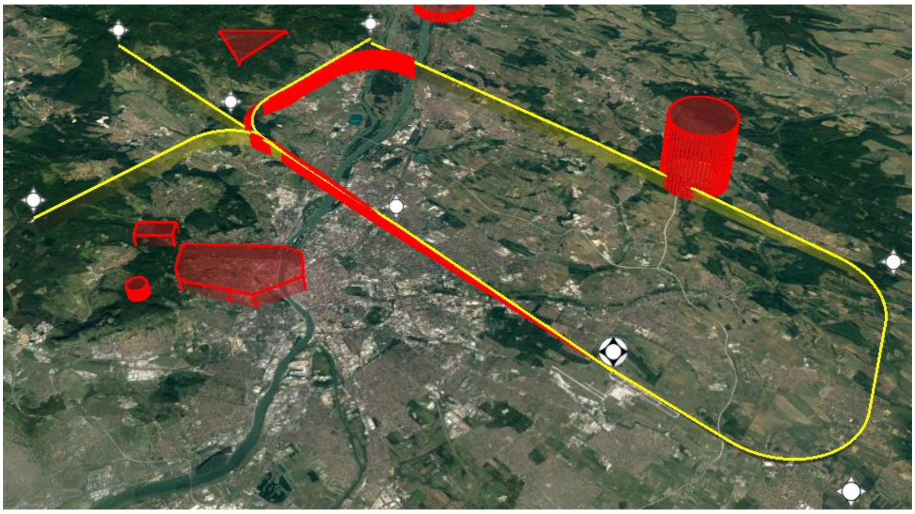


Figure 6-22: RNAV (GNSS) RWY13L approach from GIGAN (half scale down) trajectory

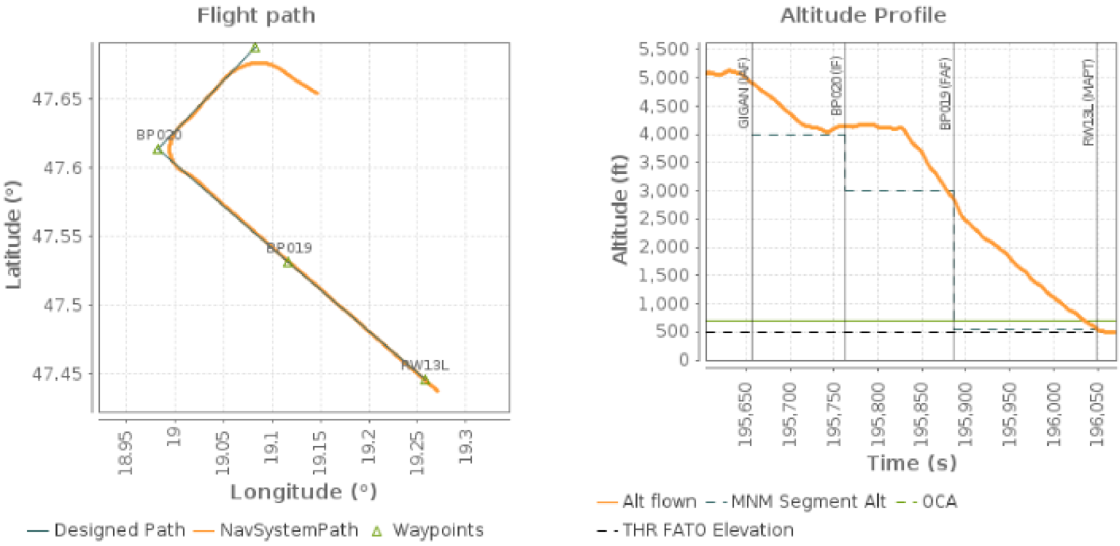


Figure 6-23: RNAV (GNSS) RWY13L approach from GIGAN (half scale down) flight path analysis

6.2.3.1.2.2 RNP APCH to RWY13R of LHBP airport

6.2.3.1.2.2.1 RNAV (GNSS) RWY13R approach from KESID (touch and go and Missed approach)

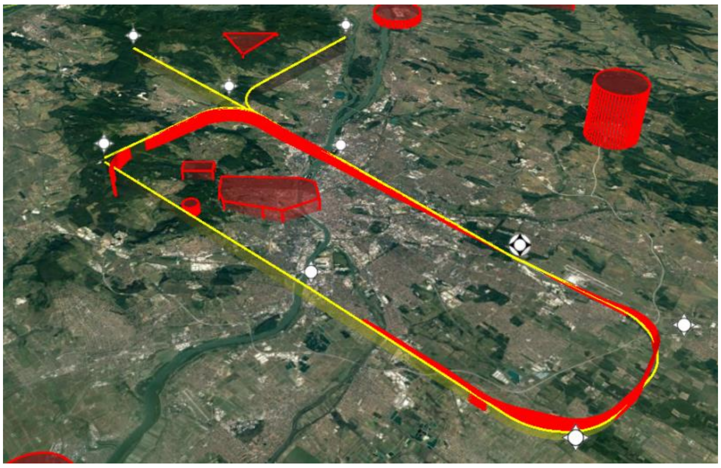


Figure 6-24: RNAV (GNSS) RWY13R approach from KESID (touch and go and MA) trajectory

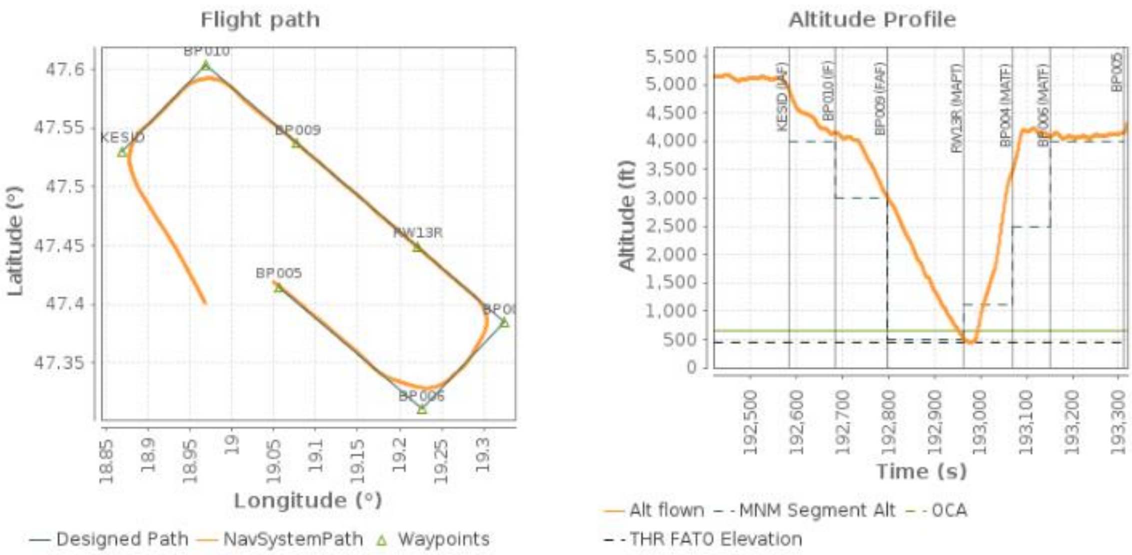


Figure 6-25: RNAV (GNSS) RWY13R approach from KESID (touch and go and MA) flight path analysis

RNAV (GNSS) RWY13R approach from KESID (half scale down)

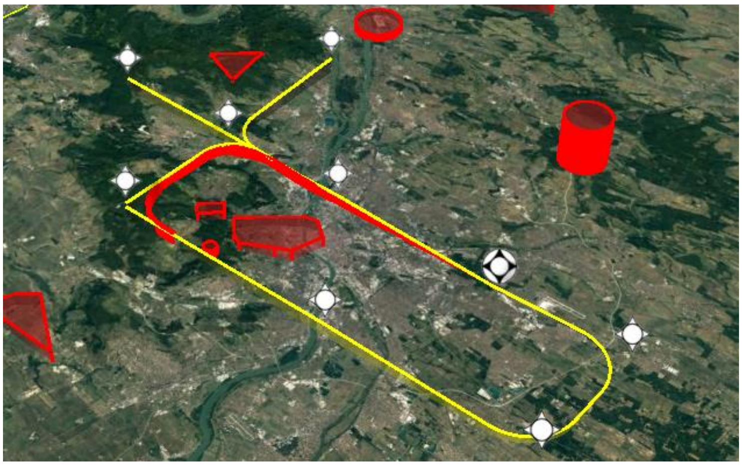


Figure 6-26: RNAV (GNSS) 13R approach from KESID (half scale down) trajectory

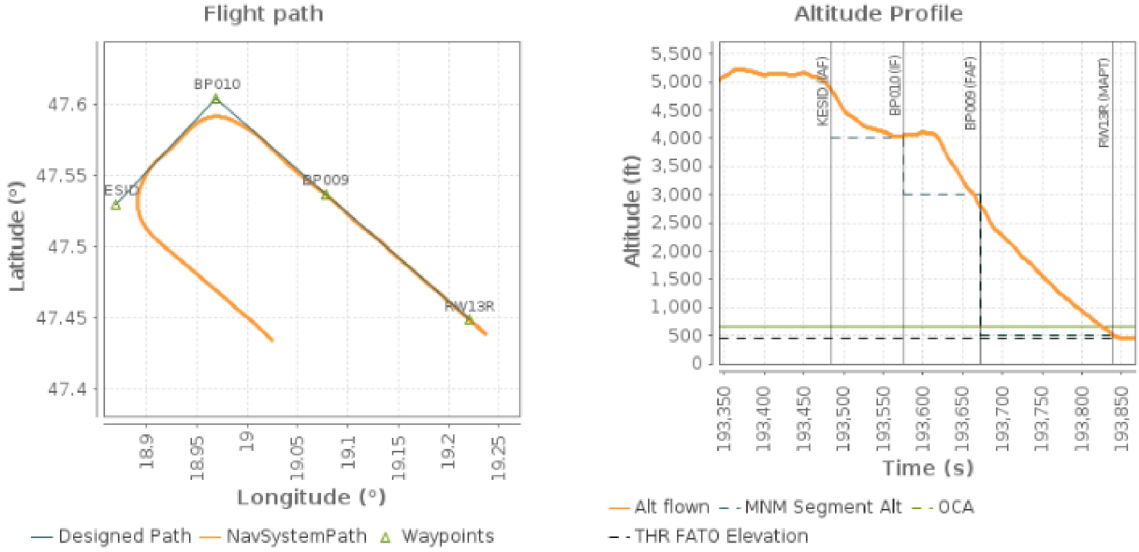


Figure 6-27: RNAV (GNSS) RWY13R approach from KESID (half scale down) flight path analysis

6.2.3.1.2.3 RNP APCH to RWY31L of LHBP airport

6.2.3.1.2.3.1 RNAV (GNSS) RWY31L approach from RESDI (not full MA)

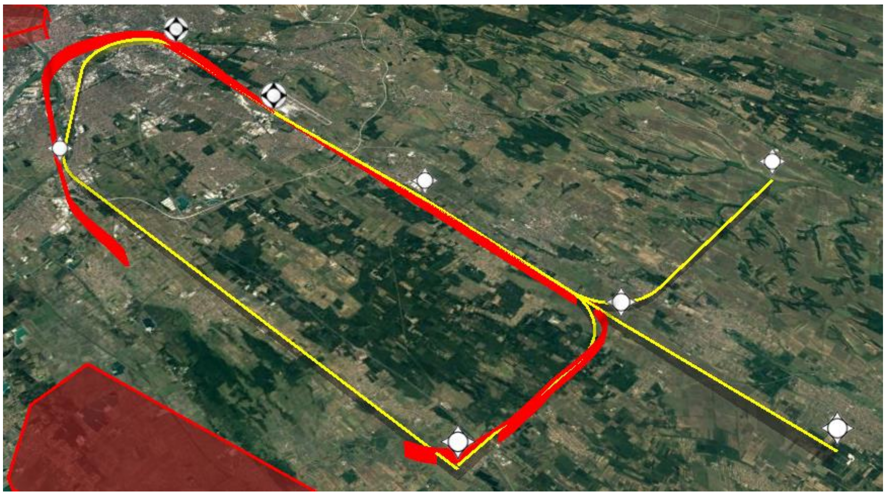


Figure 6-28: RNAV (GNSS) RWY31L approach from RESDI (not full MA) trajectory

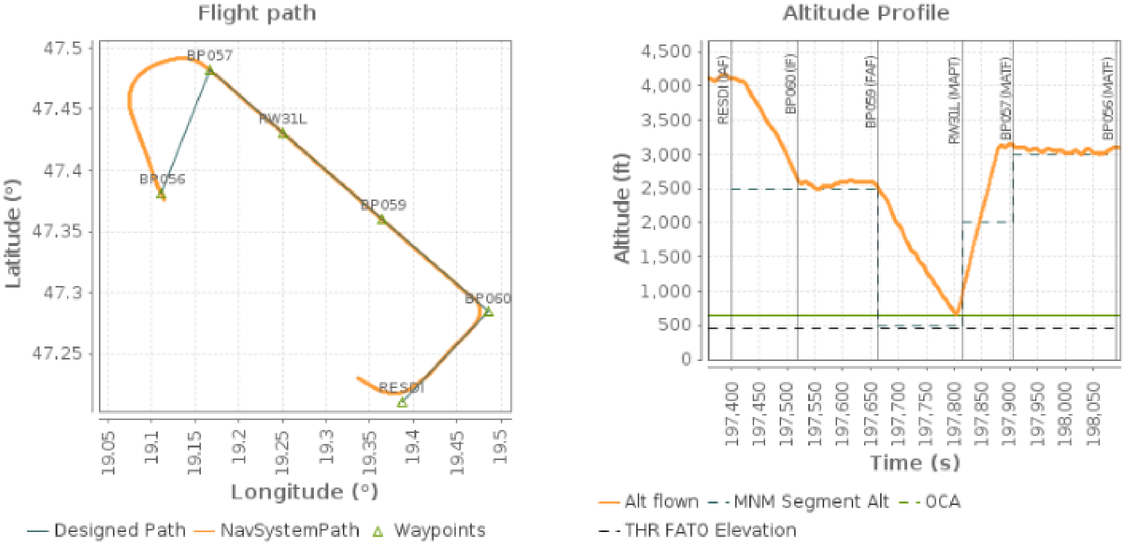


Figure 6-29: RNAV (GNSS) RWY31L approach from RESDI (not full MA) flight path analysis

6.2.3.1.2.3.2 RNAV (GNSS) RWY31L approach from RESDI (touch and go)

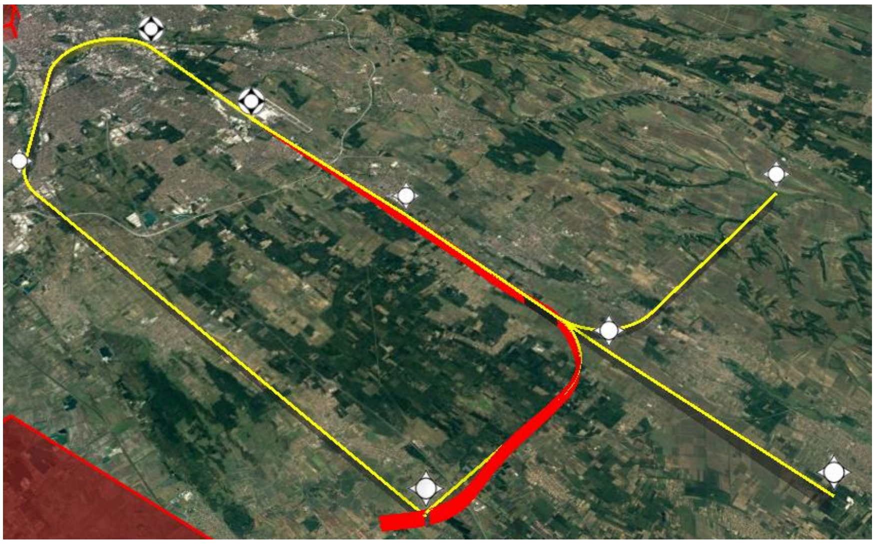


Figure 6-30: RNAV (GNSS) RWY31L approach from RESDI (touch and go) trajectory

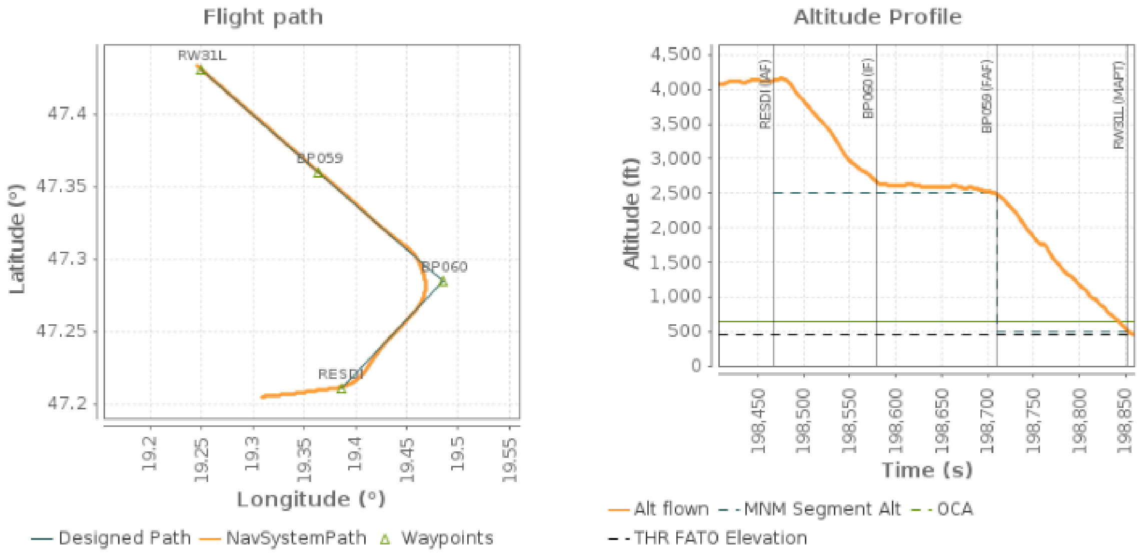


Figure 6-31: RNAV (GNSS) RWY31L approach from RESDI (touch and go) flight path analysis

6.2.3.1.2.3.3 RNAV (GNSS) RWY31L approach from RESDI (half scale down)

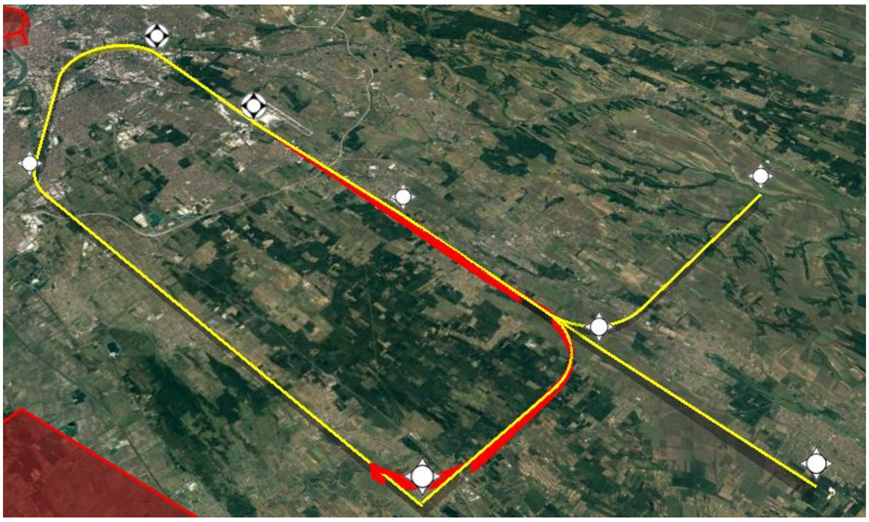


Figure 6-32: RNAV (GNSS) RWY31L approach from RESDI (half scale down) trajectory

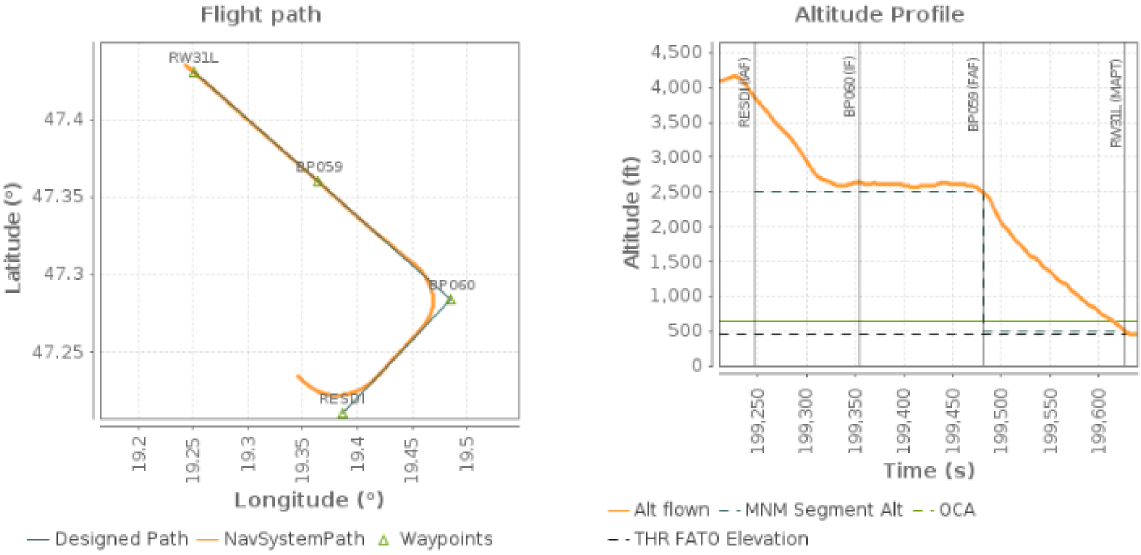


Figure 6-33: RNAV (GNSS) RWY31L approach from RESDI (half scale down) flight path analysis

6.2.3.1.2.4 RNP APCH to RWY31R of LHBP airport

6.2.3.1.2.4.1 RNAV (GNSS) RWY31R approach from DIVOX (not full MA)

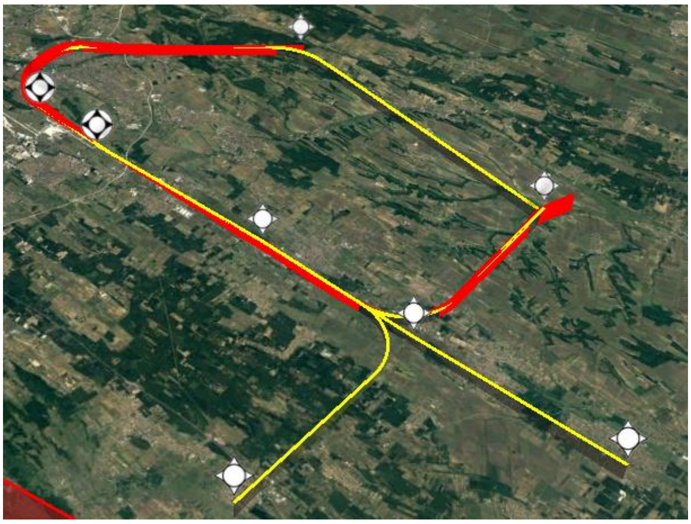


Figure 6-34: RNAV (GNSS) RWY31R approach from DIVOX (not full MA) trajectory

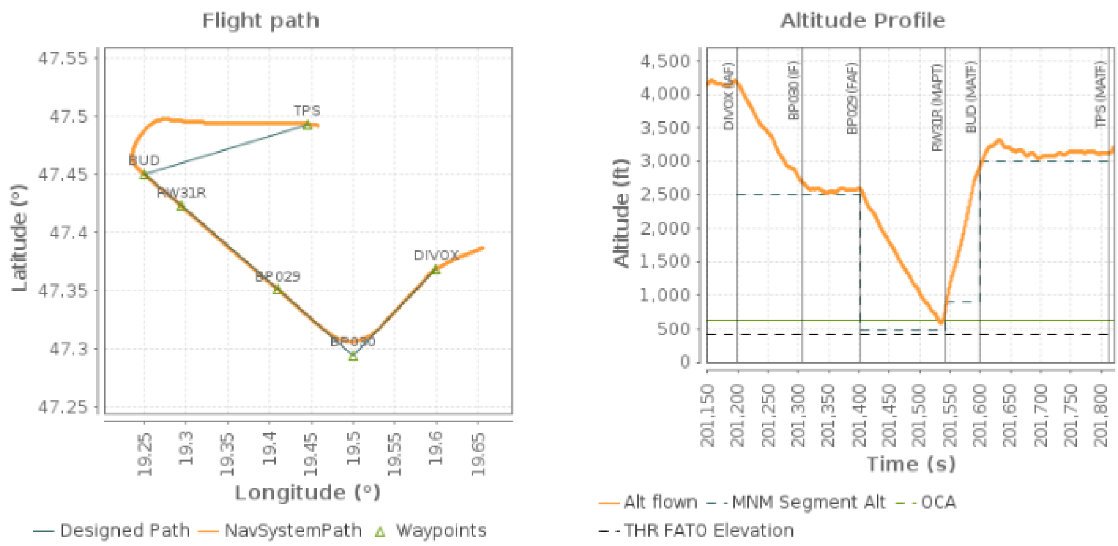


Figure 6-35: RNAV (GNSS) RWY31R approach from DIVOX (not full MA) flight path analysis

6.2.3.1.2.4.2 RNAV (GNSS) RWY31R approach from DIVOX (touch and go)

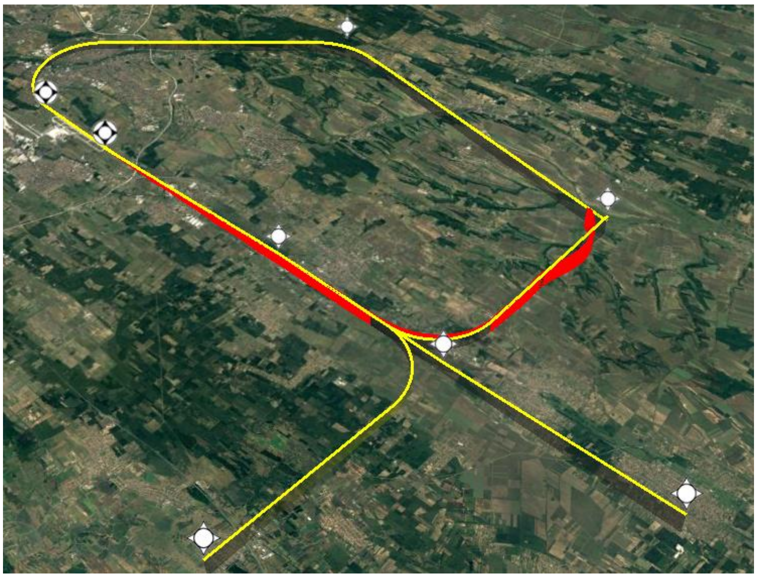


Figure 6-36: RNAV (GNSS) RWY31R approach from DIVOX (touch and go) trajectory

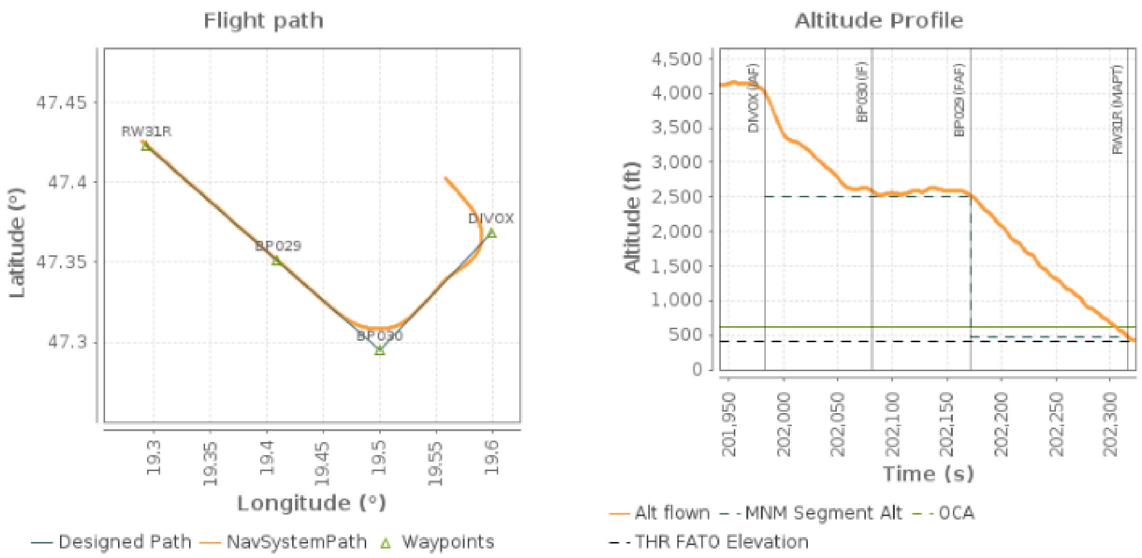


Figure 6-37: RNAV (GNSS) RWY31R from DIVOX (touch and go) flight path analysis

6.2.3.1.2.4.3 RNAV (GNSS) RWY31R from DIVOX (half scale down)

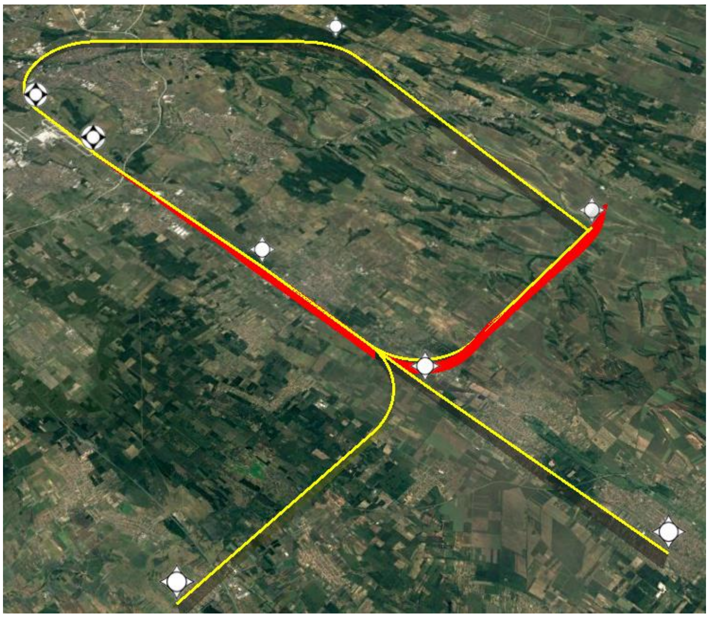


Figure 6-38: RNAV (GNSS) RWY31R DIVOX (half scale down) trajectory

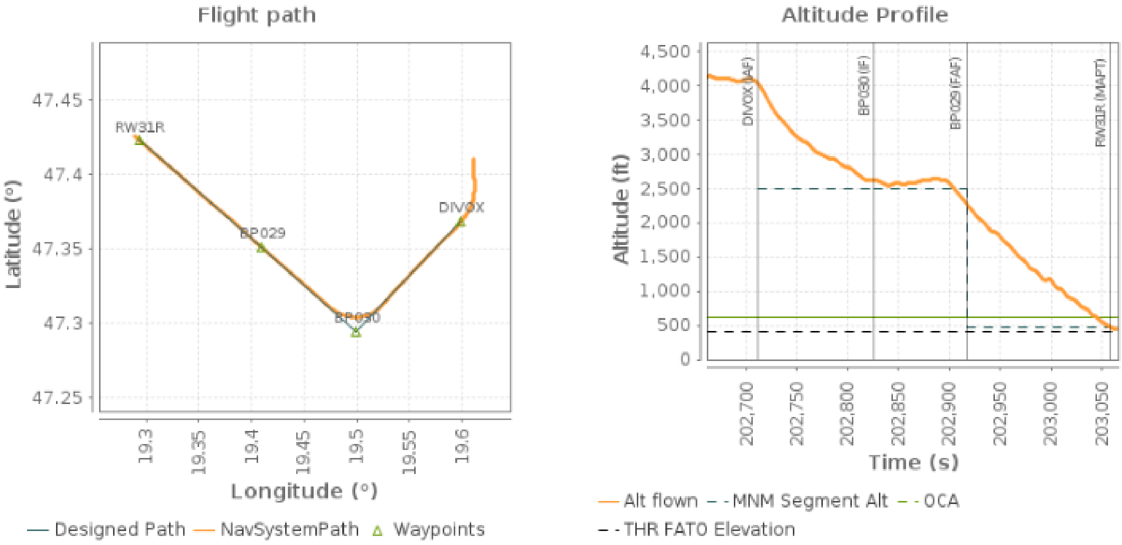


Figure 6-39: RNAV (GNSS) RWY31R DIVOX (half scale down) flight path analysis

6.2.4 Results per KPI

6.2.4.1 Flyability of the procedures

A successful flyability assessment is the result in this area, according to the subjective evaluation of the pilot based on the feedback of conversations held during and after the flights and the average deviations obtained after processing the flight data.

The average of the deviations (for approach procedures, the average corresponds to the final approach segment (FAS), where the vertical deviations are computed) is depicted in the following table:

Procedure	Average Horizontal Deviation (m)	Average Vertical Deviation (m)
RNP APCH to LHBP RWY 13L	11	4
RNP APCH to LHBP RWY 13R	17	4
RNP APCH to LHBP RWY 31L	10	4
RNP APCH to LHBP RWY 31R	11	4

Table 6-10: Average flight deviations

6.2.4.2 Degree of satisfaction of pilots

The degree of satisfaction of the pilots was very high according to the feedback received from the questionnaires filled by the pilots.

6.2.5 Conclusions and recommendations

6.2.5.1 Conclusions

The exercise has been successfully performed. The RNP APCH procedures have been published in the Hungarian AIP in September 2016 and the RNP SID has been successfully tested.

6.3 Demonstration Exercise #3 Report

6.3.1 Exercise Scope

Budapest 2.0 aims to demonstrate a Remote Tower solution and concept of operations for medium size airport users and stakeholders. Demonstration exercise objectives are:

- Single RWY Remote Tower operation: Demonstrating technical capabilities and boundaries of using camera technologies for visual observation of the airport traffic on a single runway
- Dual RWY Remote Tower operation: Demonstrating technical possibilities and limitations of enhancing visual observation by camera technologies on two runways simultaneously

Demonstration Exercise ID and Title	EXE-02.10-D-003.1: Single RWY Remote Tower operation	
Leading organisation	HungaroControl	
Demonstration exercise objectives	Demonstrating technical capabilities and boundaries of using camera technologies for visual observation of medium traffic volume on a single runway.	
High-level description of the Concept of Operations	Duplicating actual ATM-systems and integrating A-SMGCS and camera system including PTZ and fix cameras to demonstrate actual level of capacity and safety	
Applicable Operational Context	Budapest airport Budapest TMA	
Expected results per KPA	Safety	Increase of ATCO situational awareness by providing thermo vision and enhanced visual information
	Capacity	Remote Tower operations should have a positive effect on capacity during Low Visibility conditions, due to the additional information provided by thermo cameras and image enhancement techniques
	Cost-efficiency	Cost of implementing remote tower operation at a medium airport is not higher than the cost of implementing conventional tower operations
Number of flight trials	Data for 62 flights was collected. Shadow operations lasted for 93 hours in aggregate.	
Related projects in the SESAR Programme	Remote Tower Operations - ROT Project ART Project Remote Airport Concept of OperatioN (RACOON) Remote Towers, Shannon and Cork from Dublin	
OFA addressed	06.03.01 Remote Tower	

Demonstration Exercise ID and Title	EXE-02.10-D-003.2: Dual RWY Remote Tower - operations	
Leading organisation	HungaroControl	
Demonstration exercise objectives	Demonstrating technical possibilities and limitations of enhancing visual observation by camera technologies on two runways at a medium-sizes airport environment.	
High-level description of the Concept of Operations	Integrated A-SMGCS and camera system providing common visual references for all ATCO positions on a video-wall and supporting ATCO's responsibilities with role-dependent special views in controllers working positions Presenting thermo vision and daylight video augmented by artificial intelligence.	
Applicable Operational Context	Budapest airport Budapest TMA	
Expected results per KPA	Safety	Increase of ATCO situational awareness by providing thermo vision and enhanced visual information
	Capacity	Remote Tower operations should have a positive effect on capacity during Low Visibility conditions, due to the additional information provided by thermo cameras and image enhancement techniques
	Cost-efficiency	Cost of implementing remote tower operation at a medium airport is not higher than the cost of implementing conventional tower operations
Number of flight trials	Data for 524 flights was collected. Shadow operations lasted 27 hours in aggregate.	
Related projects in the SESAR Programme	Remote Tower Operations - ROT Project ART Project Remote Airport Concept of OperatioN (RACOON) Remote Towers, Shannon and Cork from Dublin	
OFA addressed	06.03.01 Remote Tower	

6.3.2 Conduct of Demonstration Exercise EXE-02.10-D-003

6.3.2.1 Exercise Preparation

A complete operational and technical room have been set up to provide all necessary infrastructure for an ATC service provision. The ops room includes:

Equipment	Purpose	Mode during demonstration
EAVD system	Video processing and presentation in-CWP and at video wall	Active
A-SMGCS	Control and monitor ground movements, partial control AGL system	Active
MATIAS	ATM-system including radar screen, handling flight plans, etc.	Active
VCS	Providing voice communication service	Active
STORNO	Ground/ground communication	Active
AFTN	Flight plan, slot and NOTAM processing	Passive
AWOS	Providing metrological information	Passive
AGL monitoring	Providing information about automated light control system's status	Passive
ILS monitor	Providing information about ILS	Passive
RWY Status Panel	Providing complex information about runway status	Passive
Landline phone	Ground/ground communication	Active

A basic consideration of the Concept of Operation was to create an operational environment that is as close to the current tower environment as it is reasonably possible. This way the major difference is only in the visualization, therefore the observed differences can be easier linked to this aspect and not distorted by changes in other systems. Following this principle, four ATCO positions and 1 supervisor CWP were fully duplicated. All four ATCO positions have the same capabilities and systems but designed to act as an independent and partially responsible role, namely:

- **ADC**: Aerodrome Controller (TWR): Main responsibility is to control aircrafts in CTR, to give clearances concerning the runways and operate runway lights and ILS.
- **TPC:** Tower Planner Controller: Responsible for supporting ADC and GRC with operative planning of traffic (air and ground) controlling ground vehicle movement on the movement area.
- **GRC**: Ground Controller (GRD): Responsible for delivering start-up, push-back and taxi clearances and for operating the taxiway lights.
- **CDC**: Clearance Delivery Controller: Delivering ATC clearances and coordinate slot allocation messages.
- **SV**: Supervisor: Responsible for operative management of the unit.

Figure 6-40: ATCO CWP and view of the videowall

Figure 6-41: Supervisor position with videowall in the background

Visualisation – cameras

According to the requirement written in the demonstration plans fix and PTZ cameras were deployed at Budapest Airport to provide adequate visualization of the aerodrome.

- 14 fix cameras on the tower building covering the majority of the aerodrome
- 3 fix cameras intending to provide special hot spot areas
- 2 PTZ on tower building covering the entire aerodrome and providing binocular functionalities
- 1 PTZ
- 4 fix and a PTZ to cover RWY2 as one of the main area and providing binocular functionalities

Visualisation - presentation

A large flat videowall (8x4 55” LCD) has been built in front of the CWPs to provide common visual reference for all ATCOs and SV. The presentation was designed with ATCOs involvement and contains panoramic and matrix views.

<table>
<tr><td colspan="4">Runway 2</td><td colspan="4">Runway 1</td></tr>
<tr><td colspan="8">306° Panoramic OTW-view</td></tr>
<tr><td>A-SMGCS</td><td>MET</td><td colspan="4">APRON 2</td><td colspan="2">RWY1 take-off zone</td></tr>
<tr><td colspan="2">RWY2 touching zone</td><td>Hot spot</td><td>Hot spot</td><td>Hot spot</td><td>Hot spot</td><td colspan="2">Hot spot</td></tr>
</table>

Figure 6-42: Allocation of video images on the videowall

All PTZ-views were combined into one LCD screen which is presented at every ATCO CWPs. The control of the PTZ can be linked to one CWP to control the PTZ and the other CWP can follow the presented picture. A control can be requested and shall be released by the owner of the PTZ.

An ATCO role-specific monitor is also deployed in every CWP to provide independent visualization of the airport hotspots.

ATCO rostering and ATC manual

Preparations for the demonstration made it inevitable to create a detailed rostering plan to secure the safe provision of service parallel at both locations – conventional tower and remote tower.

HungaroControl's internal ATS manual was amended with a few temporary sections concerning the passive and active shadow operations. Adjustment were made in the following major section (not exclusively):

- Roles and responsibilities, rules of operation during passive and active shadow mode for both units (TWR and rTWR).
- A transition plan that clarifies roles and responsibilities for all relevant parties (operational stuff as well as ATSEPs) and the procedures to follow during transition between TWR and rTWR operations back and forth.
- Specific rules for contingency events.

Training, ATCO licensing and human factors

13 ATCOs were selected to be part of the demonstration team. The team was planned to be representative regarding the typical distribution of ATCOs by age and attitude regarding remote tower. Some of the team members participated from early stages of the project and took part in creating the Concept of Operation, designing and testing of system elements. Other ATCOs joined the demonstration team before the specific training started.

The team went through a week long training where the following topics were covered in detail:

- Controlling the elements of the video system
- Changes in the ATS manual
- Transition plan from conventional operation to remote operation and back
- Contingency plan for demonstration period

After fulfilling the formal training requirements and a certain number of shadow operation ATCOs received a special unit endorsement to their license for the remote tower.

Beyond ATCO training and licencing, HungaroControl placed special attention to all issues concerning the human factor aspects of the operation. Changing their 360° out-the-window view to a camera sensor based visualisation where the elements of the observed area are arranged on a matrix view is a major change for ATCOs. It was expected to have some impact on their ability to maintain the necessary level of situational awareness, but it could affect workload and fatigue as well. All the possible human factor related issues were handled in a structured way based on standard *EUROCONTROL Human Factor Case methodology [3].* This part of the assessment was done by a dedicated team of human factor experts.

After the high-level understanding of the concept (phase 1 in Human Factor Case), the following main areas of interests were identified:

Issues with potential in affecting the safety level of the service	Changes in ATCO self-confidence
	Changes in situational awareness
Psychosocial issues	Increase in stress level
	Different levels of acceptance, potential conflicts in the group
	'Simulator effect' experience
Communication and cooperation	Changes in the pattern of communication
	Changes in the way or quality of communication
Impacts on human performance	Insecurities in processing information
	Difficulties in building up a full mental picture based on the visualization
	Distractions in the concentration
	Errors based on misuse of equipment
Physiological issues	Unexpected fatigue and drowsiness
	Negative effect on eyesight

Evaluation methodology

As part of the demonstration evaluation, the exercises were assessed along the following aspects:

- **Infrastructure**: This group consists of all elements of the background infrastructure, namely interior design, lighting, shading, and heating. These factors were assessed by ATCOs to make sure that the basic infrastructure is suitable for long duration of operation from the same facility that was used for demonstration.
- **ATM systems and video system**: This category collects all the system parts mentioned in section 6.3.2.1.
- **Procedures**: This part validates that current regulations laid down in the ATS manual are still applicable for remote tower operations, or to what extend they need to be changed.
- **Human factors**: Our early safety assessment raises awareness about the human factor related issues of the remote tower operation. Taken into consideration the nature of the change, human factors were covered as an independent area of validation, not just part of the generic safety assessment. The results of this field of observation were expected to bring important considerations for further implementation of rTWR.

It can be easily seen that sections concerning Infrastructure and Procedures are dependent on local environment to a great extent. As these aspects have limited value for a broad audience, in this report we focus on video system and human factor related assessment that can entail more general lessons learnt.

Feedback for the abovementioned subjects were collected through questionnaires that were asked to be filled in y every participating ATCO after every shift. After a preliminary analysis, the most relevant topics were selected for further analysis and discussed during debriefing sessions.

References

The demonstration plan took into account numerous available documents including SESAR and HungaroControl's ones:

- SESAR Validation Plan for Single Remote Tower
- Operational Concept Document by HungaroControl
- ATS Manual of HungaroControl

6.3.2.2 Exercise execution

Schedule of **passive shadow mode** operations:

Period	**25/July-19/Aug**
Total no. of days	**19**
No. of ATCO/per day	**5**
8:00-9:00	Briefing
9:00-11:00	Passive shadow mode
11:00-12:00	Break
12:00-15:00	Passive shadow mode
15:00-16:00	Debriefing

Total hours of PSM operation: **95 hours**
Total ATCO hours in PSM operation: **405 hours**

After passive shadow mode a debriefing period, we made a preliminary analysis of the results in order to determine if it is feasible to move on to active shadow mode. A briefing session was organized with the aim of getting approval for transferring into live operation. CAA approval was also received in this period.

Schedule of **active shadow mode** operations:

Day operation	22, 23, 24, 29 AUG; 2, 7 SEPT
8:00-8:45	Briefing
8:45-9:00	Transition to rTWR
9:00-10:45	Active shadow mode
10:45-11:00	Transition to TWR
11:00-12:00	Break
12:00-12:45	Debriefing/Briefing
12:45-13:00	Transition to rTWR
13:00-14:00	Active shadow mode
14:00-14:15	Transition to TWR
14:15-16:00	Debriefing

Night operation	8 SEPT
14:00-14:45	Briefing
14:45-15:00	Transition to rTWR
15:00-16:45	Active shadow mode
16:45-17:00	Transition to TWR
17:00-18:30	Break
18:30-19:00	Debriefing/Briefing
19:15-19:30	Transition to rTWR
19:30-21:00	Active shadow mode
21:00-21:15	Transition to TWR
21:15-22:00	Debriefing

Peak hour operation	9 SEPT
8:45-9:00	Briefing
9:00-10:00	Transition to rTWR
10:00-12:00	Active shadow mode
12:00-12:45	Transition to TWR
12:45-13:00	Debriefing

Total hours of live operation: **25 hours**
Total ATCO hours in live operation: **125 hours**

6.3.3 Exercise Results

6.3.3.1 Summary of Exercise Results

Exercise	No. hours of demonstration	No. of a/c controlled during demonstration	
EXE-02.10-D-003.1: Single RWY Remote Tower operation	93 hours	active control of 62 movements in total; most of the exercise was in passive shadow mode	SCN-02.10-004 IFR flights arriving at, and departing from, an aerodrome
			SCN-02.10-005 VFR flights arriving at, and departing from, an aerodrome
			SCN-02.10-009 Ground surface movements at an aerodrome - vehicles and aircraft
EXE-02.10-D-003.2: Dual RWY Remote Tower - operations	27 hours	480 flights	SCN-02.10-004 IFR flights arriving at, and departing from, an aerodrome
		44 flights	SCN-02.10-005 VFR flights arriving at, and departing from, an aerodrome
		(23 hours)	SCN-02.10-006 Remote Provision of ATS during good visibility conditions
		(2 hours)	SCN-02.10-007 Remote Provision of ATS during limited visibility conditions
		(2 hours)	SCN-02.10-008 Remote Provision of ATS during hours of darkness
			SCN-02.10-009 Ground surface movements at an aerodrome - vehicles and aircraft
			SCN-02.10-0010 Simultaneous service provision of aircraft in flight and on the manoeuvring area by the ATCO

6.3.3.1.1 Results per KPA

Table 6-11: Summary of results per KPA for EXE-02.10-D-003

Exe.	Objective	KPA	KPI	Hypothesis ID	Hypothesis	Measurement method	Result		Requirements	Refrence
EXE-02.10-D-003.1, EXE-02.10-D-003.2	**OBJ-02.10-08** Setting up a Remote TWR ops room with all the capabilities needed for live trials (including visualization)	Cost-efficiency	Initial investment; operational expenditures	HYP-02.10-15	Setting up a remote tower needs less capital investment than setting up a new conventional tower.	Expert analysis	Confirmed	High level financial analysis shows that the implementation costs for a remote tower facility are considerable lower than those of a conventional tower. The model builds on the assumption that the ATM systems are similar in both cases. An other important assumption is that remote tower can be set up in an already excisting (even office like) environment. What makes the difference is the deployment of camera sites, video system and the necessary network elemenst on one hand and the investment needed for building a new tower building and basic infrastructure on the other hand.	In order to make a detailed assessment for specific cases, the basic assumptions need to be validated in the first place. Than, the model should be adjusted with local characteristics like available network, visualization needs, state of the current tower an other relevant elements of the concept of operation.	HungaroControl internal CBA *(not attached due to confidential information)*
				HYP-02.10-16	There is no significant difference in operational expenditures related to remote tower and conventional tower.	Expert analysis	Confirmed	In case of a single medium traffic airport operation, the basic assumption was that the remote solution does not cause any changes in ATCO staffing. The main elements of the comparison are the maintanace costs of conventional and remote tower infrastructure. In our specific case, these costs elements are at similar level, so the concept does not cause a significant difference.	Actual comparison is dependent on the concept of operation, local environmewnt and the validity of basic assumptions.	HungaroControl internal CBA
		Safety	Ergonomics	HYP-02.10-17	rTWR working environment can provide the same level of comfort and ease for ATCOs as the CWPs at the conventional tower.	ATCO questionnaires and interviews; on-the-job observation	Confirmed	ATCO feedback suggests that the rTWR facility is appropriate for its purpose and it can be a comfortable working environment even for longer durations. ATCOs reported a mild increase in their stress levels that can be attributed to the 'first-time' effect during the demonstration. After a short accustomization period their behaviour implied the same level of comfort as in the conventional tower.	The importance of this subject should be assessed according to the purpose of the rTWR solution: contingency facility, temporary operation or full-time operation center.	HungaroControl internal ergonomics study; Annex C 2.4

Exe.	Objective	KPA	KPI	Hypothesis ID	Hypothesis	Measurement method		Result	Requirements	Refrence
EXE-02.10-D-003.1, EXE-02.10-D-003.2	**OBJ-02.10-09** Demonstrating technical capabilities and boundaries of using camera technologies for visual observation of the airport traffic	Safety	Workload	HYP-02.10-18	ATCO workload does not change significantly as a result of the extra controlling needs of the new equipment.	ATCO questionnaires and interviews	Confirmed	After the mandatory learning period ATCOs were able to control the elements of the visualization in a way that did not effect their workload considerably. ATCO feedback was collected about the necessary adjustments to the video control system that would decrease their workload and frustration, therefore potentially increase capacity.	In a medium size airport environment with several ATCO positions the controlling of the visualization system can be a cause of extra workload. In order to avoid this effect, visualization system should be configured to support work by multiple people (ie. position specific presets, easy PTZ control, effective target tracking).	Human factor case
			Confidence in system	HYP-02.10-19	Video wall provides reliable visual information to build up a mental image of the traffic situation.	ATCO questionnaires and interviews	Confirmed	The result of the analysis shows that ATCOs have different patterns in using the elements of the ATM system (MATIAS, ASMGCS, videowall) when it comes to building up a mental image of the traffic. Some of them claim to rely mainly on the radar screens, others say to use the visual representation for that. Both ATCO preferences were represented during the demonstration and none of them reported major issues regarding maintaining the mental picture of the traffic.	If there is adequate radar coverage (air and ground), it might not be necessary to provide video image of the entire area of responsibility. The area displayed on the videowall should be decided based on the concept of operation and specific traffic characteristics and local procedures.	Annex C 2.1.2, C 2.1.3.
				HYP-02.10-20	New elements of the CWPs related to visualization provide useful and reliable information and control options.	ATCO questionnaires and interviews	Partially confirmed	The ATCOs confirmed that they find the information provided by the video system reliable. Regarding the usability of the different type of images, there were considerable differences. Static camera image was used most often as a common reference. PTZ and thermal camera images were used less then expected. That was explained by the limitations of the demonstration setup. Labeling of targets on the videowall was considered as a very useful feature by most ATCOs.	Static images should be the basis of common reference in terms of visualization. Usage of PTZ and thermal images is a subject of careful consideration based on the specific concept of operation and the camera capabilities.	Annex C 2.2

Exe.	Objective	KPA	KPI	Hypothesis ID	Hypothesis	Measurement method		Result	Requirements	Refrence
EXE-02.10-D-003.1, EXE-02.10-D-003.2	**OBJ-02.10-10** Demonstrating technical possibilities and limitations of enhancing visual observation by camera technologies during limited visibility conditions (occurring within the demonstration time of period)	Capacity	Capacity in limited visibility	HYP-02.10-21	ATCOs are able to handle the normal traffic from the rTWR facility during limited visibility conditions.	ATCO questionnaires and interviews	Confirmed	Live operation was demonstrated during limited visibility conditions (heavy rain and mist) without any issues. Visualization provided adequate support for maintaining the required capacity.	In a further stage of development, IMC and LVP capacity could be revised based on the enhancement potential of the visualization.	
	OBJ-02.10-11 Demonstrating what level of situation awareness can be reached compared to a conventional TWR ops room	Safety	Situational awareness	HYP-02.10-22	Video wall provides enough visual information to build up a mental image of the traffic situation.	ATCO questionnaires and interviews	Confirmed	As stated above (HYP-02.10-19), the video wall together with the other relevant ATM systems provides sufficiant information to support the level of situational awareness required by ATCOs. However, ATCOs claimed occasional confusion that can be attributed to the small amount of experience with this specific visual representation.	Adequate time should be allocated to accustomization with the visualization during ATCO training. This is not equal to the time that it takes to learn the functionalities, it takes longer to gain confidence to handle the system with the necessary routine, and mailny to get used to working with a different image of the movement area.	Annex C 2.1.1. C 2.1.2.
			Availability of information	HYP-02.10-23	Visibility and accessibility of information on the video wall is adequate for providing ATS service.	ATCO questionnaires and interviews	Partially confirmed	Due to the fact that there is a single video wall for 4+1 controller working positions, there are differencies in the visibility of certain parts of the videowall.	Placement of image and information on the videowall should be considered according to their angle of view from different CWPs.	Annex C 2.1.1. C 2.1.2. C 2.1.3 C 2.3
			Ease of communication	HYP-02.10-24	There is no significant change in the communication within the group or with other units.	ATCO questionnaires and interviews	Not consistent	Most of the ATCOs shared the opinion that communication within the group in the rTWR facility is not considerably different from the conventional TWR situation. On the other hand, it was also mentioned that the change of the layout meant changes in the communication patterns as well. Extra screens (part of the visualization) at the CWPs also contribute to the perceived distance and isolation between the CWPs.	Changes in the way of communication inside the group needs to be mapped carefully when transfering into a remote tower environment. If necessary changes should be handled in a formal way (ie. ATS manual). This factor shall be considered during the planning phase of remote TWR facilities.	Annex C 2.3; Human factor case

6.3.3.1.2 Results impacting regulation and standardisation initiatives

The demonstrations were not conducted with the purpose of providing arguments for directions in regulation; however, there were some areas identified were an extension to the current regulation (ie. ICAO ATC service definition, EASA guideline for implementing remote tower and the EUROCAE ED-240 MASPS) is recommended to better fit the remote tower operations.

- •Further elaboration on the definition of „continuous watch" due to the fact that it can't be fulfilled even with a well-equipped environment. This requirement is advised to be considered as sequential observation.
- Measurement of safety level in advance is not defined in any documentation so justifying the same level of safety comparing normal and remote service is hardly achievable.
- Further clarification would be useful about the requirement of remote tower specific ATCO licensing: when and why any extension is needed for providing remote tower service or local NSA should have decide on that question.

6.3.3.1.3 • Unexpected Behaviours/Results

None.

6.3.3.1.4 Quality and significance of Demonstration Results

Demonstration exercises EXE-02.10-D-003.1 and EXE-02.10-D-003.2 successfully covered all the planned scenarios, therefore it was representative of the typical traffic scenarios of a medium size airport. Regarding operational hours and controlled aircrafts, the demonstration exceeded the expectation to a great extent (586 a/c controlled during live trial versus the planned 50), so the results have a higher level validity as well. The Demonstration plan presented a careful approach regarding the traffic scenarios covered by the demonstration, but as the active shadow period proceeded successfully a few complicated, unplanned traffic situations (ie. training flights, ILS calibration, bird strike, special VFR flights) were also incorporated in the trial.

The technology used for demonstration is also close to a solution ready for implementation, there were no serious constraints as a side effect of the temporary setup. Therefore, the demonstration of the technical capabilities can be accepted as a representative result.

6.3.4 Conclusions and recommendations

The basic conclusion of the remote tower demonstration exercises is that the current level of technology is generally capable of providing the background for safe ATS service provision. However, to secure the continuous and safe operation from a remote tower facility, the visualization needs to be carefully fine tuned to the local environment and the well-defined concept of operations.

Another significant conclusion from the demonstration is the importance of human factor aspects of the solution. The change of visualization is big enough on its own to put the focus on the human actors in the system, but in an operational environment where several ATCOs work together as a team and rely on the video images, it gains special importance. It is recommended to manage the human factor related issues of the change with the same attention as those of the technological aspects.

As the medium size airport environment is considerably different from the small airports where the benefits of the remote tower solution were first validated, the implementation has its special challenges. It should also be kept in considerations that the implementation at medium size airports has other motivations than that of small airports which shifts the emphasis from pure cost-efficiency motives to capacity considerations. Naturally as the size and complexity of the airport environment grows, the implemented solution needs more customization to local characteristics. The implementation is highly dependent of local procedures and safety barriers and the deployed visualization should not be expected to make up for the weaknesses of those. The adaptation process is the key to the acceptance and success of the remote tower solution at this scale.

7 Summary of the Communication Activities

This section presents the list of communication activities performed in the framework of the project:

- **BUDAPEST 2.0 Press Releases**

  Distributed along a large list of contacts detailed in the demonstration plan [1]

  The ESSP published a Press Release informing about the publication of the first EGNOS-based procedure in Hungary. The content of the Press Release distributed can be found in https://www.essp-sas.eu/communication/news/first-egnos-based-approaches-implemented-hungary/

  Pildo Labs generated a Press Release that has been sent to SESAR's Communications Department in order to be published in the next SESAR e-news bulletin. See Appendix D for further information.

  HungaroControl also generated Press Releases that have been published in their website. See Appendix D for further information. This article was featured on the following websites (among others):
  - HungaroControl company website: 300 views of BUD 2.0 article in three weeks after release, http://en.hungarocontrol.hu/press-room/news/budapest_2.0_en
  - Budapest Business Journal http://bbj.hu/budapest/budapest-20-completes-demonstration-in-november_125270
  - Air Traffic Management http://www.airtrafficmanagement.net/2016/11/budapest-20-demonstrates-live-traffic-benefits/

- **BUDAPEST 2.0 – Website:**

  A dedicated Project website has been generated where generic information about the Project can be consulted: objectives of the project, concepts to be tested, demonstrations performed, and benefits expected to be achieved, among others.

  www.budapest.pildo.com

- **BUDAPEST 2.0 WP3 workshop:**

  A workshop was organized and hosted by HungaroControl on the 6th October to share knowledge and experience on remote tower demonstrations. The attendants were the representatives of remote tower demonstration sites:

  Italy, Milan Malpensa (project LSD 02.03, RACOON)
  Ireland, Dublin (project LSD 02.04, Remote towers)
  Sweden, Sundsvall (project LSD 02.05, RTO)
  Germany, Saarbrücken ((project LSD 02.05, RTO)

  During the workshop, HungaroControl presented its remote tower facility. This was followed by a discussion were the attendance had a chance to get some insight in each other's solutions and demonstration setups and to understand the differences and the commonalities.

- **BUDAPEST 2.0 – Final Workshop:**

  A Major workshop will take place at Budapest by the beginning of November in order to present the results of the demonstrations and the facilities at HungaroControl premises. A real-time demonstration will be performed for Remote Towers, so the audience can have a chance of witness the work that has been carried out during the duration of the Project.

  The results of the three exercises will be presented to the audience.

- **Multimedia material collected during the Project:**

  During the execution of the activities, multimedia material has been collected, both videos and pictures, which will be used to disseminate the results of the Project.

- **Promotion of the Project in the News section of the Partners websites and social networks:**

  Partners published news related with the demonstrations performed in their own Websites and Social networks. See Appendix D for further information.

- **Attendance to communication events:**

  As planned in the Demonstration Plan [1], representatives of BUDAPEST2.0 Consortium attended the following International events, where they had the opportunity to share experiences with other Stakeholders:

  - Eurocontrol NSG/PBN Task force 2015
  - ATM World Congress 2015
  - ATM World Congress 2016 (almost 200 registered attendees at HungaroControl stand)
  - CANSO HRWG 2016
  - Airport Operators Forum at LHBP
  - ICAS meeting
  - EUROCAE WG-100 plenary meeting

- **Showroom generation:**

  A showroom has been generated in order to show the results and benefits of the CDOs implementation in Budapest Airport.

  This tool provides the user with the statistics of fuel consumption, CO2 emissions, % of CDOs, TOD and arrivals per month.

  The showroom can be accessed from www.dailyfuel.pildo.com. In case that some party is interested in accessing to the data, a Demo User and Password has been generated and must be requested to Pildo Labs.

8 Next Steps

Solutions described in EXE-02.10-D-001 and EXE-02.10-D-002 are basically implemented. There are some required minor changes and reconfigurations based on the results of the demonstrations which will be done in the upcoming month.

Regarding EXE-02.10-D-003, the setup was deployed for demonstration purposes, but with the vision in mind that it would be the foundation of a future contingency facility. The upcoming implementation steps will move on to this direction with creating the obligatory redundancies and independency in the background infrastructure, training and licencing of ATCOs and obtaining the authority approval.

8.1 Conclusions

Main conclusions of the demonstration exercise EXE-02.10-D-001 are the following:

- **Conclusion 1:** Continuous Descend Operations can be effectively supported with the procedural and the software tools that were subject of the demonstration.
- **Conclusion 2:** CDO support could bring the most benefits if implemented with a system-wide approach, not simply altering certain elements, like arrival procedures only. Full potential of CDO can only be achieved if all major elements and stakeholders align their operation to the same principles. Namely, when the routes correspond to the shortest and most predictable tracks, a supporting tool is used to provide ToD information without extra workload and pilots and ATCOs are both properly trained about CDO.
- **Conclusion 3:** Pildo Labs in cooperation with UPC developed a CDO monitoring tool that is able to compute the number of CDOs performed at a given airport, the fuel consumption and CO2 emissions. This tool, DailyFuel, can be of interest for other airports, and it is a powerful means to compute the benefits of implementing CDOs and the CDO enhancement tool.
- **Recommendation 1**: The vast majority of modern aircraft use CDOs automatically if RNAV/ RNP arrivals are available. The percentage of CDOs for T-bar approaches could increase significantly if this kind of arrivals were published.

Regarding the execution of EXE-02.10-D-002 carried out in the framework of BUDAPEST2.0 project, the following conclusions have been raised:

- **Conclusion 1:** SESAR concepts have been operationally demonstrated, by involving pilots from Operators and Air Traffic Controllers from Budapest ATC.
- **Conclusion 2:** Successful flight validation campaign performed at Budapest Airport with local Pilots and ATCOs involved in the trial.
- **Conclusion 3:** First EGNOS-based procedure published in Hungary in the framework of BUDAPEST2.0 Project.
- **Conclusion 4:** Questionnaires to Pilots and ATCOs shown an overall acceptance of the procedures validated and implemented at Budapest Airport.
- **Conclusion 5:** The Flight Validation campaign performed in the framework of BUDAPEST2.0 Project was a good opportunity for Pildo Labs in order to demonstrate to the National Authorities that their flight validation platform, PLATERO, is a suitable means to perform the flight validation of PBN procedures. The results of the demonstration will be used to present Pildo Labs service to other States interested in the solution.
- **Recommendation 1:** Four LPV200 procedures have already been implemented in Budapest Airport. It can be used as a model case for the implementation of EGNOS-based procedures not only in all the Hungarian airports but also other European airports.

Demonstration of EXE-02.10-D-003 resulted in the following conclusions:

- **Conclusion 1:** Remote tower solution has been successfully demonstrated at a medium size airport environment, presenting the capabilities of the technology.

- **Conclusion 2:** Next to relevant technological aspects (like visualization functionalities), human factor related changes are equally important elements to a successful implementation of the solution.
- **Conclusion 3:** Complexity of a medium size airport requires more customization from the technology side and more adaptation side from the human actors than in a small, single runway environment.

9 References

9.1 Reference Documents

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

[1] BUDAPEST 2.0 Deliverable D2 – Demonstration Plan, version 01.00.01, date 20/06/2016

[2] European ATM Master Plan, https://www.atmmasterplan.eu

[3] EUROCONTROL Human Factor Case methodology

[4] CDO Step 1, Operational Service and Environmental Definition (OSED), OFA 02.01.01

[5] SESAR Solutions Catalogue, http://www.sesarju.eu/newsroom/brochures-publications/sesar-solutions-catalogue

[6] Operational Focus Areas, https://www.atmmasterplan.eu/data/ope_focus_areas

Appendix A Evaluation of EXE-02.10-D-001

A.1 Interviews with Air traffic controllers on CDO APP operations

A.1.1 Basic information on the interviews

TERM	DEFINITION	
Demonstration exercise	EXE-02.10-D-001.1	CDO Enhancement Tool
Scenario	SCN-02.10-001	In LHBP TMA the deployment of T-Bar Procedures and the further development of the currently used CDO Enhancement Tool will take place for full CDA implementation in LHBP.
Corresponding objectives	OBJ-02.10-01	Deployment of T-Bar Procedures and CDO Enhancement Tool for full CDO implementation in LHBP.
	OBJ-02.10-02	Demonstrating capabilities and limitations of restructured TMA routes and the application of T-bar procedures together with CDO enhancement tool

Methodology	Structured personal interview covering the following topics:
	• **A 1.2** Evaluation of T-Bar operation concept in general
	• **A 1.3** Evaluation of CDO Enhancement Tool concept in general
	• **A 1.4** Evaluation of CDO Enhancement Tool concept related to the human factors
	  o Workload
	  o Stress
	• **A 1.5** Evaluation of CDO Enhancement Tool concept related to the key performance indicators
	  o Safety
	  o Capacity
	  o Environment	

Respondents	12 APP Air Traffic Controllers of HungaroControl	
Period of the interviews	15th July – 29th July, 2016	

A.1.2 Evaluation of T-Bar operation in general

This section is about the analysis of the T-Bar concept and the local implementation.

A.1.2.1 To what extent do you think T-bar is a good method for managing traffic?

Purpose of this question to establish that according to the ATCOs' opinion if the T-BAR concept is a good idea for managing traffic considering the characteristics of current airspace.

ID	Factors	Sum of responds (out of 12)
1.2_1	T-Bar operation's concept is appropriate.	7
1.2_2	The concept will be able to serve its original purpose, if appropriate changes are made on the first implemented version.	3
1.2_3	T-Bar operation's concept is not an adequate solution considering the characteristics of current airspace.	1

The majority of ATCOs considered that the T-BAR concept is a good idea to manage the traffic or at least it could be after some changes in the implementation.

A.1.2.2 What kind of advantages and possible disadvantages do you see?

The aim of this question is to collect ATCOs' opinion on necessary improvements to the concept and the way it was implemented..

ID	Factors	Sum of responds (out of 12)
1.2_4	Shorter final would be required.	6
1.2_5	Two (double) T-Bar would be required.	2
1.2_6	T-Bar does not support the CDO in this current format, but it would be reachable with right amendments.	3
1.2_7	N/A	4

Majority of the ATCOs said that shorter T-BAR procedure is required for efficient use of the procedure. It was also said that with some modifications the new procedure would be easier to use and could bring better results. Some ATCOs said that T-BAR procedure needs more flexibility.

It should be noted that the current length of the T-bar was designed to fit the most traffic scenarios, even worst case scenarios regarding weather circumstances and aircraft performance. A possible way of development for the T-bar would be to create a shorter version suitable for optimal traffic scenarios and keep the long one to secure safety.

A.1.3 Evaluation of CDO Enhancement Tool concept in general

This section establishes the opinion of ATCOs about the CDO Enhancement Tool concept and not regarding the implemented tool.

A.1.3.1 Please evaluate the concept of CDO Enhancement Tool, how useful such a decision support tool can be in general, regardless of the actual implementation of the system?

Purpose of the question is to evaluate how ATCOs see the concept itself based on the CDO Enhancement Tool, but not taking into consideration its present implementation.

ID	Factors	Sum of responds
1.3_1	The concept is basically appropriate.	7
1.3_2	Conceptually correct, but the implementation should be further developed to reach the set goals.	10
1.3_3	The concept is not appropriate and/or cannot be implemented.	3

The majority of the ATCOs agreed that the concept is viable and with the further development it could became a very helpful tool for them. It was said that with better integration and with implementation of more variables like wind data and aircraft type the results would be much better.

A.1.4 Evaluation of CDO Enhancement Tool concept related to the human factors

This section establishes the opinion of ATCOs about the CDO Enhancement Tool concept and its relation to the human factors.

A.1.4.1 Does the workload increase or decrease when comparing a procedure using CDO Enhancement Tool to a one where it was not used?

The questions was focusing on workload comparison among two situations: one with the new tool and one without the new tool.

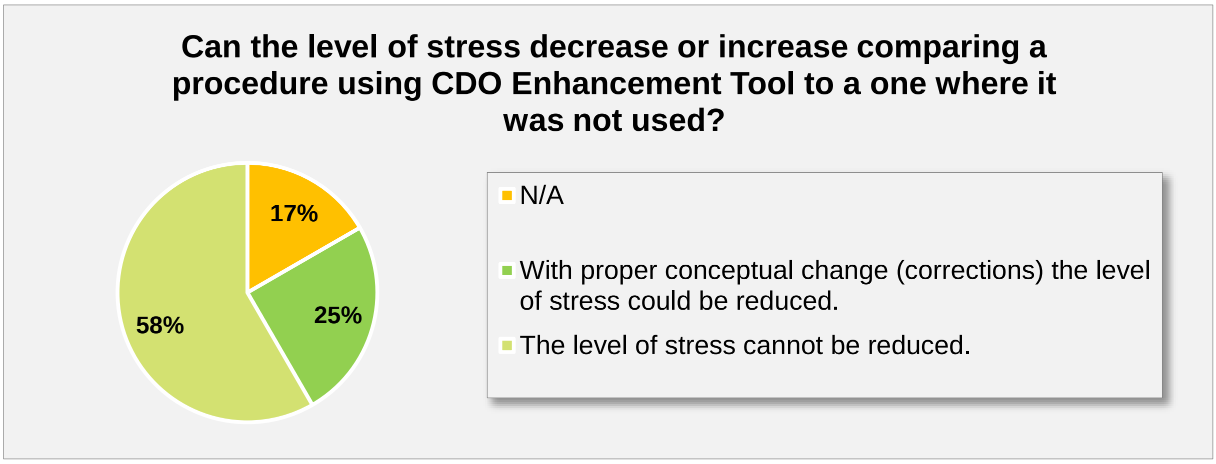
ID	Factors	Sum of responds (out of 12)Sum of responds	Percentage
1.3_6	With proper conceptual change (corrections) the workload could be reduced.	5	42%
1.3_7	Conceptually the workload can be reduced.	5	42%
1.3_8	Irrelevant.	3	25%
1.3_9	The workload cannot be reduced.	2	17%

A high number of the ATCOs agreed that with further development it could lower the workload. It was said that with better integration and with implementation of more variables like wind data and aircraft type the work with the tool will easier and wouldn't require extra effort in terms of updating the data due to weather situation and due to aircraft type differences.

A.1.4.2 Can the level of stress decrease or increase comparing a procedure using CDO Enhancement Tool to a one where it was not used?

This section establishes the opinion of ATCOs about the ability of the CDO Enhancement Tool concept to decrease the level of stress during the operations.

The opinion of the majority of the ATCOs is that the CDO Enhancement Tool concept at this point cannot reduce the stress. However, there were opinions that with application of some conceptual changes it may reduce the stress.



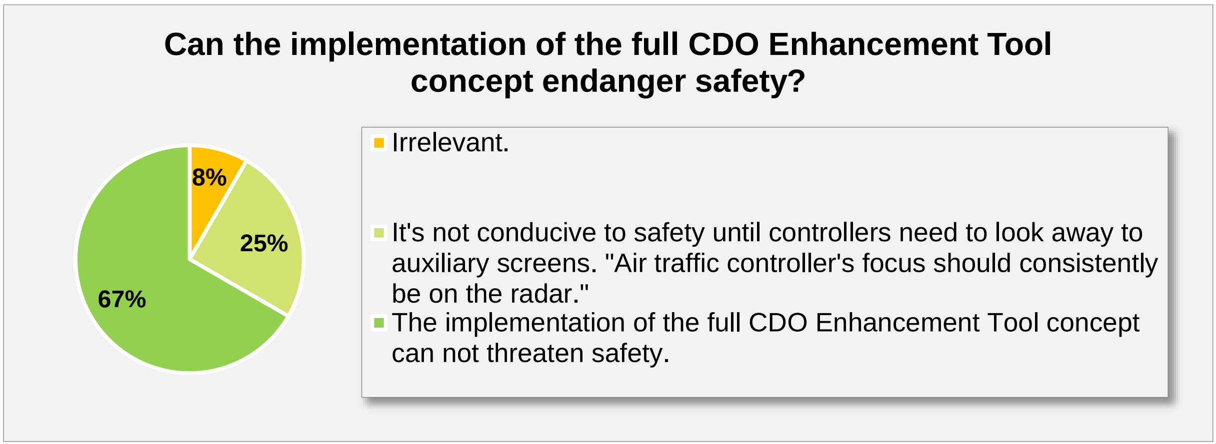
A.1.5 Evaluation of CDO Enhancement Tool concept related to the key performance indicators

The section focuses on the main key performance indicators Budapest 2.0 has chosen to measure the project's performance.

A.1.5.1 Does the implementation of the full CDO Enhancement Tool concept endanger safety?

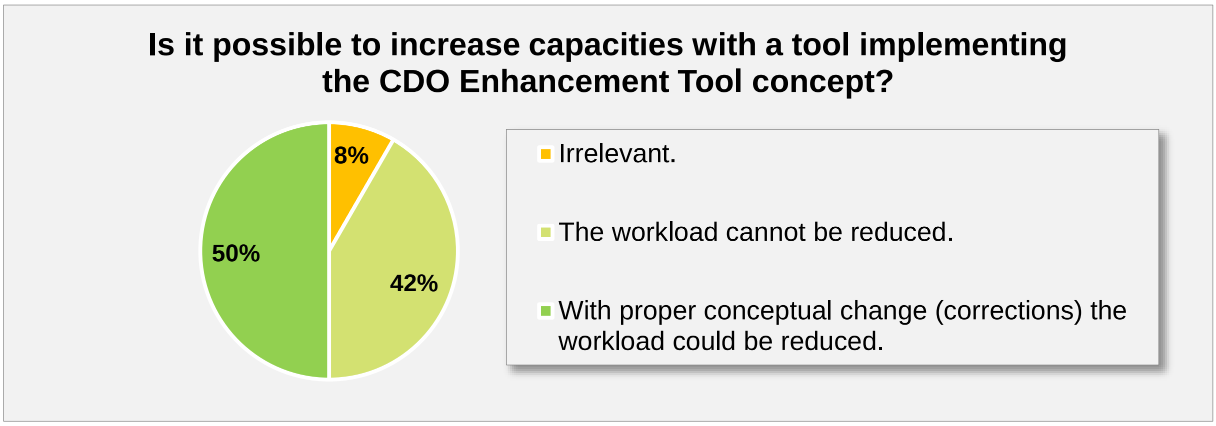
Purpose of this question is to evaluate if the ATCOs think that the implementation of the full CDO Enhancement Tool concept endanger safety.

The majority of the ATCOs said that as long it is not mandatory it cannot endanger safety as the ATCO in position to decide if he considers safe the use of the system or decides to use vectoring. Another argument was that the ATCO should focus mainly on the radar screen.



A.1.5.2 Is it possible to increase capacities with a tool implementing the CDO Enhancement Tool concept?

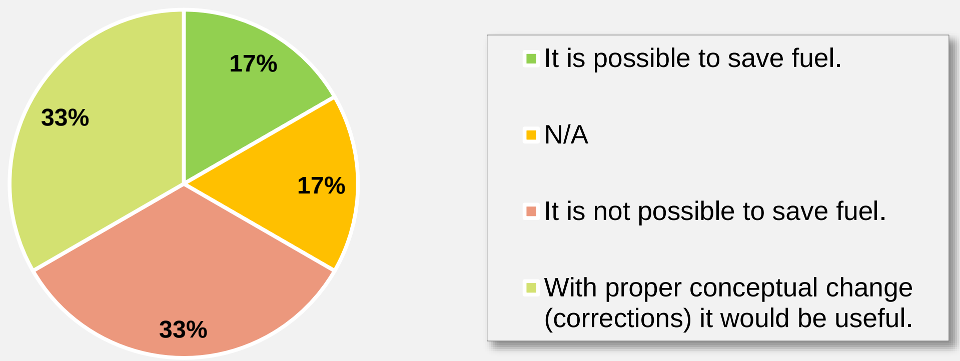
The question asks that according to the ATCOs' opinion if it is possible to lower the workload by implementation of the CDO Enhancement Tool concept.
Most of the ATCOs think that with some corrections the implementation of the CDO Enhancement Tool concept could result reduced workload. Some of them thinks that the concept is hard to upgrade to a level that is needed to lower the workload.



A.1.5.3 Is the implementation of the CDO Enhancement Tool concept useful in terms environment protection (emission, noise reduction)? Is it possible to save fuel at aircraft controlled by a procedure using CDO Enhancement Tool?

Purpose of this question to establish that according to the ATCOs' opinion if the implementation of the CDO Enhancement Tool would have positive impact on the environment. A related question if it is possible save fuel at aircraft controlled by a procedure using CDO Enhancement Tool. The majority of ATCOs considered that the implementation of the CDO Enhancement Tool could have positive impact on the environment or it could have positive impact after some changes (corrections) in the concept.

Is the tool implementing the CDO Enhancement Tool concept useful in terms environment protection (emission, noise reduction)?



A.1.5.4 Extract from a study about the effect of T-bar concept on the noise pollution (done by HungaroControl)

A result of the study shows that implementing the T-bar concept will not change the noise pollution in the area significantly. This comes after observing the changes in the dispersion of track in the TMA which is expected to be less deviant from the previous routes. However, more concentration along the tracks mean larger noise pollution under the affected areas.

Together with the implementation of the T-bar, altitude constraints were also put in place at the base points of the T-bar. These constraints are relevant from a noise mitigation point of view as they secure a significant distance between the source of the noise and the immission point. This distance guarantees that noise from the aircraft does not exceed the communal background noise level.

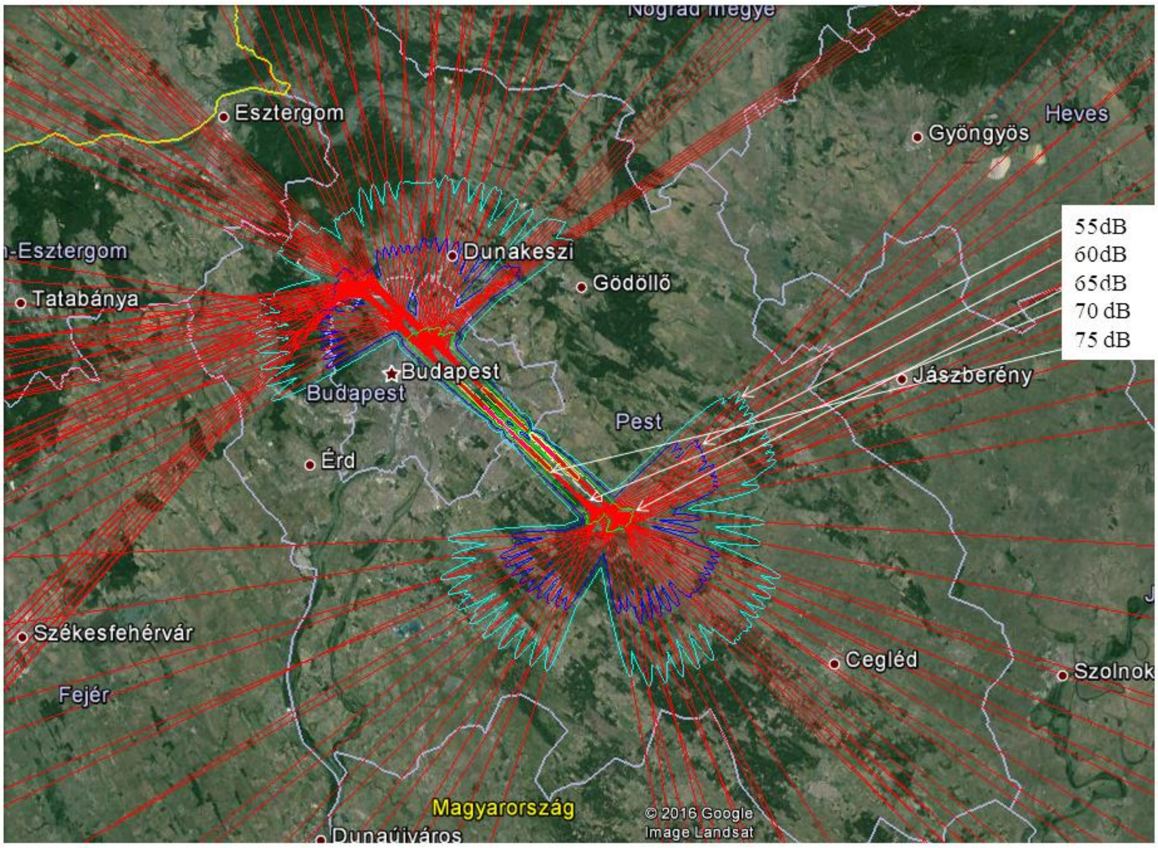


Figure 9-1: Calculated isophones presenting noise levels before T-bar implementation (medium turbulence category)

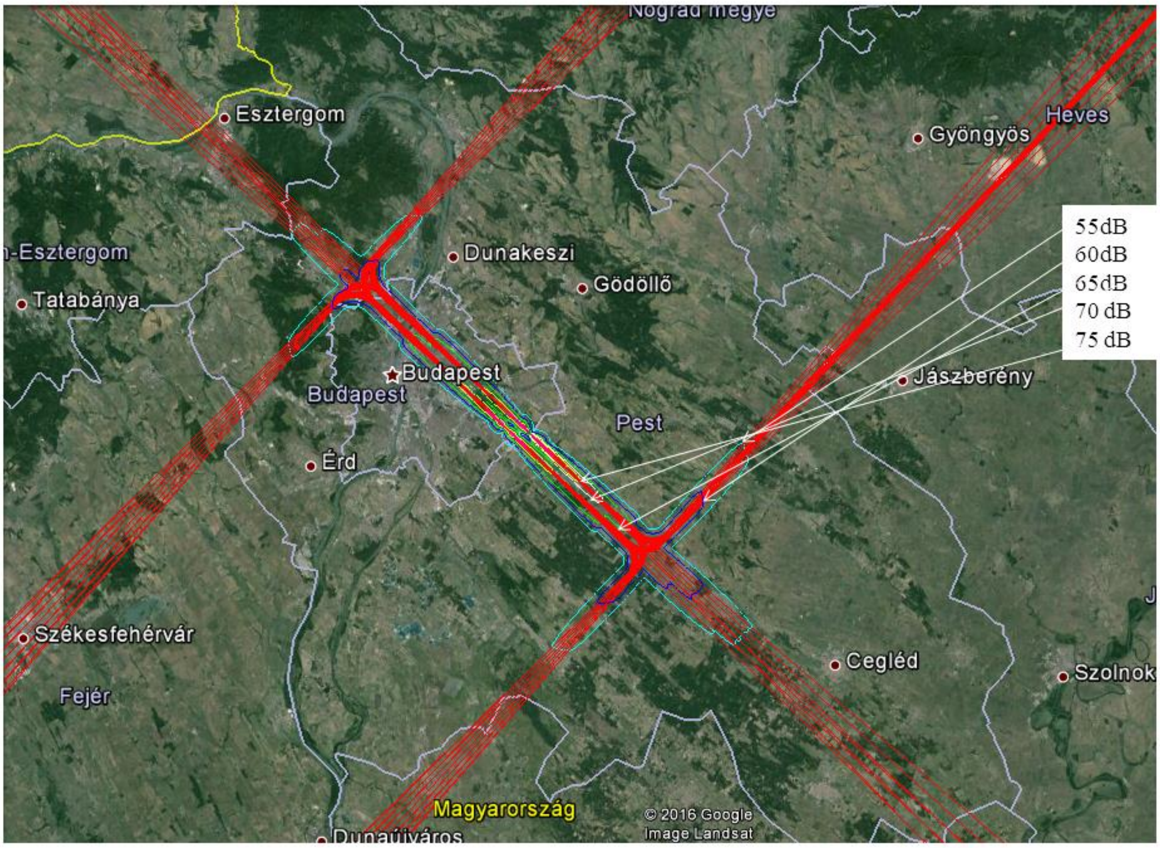


Figure 9-2: Calculated isophones presenting noise levels after T-bar implementation (medium turbulence category)

A.2 Survey with Pilots on CDO APP Operations

A.2.1 Basic information of the survey

TERM	DEFINITION	
Demonstration exercise	EXE-02.10-D-001.1	CDO Enhancement Tool
Scenario	SCN-02.10-001	In LHBP TMA the deployment of T-Bar Procedures and the further development of the currently used CDO Enhancement Tool will take place for full CDA implementation in LHBP.
Corresponding objectives	OBJ-02.10-01	Deployment of T-Bar Procedures and CDO Enhancement Tool for full CDO implementation in LHBP.
	OBJ-02.10-02	Demonstrating capabilities and limitations of restructured TMA routes and the application of T-bar procedures together with CDO enhancement tool
Methodology	Online questionnaire covering the following topics: • **A 2.3-5** Details and evaluation of the arrival route and approach procedure they have actually flown • Evaluation of CDO Enhancement Tool concept related to the human factors ○ **A 2.6** Workload ○ **A 2.7** Performance and stress • **A 2.8** Subjective opinion about the T-bar procedures	
Respondents	30 responds from 30 Commercial Pilots of WIZZ Air	
Period of data collection	2nd June – 5th August, 2016	

A.2.2 Evaluation of the personal details

This section shows the personal details. Personal details were asked but just for the reason to enable clarifications if needed. The analysis is made in a generalised manner.

A.2.2.1 Dispersion of the pilot's roles during demonstration operations

The question relates to roles of the crew.

Row Labels	Responds
CPT	15
F/O	14
Grand Total	**29**

The share of captains and first officers among respondents is about 50/50.

A.2.3 Evaluation of definitions of the arrival procedure

This section deals with the new definitions of the arrival procedure.

A.2.3.1 Have you flown the whole length of the arrival procedure specified in the FPL?

The possible answers and the outcome are shown below.

- Option 1: Yes. I have flown the whole length of the arrival procedure specified in the FPL. > No one choose.
- Option 2: No. I have received a shortcut that contained way points.
- Option 3: No. I have received a shortcut that contained waypoints, thereafter radar vectoring was necessary.
- Option 4: No. Radar vectoring was necessary. > Between T-bar and FAP was selected by the two respondents.

Row Labels	Responds
Option 2: No. I have received a shortcut that contained waypoints	15
Option 3: No. I have received a shortcut that contained way points, thereafter radar vectoring was necessary.	13
Option 4: No. Radar vectoring was necessary.	2
Grand Total	**30**

Most of the pilots reported that they have received a shortcut.

A.2.4 Evaluation of the shortcuts

This section evaluates the role of shortcuts.

A.2.4.1 When did you received the shortcut?

It is asked whether the ACC or the APP gave the shortcuts.

- Option 1: The shortcut was given by ACC.
- Option 2: The shortcut was given by APP.

#	Row Labels	Responds frequency
01	The shortcut was given by ACC.	16
02	The shortcut was given by APP.	12
03	N/A	2
	Grand Total	**30**

Approximately 60% of the shortcuts were given by ACC which is a consequence of planning ahead by APP controllers with the CDO support tool and transfer coordinated shortcuts via ACC to pilots. More than half of the shortcuts were given more than 100NM before threshold which could be roughly estimated as 'before ToD' shortcuts. This type of early information is the most beneficial to pilots for planning the ideal descent profile.

#	Specified position:	Responds frequency
01	more than 100NM before threshold	7
02	between 50NM and 100 NM before threshold	6
03	less than 50 NM before threshold	1
04	N/A	2

12 respondents have responded that APP gave them a shortcut. Considering the FL where the aircraft was flying when receiving the shortcut, it can be concluded that last minute shortcut is very rare, pilots know their final vertical profile when crossing FL100.

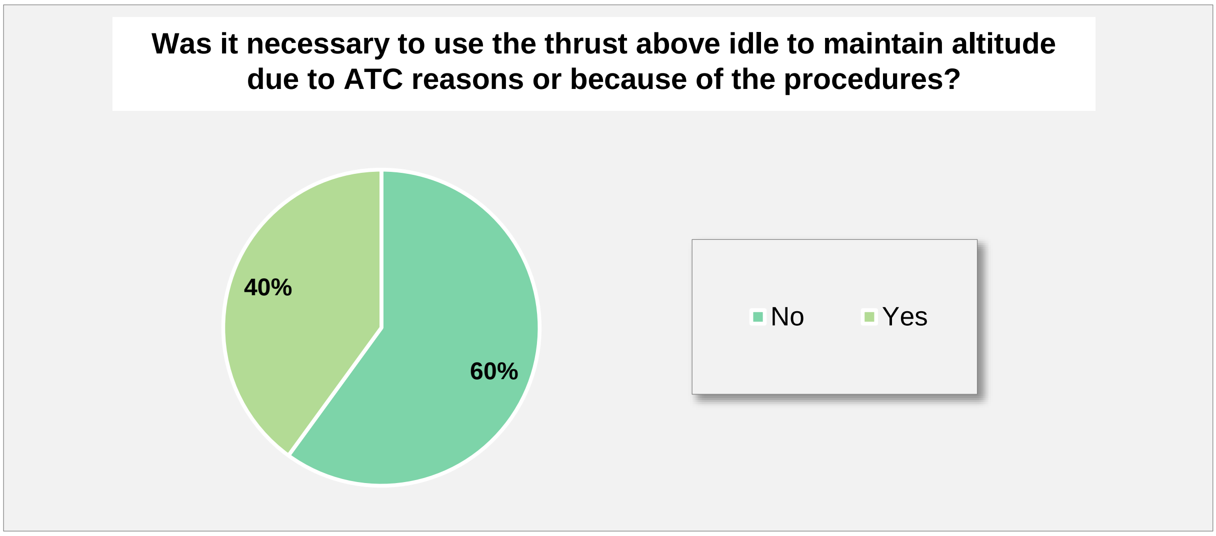
#	Specified position:	Responds frequency
01	above FL100	7
02	below FL100	2
03	N/A	3

A.2.5 Evaluation of the approach

This section evaluates the approach phase.

A.2.5.1 Was it necessary to use the thrust above idle to maintain altitude due to ATC reasons or because of the procedures?

The question judges the efficiency of CDO, if trust had to be used. In most cases trust was not necessary.



A.2.6 Evaluation of the workload changes

This section evaluates the effect of the new procedures on workload.

A.2.6.1 I have felt changes in the workload after the new procedures were implemented. Why?

The question focuses on workload changes of pilots due to the new procedures.

#	Row Labels	Responds	Percentage
01	There is no increment on the workload after the new procedures were implemented.	12	33%
02	There is an increment caused by the longer distance to be flown.	7	19%
03	There is an increment on the workload after the new procedures were implemented.	4	11%
04	There is a tendency of often being held high.	4	11%
05	There is an increment caused by new confusing waypoint names.	3	8%
	Grand Total	**30**	**100%**

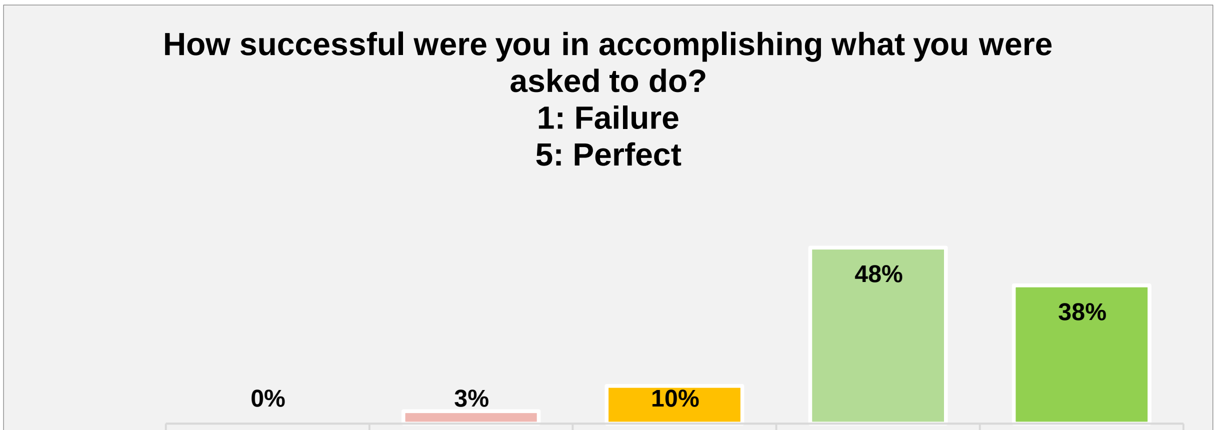
Pilots reported a minor increase in the workload, but the majority of reasons given for that are temporary. The causes mentioned are typically related to learning and getting used to the new procedures that will most likely decrease with time. Considering this factor, the answers to this question are not representative to the final solution.

A.2.7 Evaluation of the performance

This section analyses the performance changes.

A.2.7.1 How successful were you in accomplishing what you were asked to do?

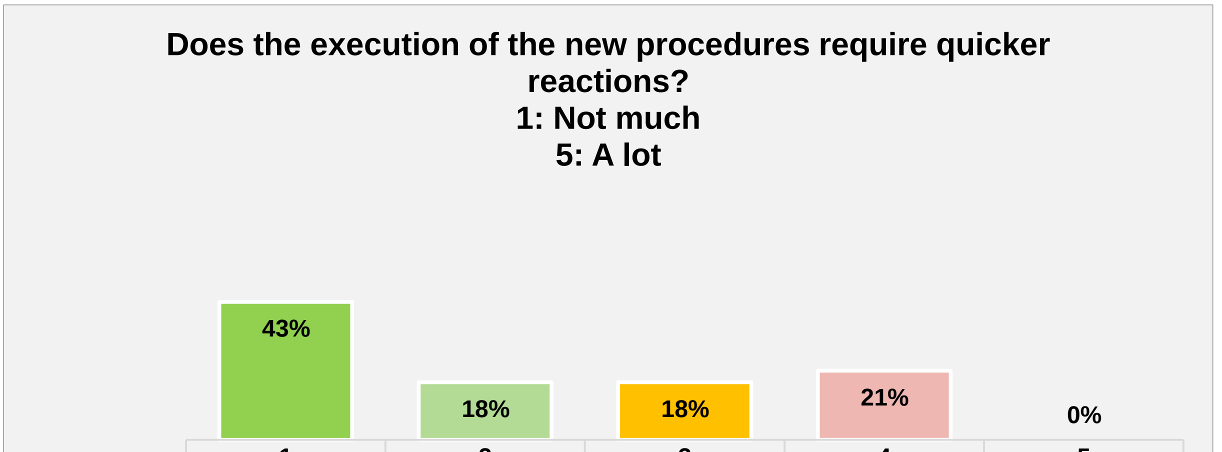
This question is asking whether the pilots consider themselves successful when doing the new procedures.
Most of the pilots are satisfied with their own performance.



	1	2	3	4	5
Series1	0%	3%	10%	48%	38%

A.2.7.2 Does the execution of the new procedures require quicker reactions?

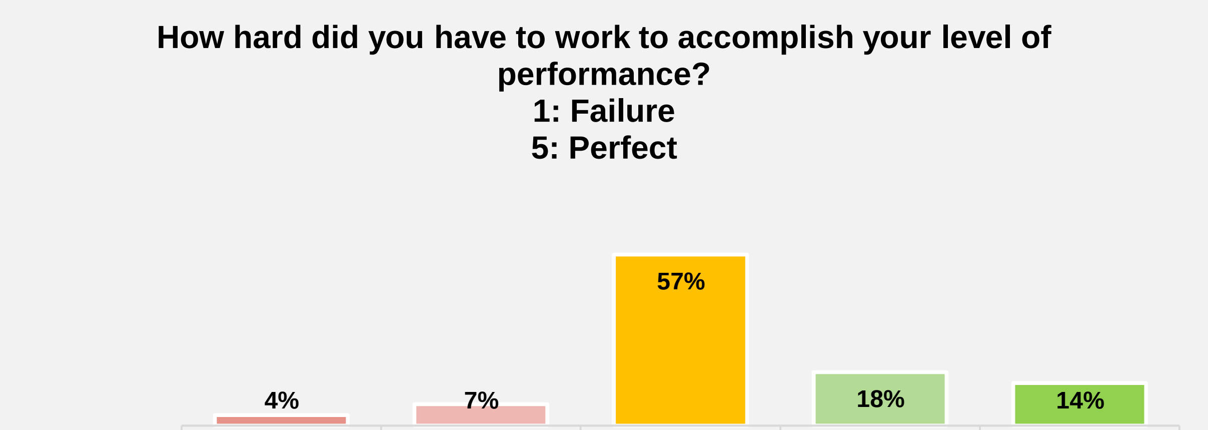
This question asks whether quicker reaction is needed to accomplish the new procedures.
The majority of the pilots think that there is no need for quicker reactions to accomplish the new procedures.



	1	2	3	4	5
Series1	43%	18%	18%	21%	0%

A.2.7.3 How hard did you have to work to accomplish your level of performance?

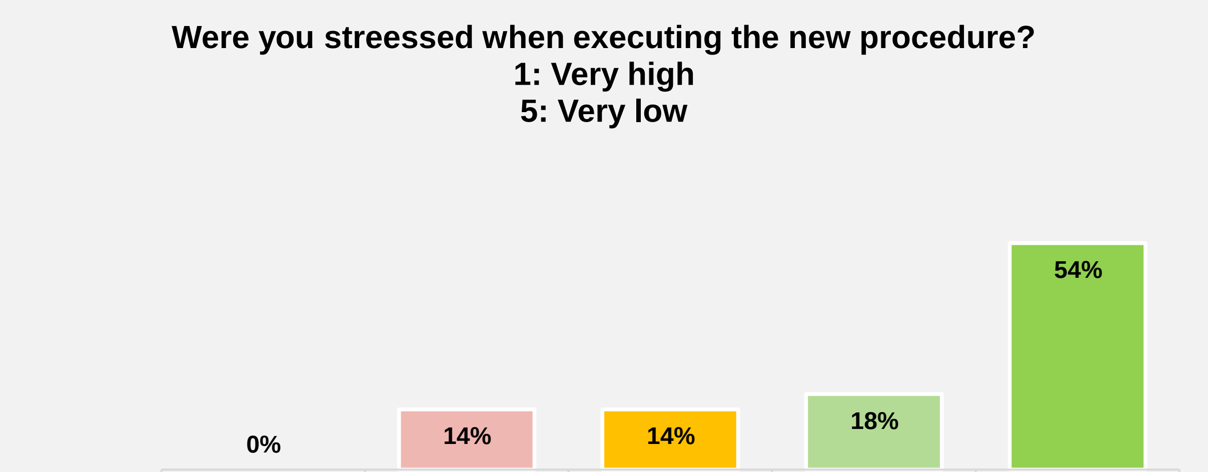
This question relates to need for a harder work to perform the procedures correctly.
For most of the pilots it seems that the new procedure requires the same level of work as the older ones.



	1	2	3	4	5
Series1	4%	7%	57%	18%	14%

A.2.7.4 Were you stressed when executing the new procedure?

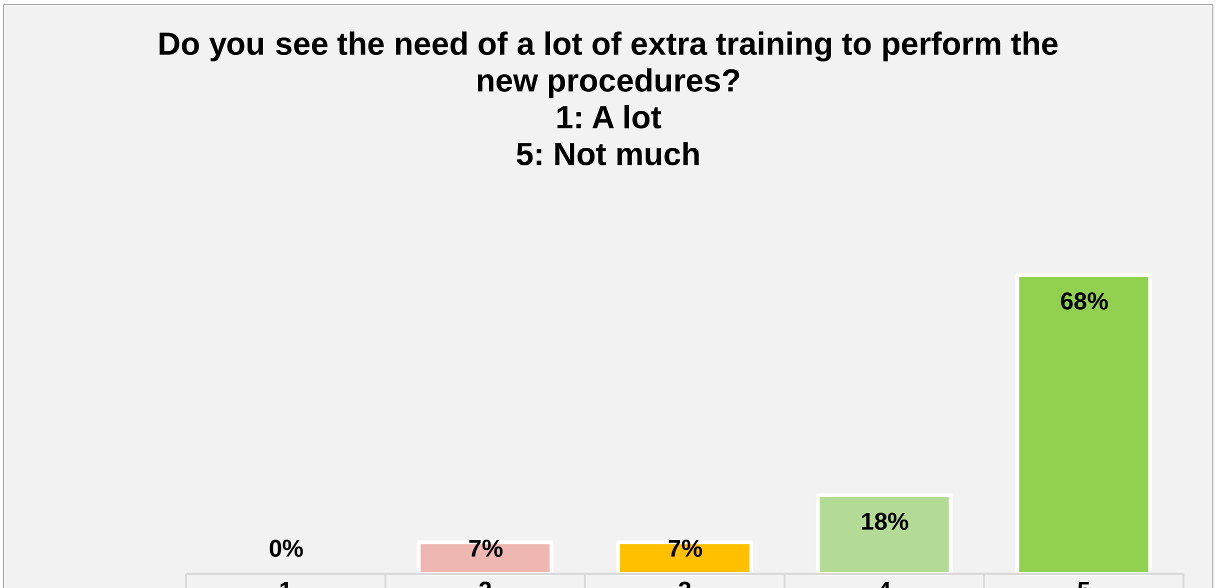
The question relates to a possibility of stress during the execution of the new procedure.
Most of the pilots do not feel significant stress when performing the new procedure.



	1	2	3	4	5
Series1	0%	14%	14%	18%	54%

A.2.7.5 Do you see the need of a lot of extra training to perform the new procedures?

The question relates to the training needs to accomplish the new procedures.
For the majority of the pilots there is no need for a significant extra training.



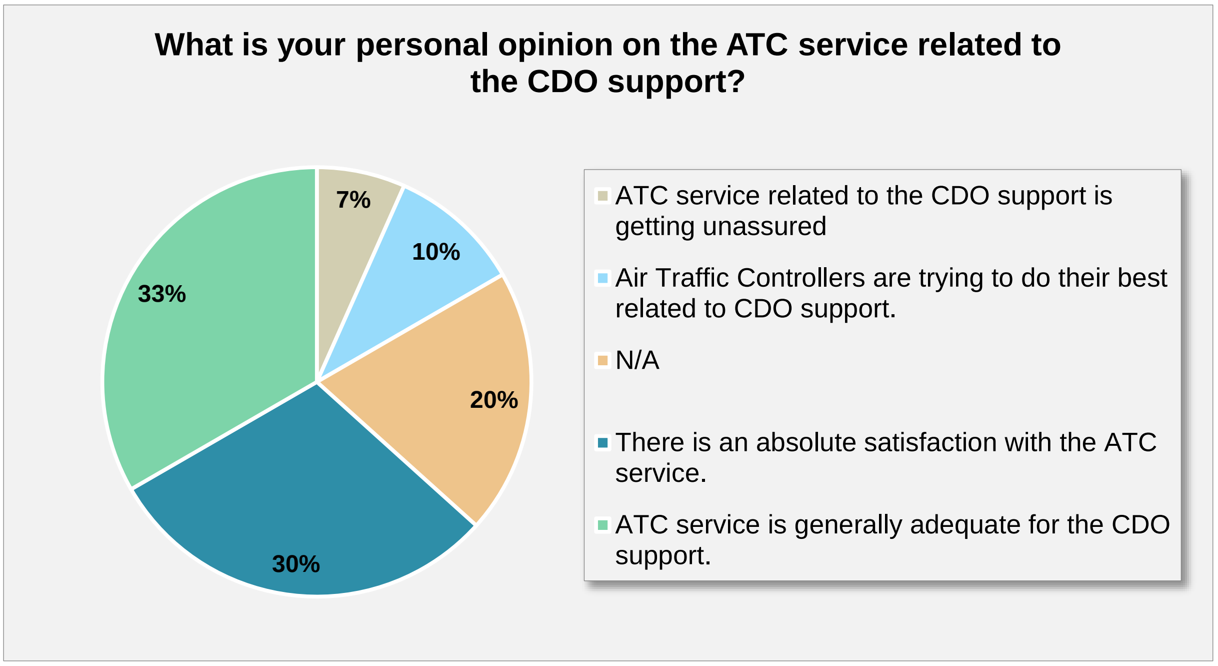
	1	2	3	4	5
Series1	0%	7%	7%	18%	68%

A.2.8 Evaluation of the subjective opinion expressions

This section analyses the opinion of pilots on the new procedures.

A.2.8.1 What is your personal opinion on the ATC service related to the CDO support?

This question is about the level of ATC service in terms of CDO operations.
The majority of the pilots are satisfied with the ATC service provided.



A.2.9 Evaluation of the new operation

This section evaluates the new operations after they are published in the AIP.

A.2.9.1 Did you have any missed approach or rejected landings at LHBP due to ATC reasons or due to new procedures after 26th May?

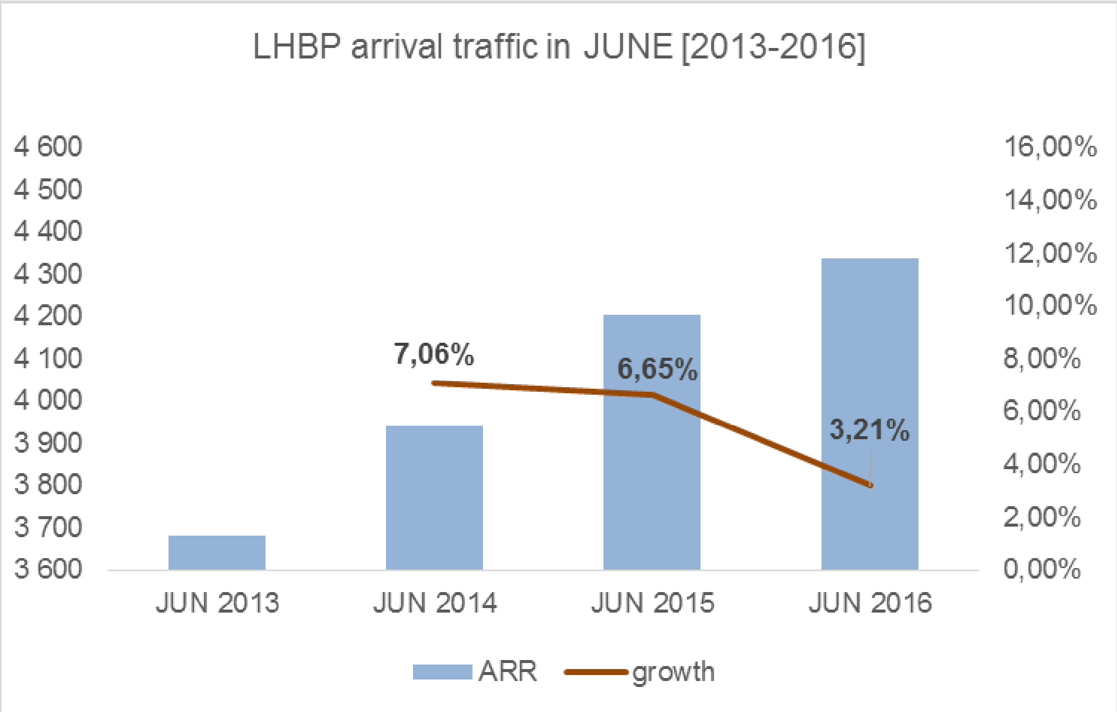
This question relates to the possible problems after the implementation of the new procedures whether there were missed approaches or rejected landings.

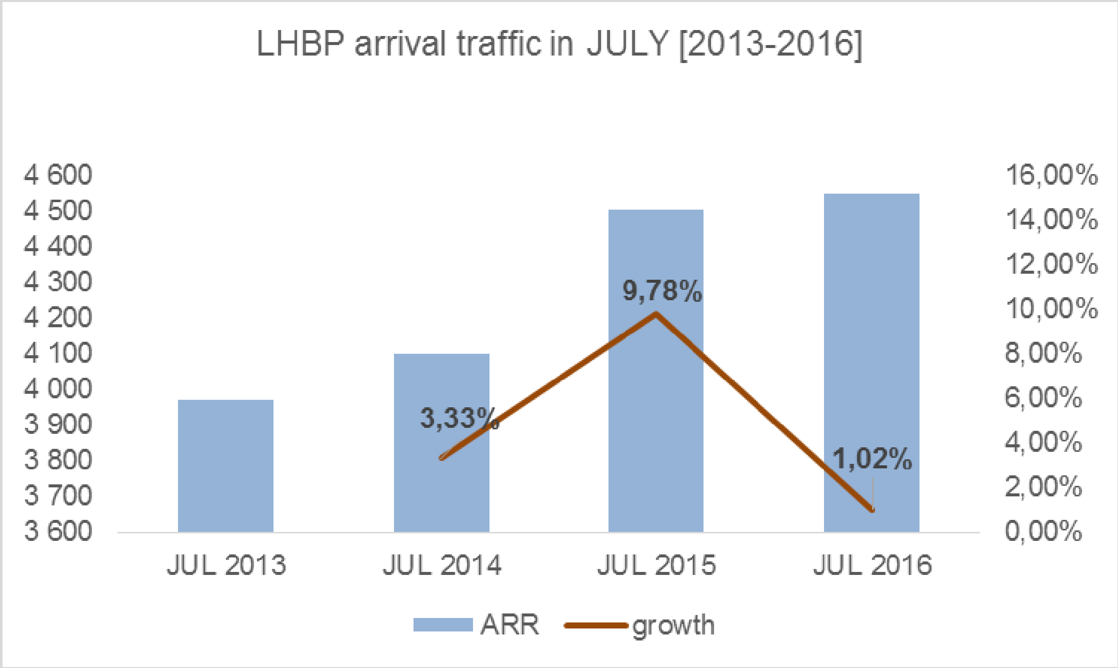
Row Labels	Count of #
No	28
Yes	2
Grand Total	**30**

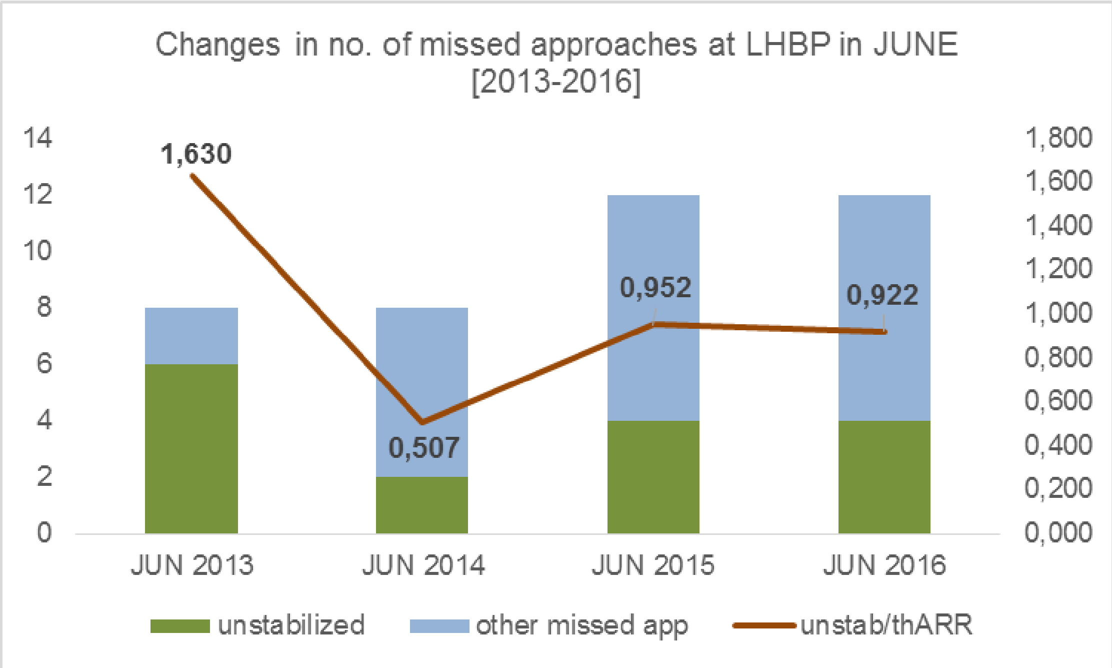
The vast majority of the pilots report that they had no missed approach or rejected landings due to the new operations.

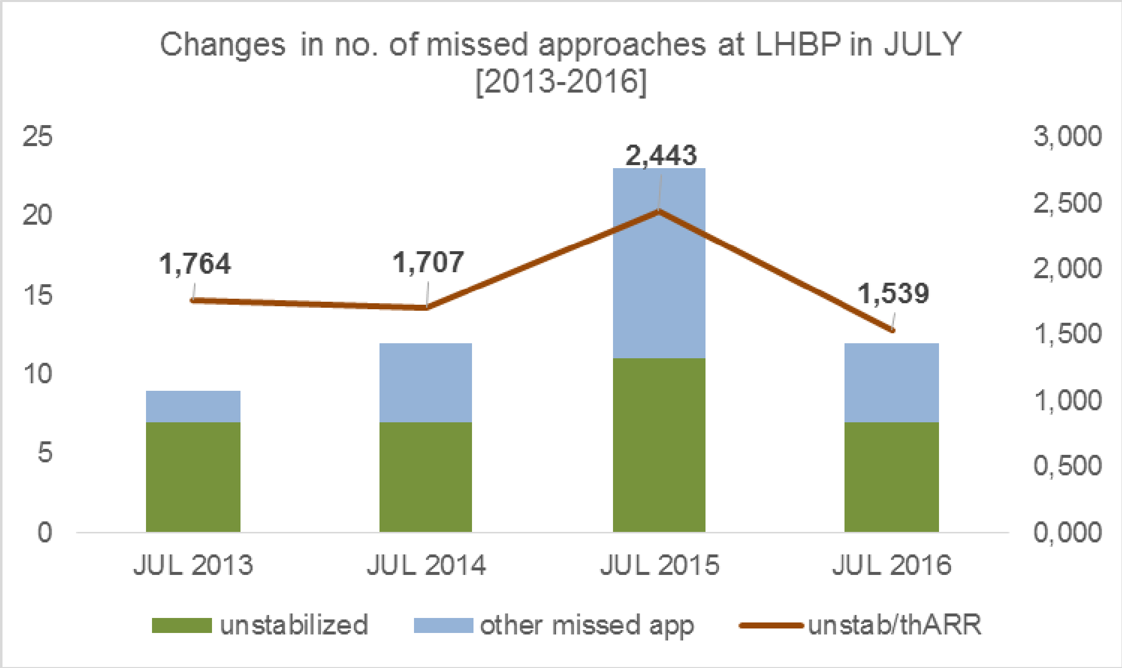
A.2.9.2 Background information based on HungaroControl statistics

Traffic arriving to Budapest had an average annual growth of 5,15% in the respective period (June-July 2013-2016). However, the number of missed approaches in the observed typical summer months showed a much greater growth in between the first three years, then dropped significantly to the fourth year, when the demonstration was ongoing. This decline can be a result of many other circumstances (ie. differences in weather, training flights), but it is also an indirect indicator on the effectiveness of the designed procedures in regard of avoiding unstabilized approaches.




LHBP arrival traffic in JULY [2013-2016]
4 600
4 500
4 400
4 300
4 200
4 100
4 000
3 900
3 800
3 700
3 600
16,00%
14,00%
12,00%
10,00%
8,00%
6,00%
4,00%
2,00%
0,00%
3,33%
9,78%
1,02%
JUL 2013
JUL 2014
JUL 2015
JUL 2016
ARR
growth


Changes in no. of missed approaches at LHBP in JUNE [2013-2016]
14
12
10
8
6
4
2
0
1,800
1,600
1,400
1,200
1,000
0,800
0,600
0,400
0,200
0,000
1,630
0,507
0,952
0,922
JUN 2013
JUN 2014
JUN 2015
JUN 2016
unstabilized
other missed app
unstab/thARR


Changes in no. of missed approaches at LHBP in JULY [2013-2016]
25
20
15
10
5
0
3,000
2,500
2,000
1,500
1,000
0,500
0,000
1,764
1,707
2,443
1,539
JUL 2013
JUL 2014
JUL 2015
JUL 2016
unstabilized
other missed app
unstab/thARR

A.3 Survey with Air traffic controllers on CDO ACC operations

A.3.1 Basic information on the survey

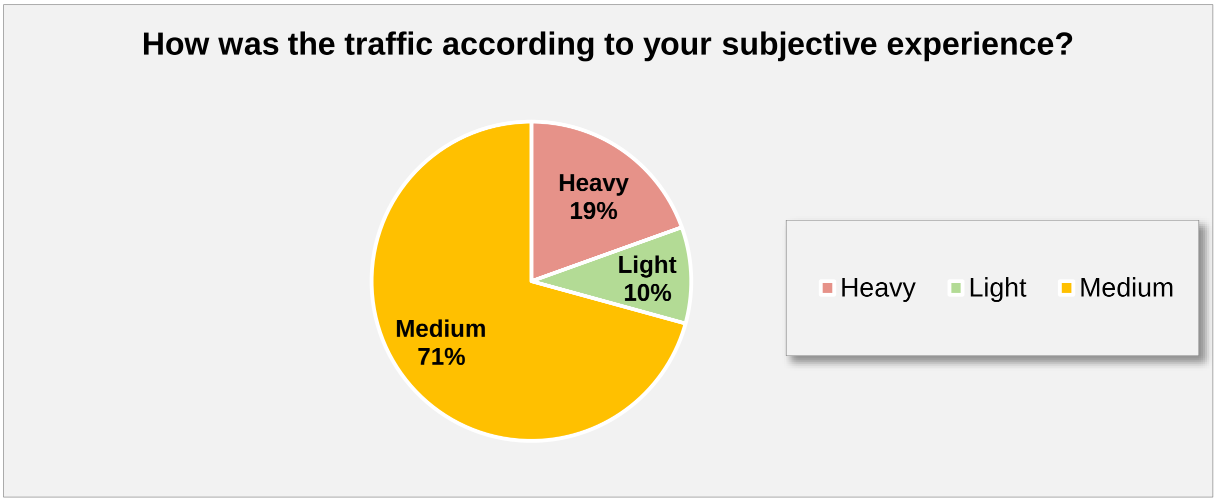
TERM	DEFINITION	
Demonstration exercise	EXE-02.10-D-001.2	CDO Enhancement Tool in ACC
Scenario	SCN-02.10-002	In LHBP ACC the CDO Enhancement Tool will be deployed to facilitate the sequencing and enhance efficiency concerning flights with destination LOWW via LHCC FIR. In this scenario traffic proceeding to NATEX from all directions is being sequenced.
Corresponding objectives	OBJ-02.10-03	Demonstrate the potential in efficiently substituting current separation tools with CDO enhancement tool in the en-route phase in order to achieve benefits on workload.
Methodology	Paper-based questionnaire covering the following topics: • **A 3.2** General workload during trial • **A 3.3** CDO supporting tool specific workload • **A 3.4** CDO supporting tool specific situational awareness • **A 3.5** Evaluation of confidence in System • **A 3.6** Safety	
Respondents	42 responds from 9 Air Traffic Controllers of HungaroControl	
Period of data collection	2nd June – 20th July, 2016	

A.3.2 Evaluation of General Workload

This section is aimed at the evaluation of general workload of the ATCOs.

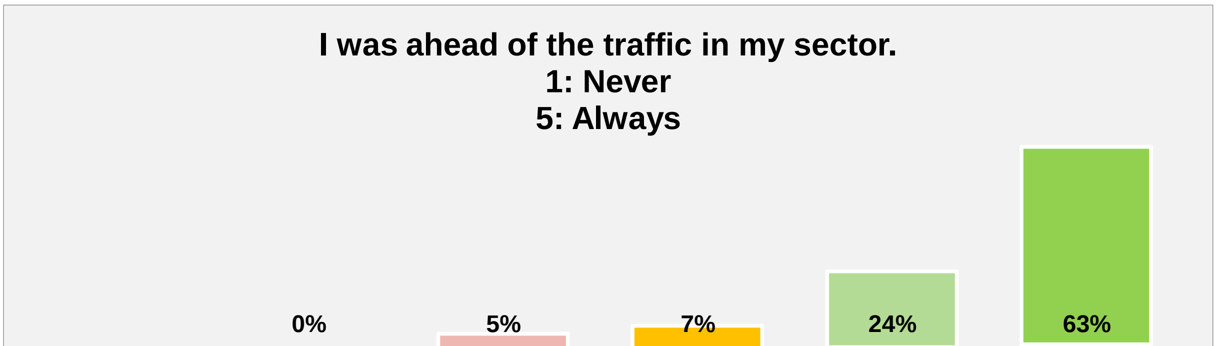
A.3.2.1 How was the traffic according to your subjective experience?

This question is about personal experience of the ATCO’s related to the traffic experience at the time of inquiry.
Most of ATCOs reported medium traffic at the time of inquiry and less than the third of them reported heavy or light traffic. According to this it can be stated that the Tool is useful mainly in case of medium traffic, less useful in low traffic situation and it becomes progressively harder to use the tool during periods of high traffic density.



A.3.2.2 I was ahead of the traffic in my sector.

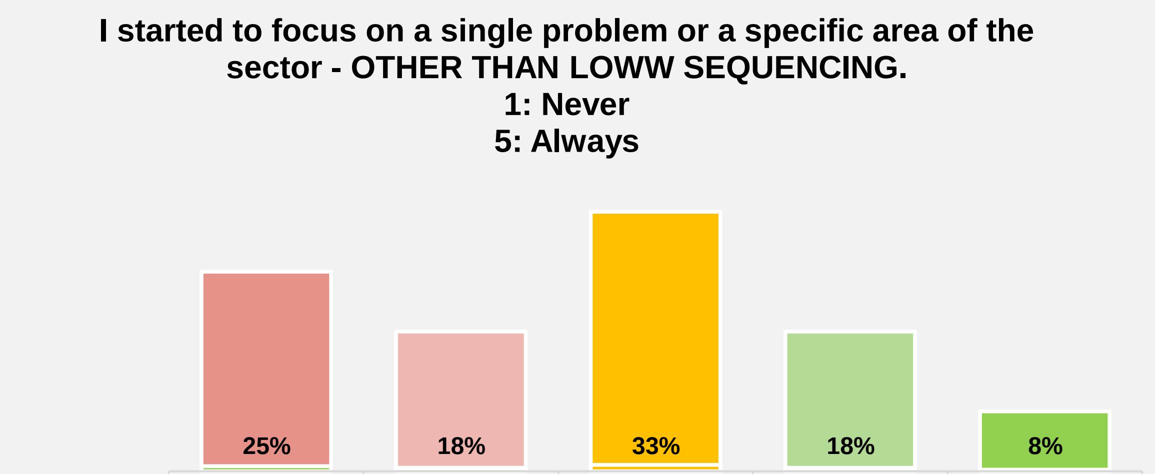
A subjective evaluation of the traffic situation the performance by the ATCOs was asked.
The majority of ATCOs were positive that he/she had the full control of the situation and only less than third of the reported some sort of difficulties. This fully understandable if compare to previous question where the ATCOs have reported medium traffic density at the similar rate.



	1	2	3	4	5
Responds	0	2	3	10	26
Percentage	0%	5%	7%	24%	63%

A.3.2.3 I started to focus on a single problem or a specific area of the sector - OTHER THAN LOWW SEQUENCING.

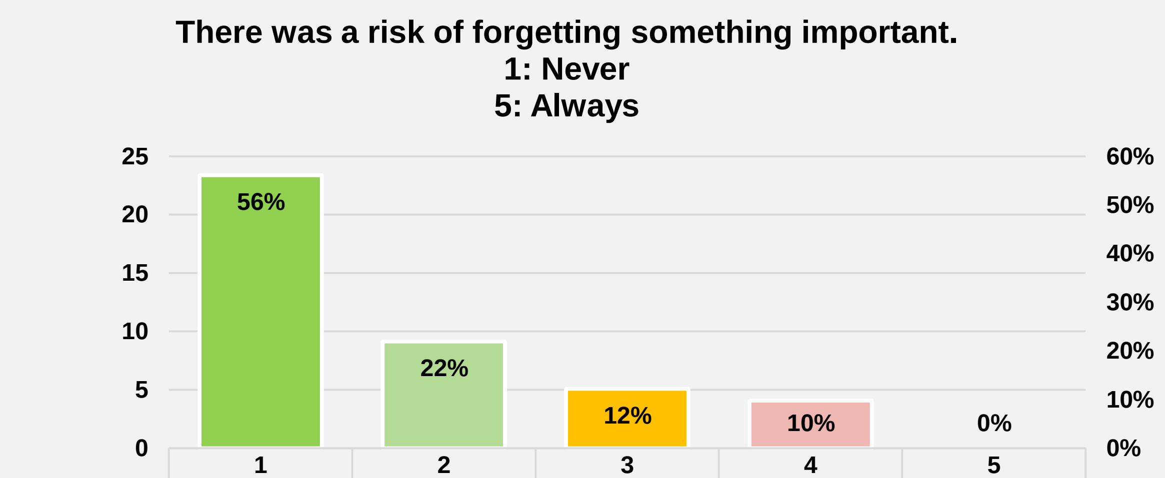
This question is aiming at if the ATCOs had to focus on a particular situation other than LOWW sequencing during the time of the inquiry.
The answers show that the majority of the ATCOs concentrated on the LOWW sequencing rather than to a particular area. It also reflects the situation that majority of the ATCOs have reported medium level of traffic at the time of the inquiry.



	1	2	3	4	5
Responds	10	7	13	7	3
Percentage	25%	18%	33%	18%	8%

A.3.2.4 There was a risk of forgetting something important.

This question is asking about the risk of forgetting something important and the confidence of ATCOs. Most of the ATCOs have reported that there was no such threat, of course this have a relation to the fact that majority of the ATCOs reported medium density of traffic during the inquiry.



	1	2	3	4	5
Responds	23	9	5	4	0
Percentage	56%	22%	12%	10%	0%

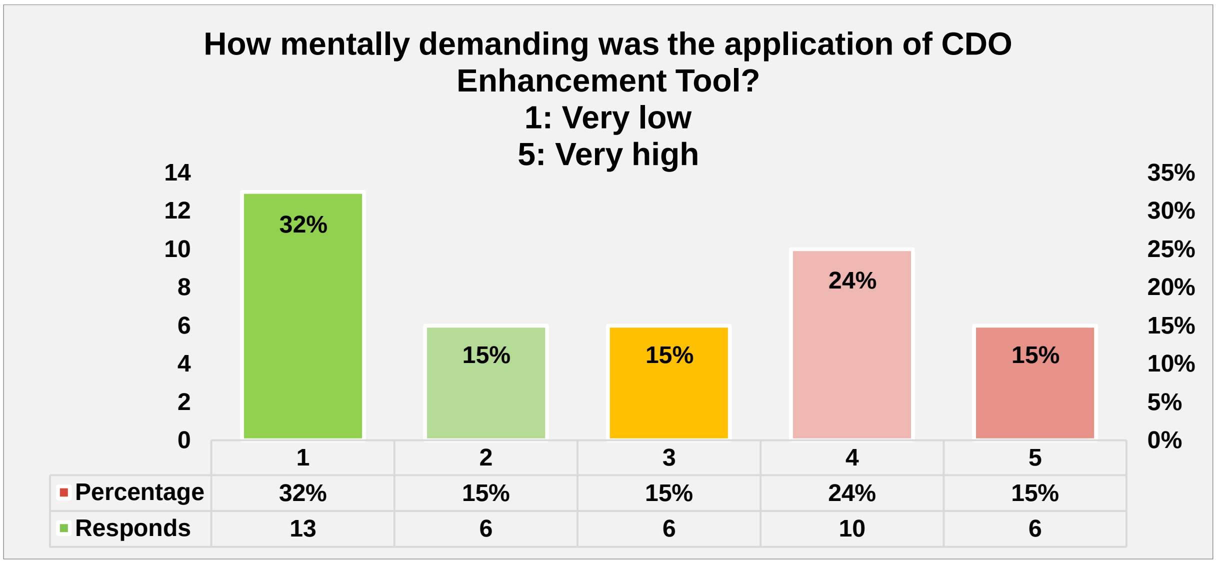
A.3.3 Evaluation of CDO Enhancement Tool Specific Workload

This section is evaluating the workload specific to the CDO Enhancement tool.

A.3.3.1 How demanding was the application of CDO Enhancement Tool?

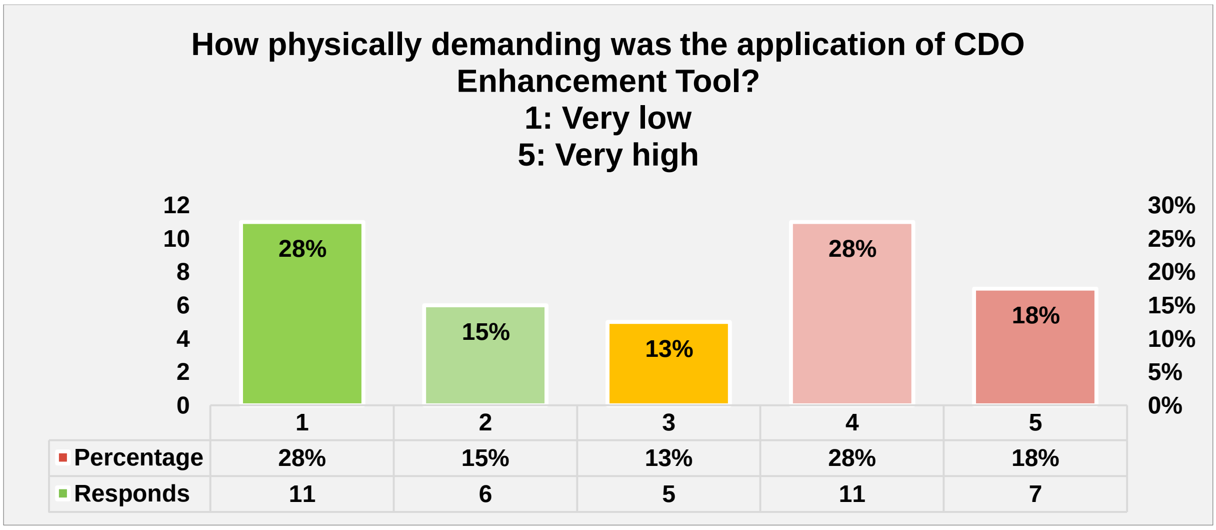
The first related question is asking the ATCOs how mentally demanding is to use the CDO Enhancement tool on a scale from 1 to 5.

The majority of the ATCOs are answered between low and moderate. It shows the similar pattern as the traffic density related question. During the interviews it was recognised that the higher the traffic density the more likely is that the ATCO will turn to vectoring instead of use of the CDO Enhancement tool.



	1	2	3	4	5
Percentage	32%	15%	15%	24%	15%
Responds	13	6	6	10	6

The second sub-question is asking the ATCOs how physically demanding is to use the CDO Enhancement tool on a scale from 1 to 5. The results are similar: A large percent of the ATCOs are answered between low and moderate but there were also significant portion on high demand. It shows the similar pattern as the traffic density related question. During the interviews it is established that the higher the traffic density the more likely is that the ATCO will turn to vectoring instead of use of the CDO Enhancement tool.

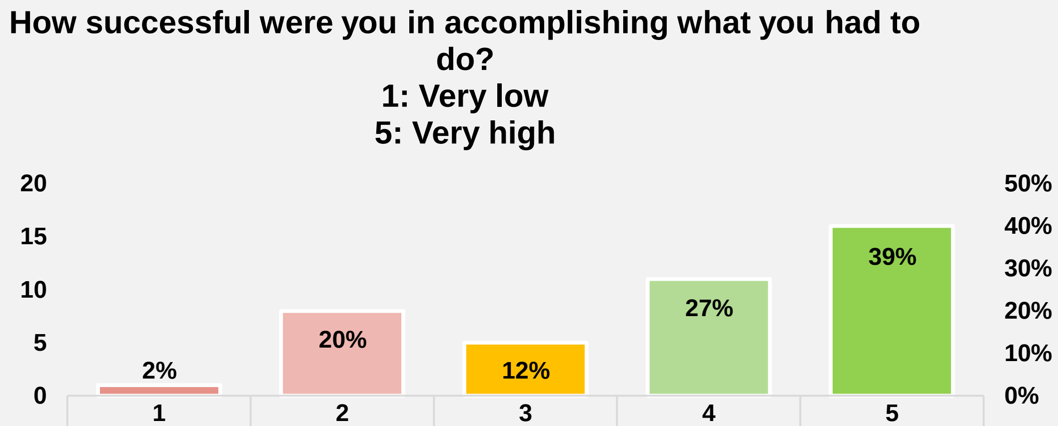


	1	2	3	4	5
Percentage	28%	15%	13%	28%	18%
Responds	11	6	5	11	7

A.3.3.2 How successful were you in accomplishing what you had to do?

This question is asking the ATCOs how successful they were at using the CDO Enhancement tool on a scale from 1 to 5.

The majority of the ATCOs are answered between high and moderate. The ATCOs had a thorough training before the introduction of the tool, so it seems natural that they are familiar with the procedure. It also shows the similar pattern as the traffic density related question. During the interviews it is established that the higher the traffic density the more likely is that the ATCO will turn to vectoring instead of use of the CDO Enhancement tool.

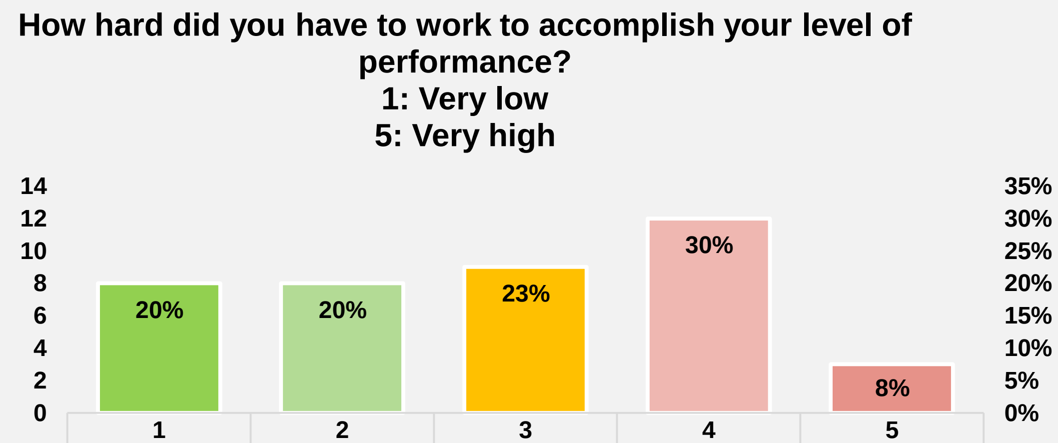


	1	2	3	4	5
Percentage	2%	20%	12%	27%	39%
Responds	1	8	5	11	16

A.3.3.3 How hard did you have to work to accomplish your level of performance?

The question is asking the ATCOs about the level of effort they had to apply to reach the usual level of performance using the new tool on the scale from 1 to 5.

The question is a bit controversial as ATCOs are asked to evaluate how hard they were working in the period falling under the inquiry and some of them might be reluctant to say that they are not working hard, still the majority answered that the workload was moderate or low as it could be expected from the traffic density related answers.

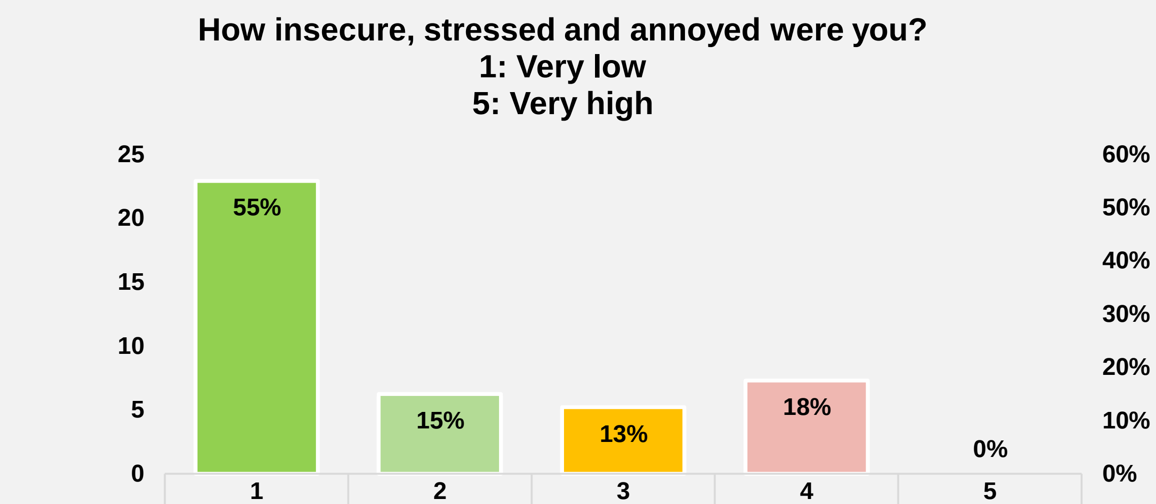


	1	2	3	4	5
Percentage	20%	20%	23%	30%	8%
Responds	8	8	9	12	3

A.3.3.4 How insecure, stressed and annoyed were you?

Purpose of this question was to establish how insecure, stressed and annoyed was the ATCO during the usage of the CDO Enhancement tool.

The majority of the ATCOs answered positively that is that they are not insecure, stressed and annoyed at all or somewhat. This shows that the new CDO Enhancement tool is well accepted and that the ATCOs are familiar with it.



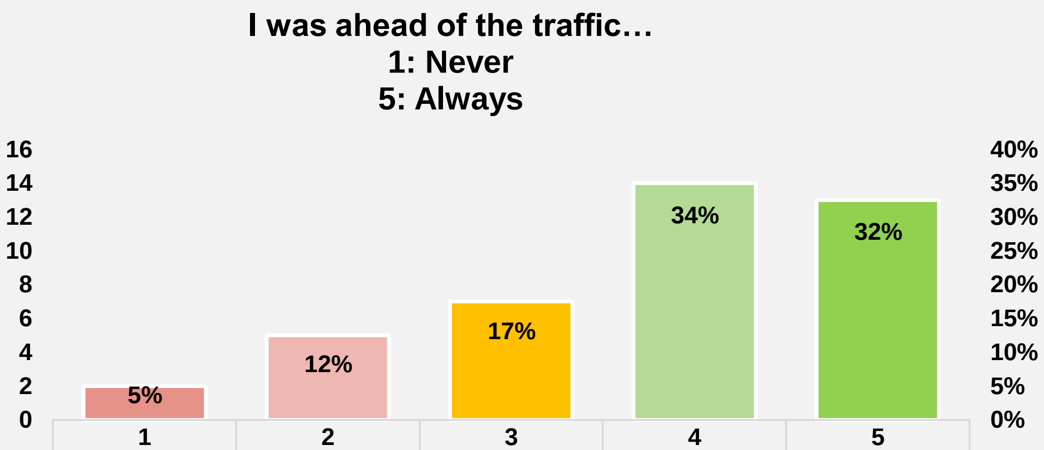
	1	2	3	4	5
Responds	22	6	5	7	0
Percentage	55%	15%	13%	18%	0%

A.3.4 Evaluation of CDO Enhancement Tool Specific Situational Awareness

This section is evaluating the effect that the new CDO Enhancement Tool made on the situational awareness of the ATCOs.

A.3.4.1 I was ahead of the traffic…

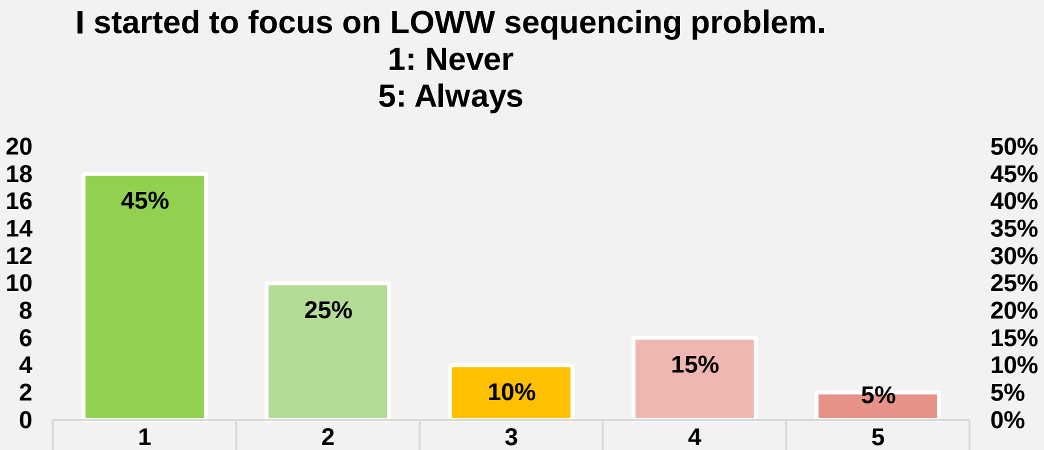
Purpose of this question is to establish the level of the situational awareness of the ATCOs on the scale of 1 to 5.
The majority of the ATCOs answered positively to the question and the proportion of the positive and negative answers reflects the proportion associated with the traffic density related question.



	1	2	3	4	5
Percentage	5%	12%	17%	34%	32%
Responds	2	5	7	14	13

A.3.4.2 I started to focus on LOWW sequencing problem.

This question asks whether ATCOs were focusing on a LOWW sequencing problem.
The majority of the ATCOs answered negatively, so they were not focusing on LOWW sequencing problem.

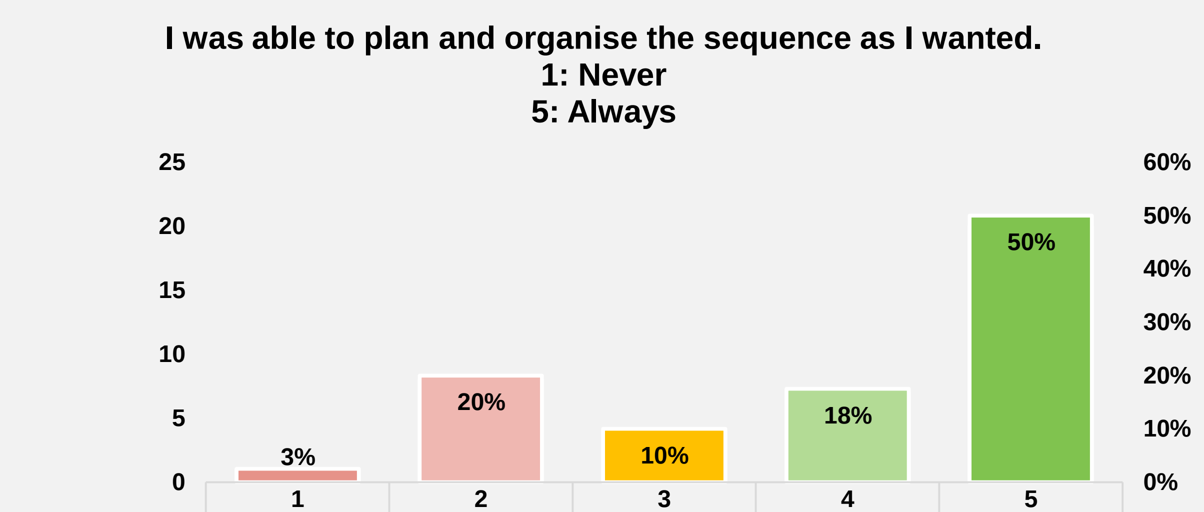


	1	2	3	4	5
Percentage	45%	25%	10%	15%	5%
Responds	18	10	4	6	2

A.3.4.3 I was able to plan and organise the sequence as I wanted.

The purpose of the question is to establish if the ATCO was able to organise the sequence as he wanted and to evaluate his success on the scale from 1 to 5.

Most of the ATCOs answered positively to this question. The proportion of negative and positive answers reflects the proportion of answers relate to the traffic density.

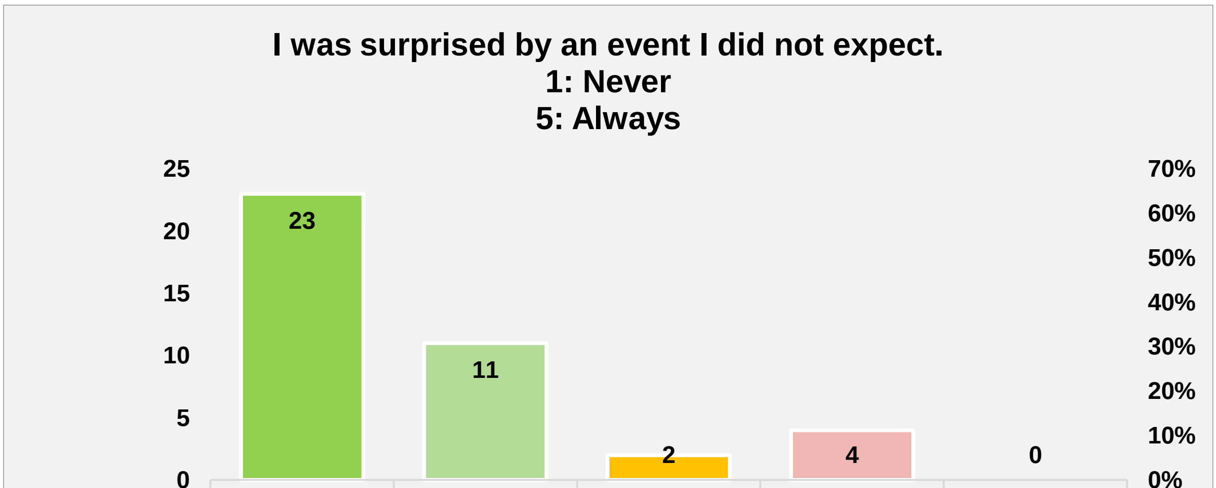


	1	2	3	4	5
Responds	1	8	4	7	20
Percentage	3%	20%	10%	18%	50%

A.3.4.4 I was surprised by an event I did not expect.

The purpose of the question is to establish if the ATCO has encountered any unexpected events during the evaluation period.

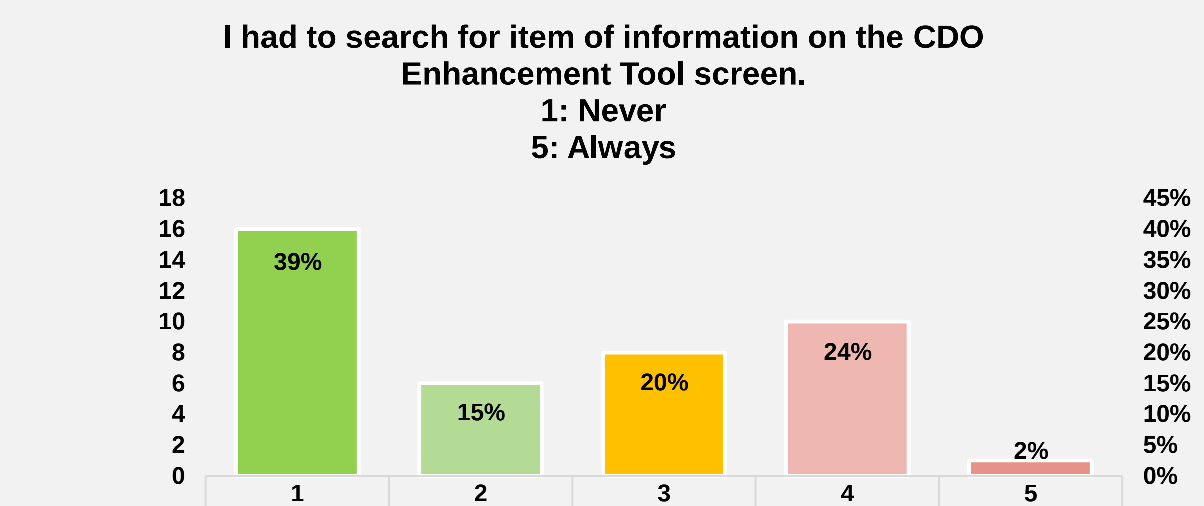
The majority of the ATCOs have not encountered unexpected events during the evaluation period.



	1	2	3	4	5
Percentage	58%	28%	5%	10%	0%
Responds	23	11	2	4	0

A.3.4.5 I had to search for item of information on the CDO Enhancement Tool screen

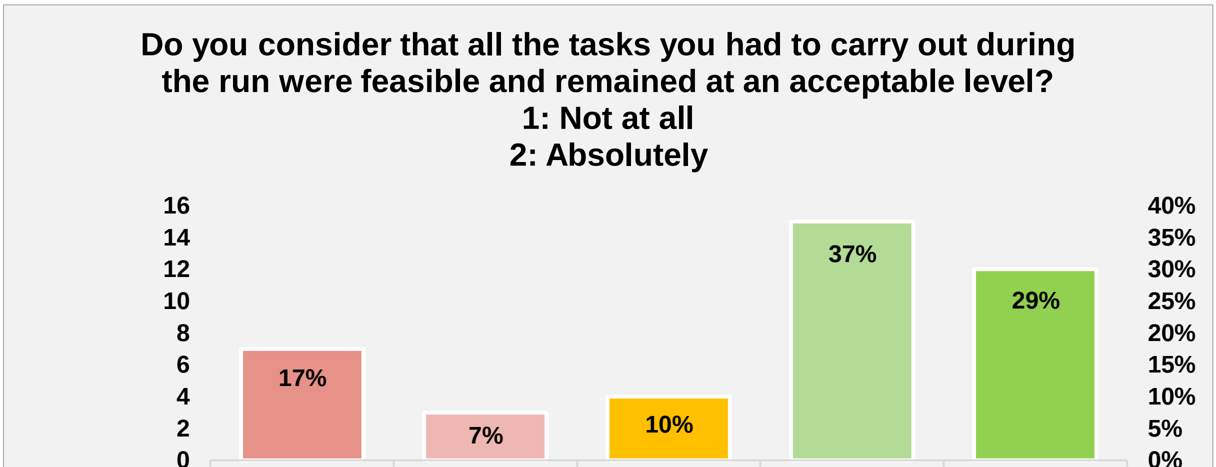
The question relates if ATCOs had to search for new information on the screen of the new tool. There is a divergence among ATCOs some had to search and some don't during the demonstration period.



	1	2	3	4	5
Percentage	39%	15%	20%	24%	2%
Responds	16	6	8	10	1

A.3.4.6 Do you consider that all the tasks you had to carry out during the run were feasible and remained at an acceptable level?

Purpose of this question is to evaluate if the ATCOs considered the required tasks were feasible and at acceptable level for them on a scale from 1 to 5.
Majority of the ATCOs considered the required tasks feasible and at acceptable levels. The results of this question correlate with the results of the traffic density related question. The strong winds could cause some extra as flights with different headings will be differently affected by the wind.



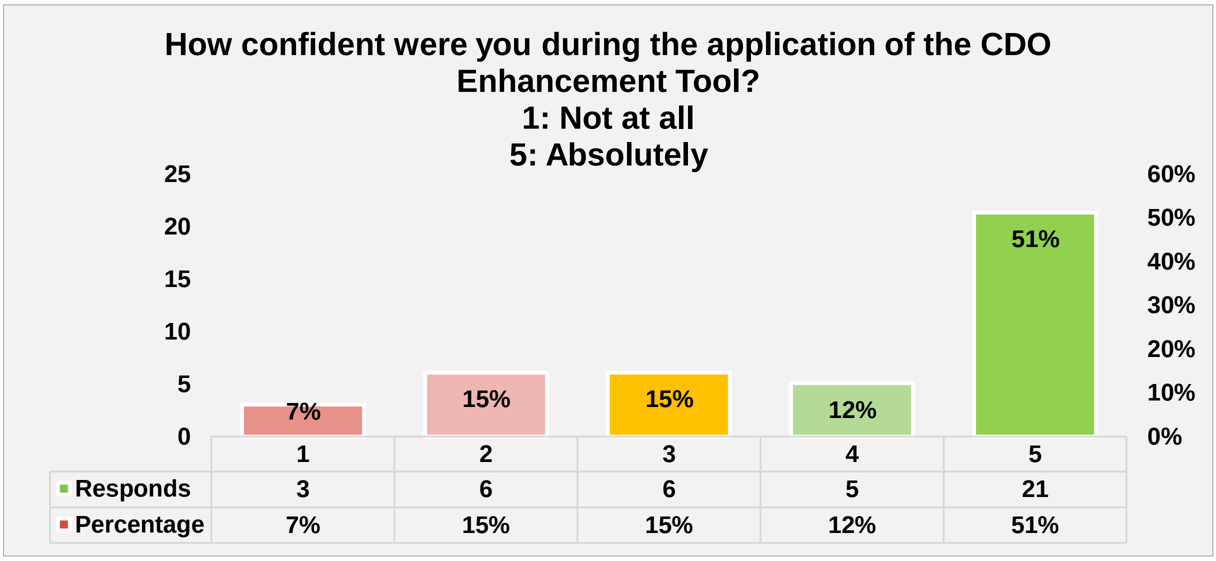
	1	2	3	4	5
Percentage	17%	7%	10%	37%	29%
Responds	7	3	4	15	12

A.3.5 Evaluation of Confidence in the System

This section will establish the confidence in the system.

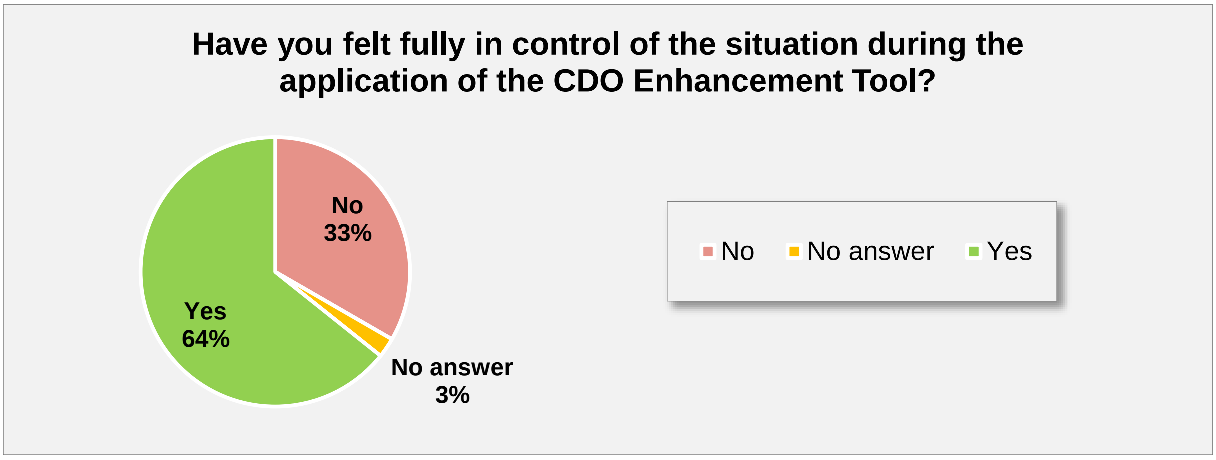
A.3.5.1 How confident were you during the application of the CDO Enhancement Tool?

Purpose of this question is to establish the level of confidence of the ATCOs in the CDO Enhancement Tool on the scale from 1 to 5.
The majority of the ATCOs showed good confidence in the system. Again the correlation with the traffic density question can be seen. During the interviews some of the ATCOs explained that the higher the traffic density the more likely they will turn to vectoring of the flights and stop using the CDO Enhancement Tool.



A.3.5.2 Have you felt fully in control of the situation during the application of the CDO Enhancement Tool?

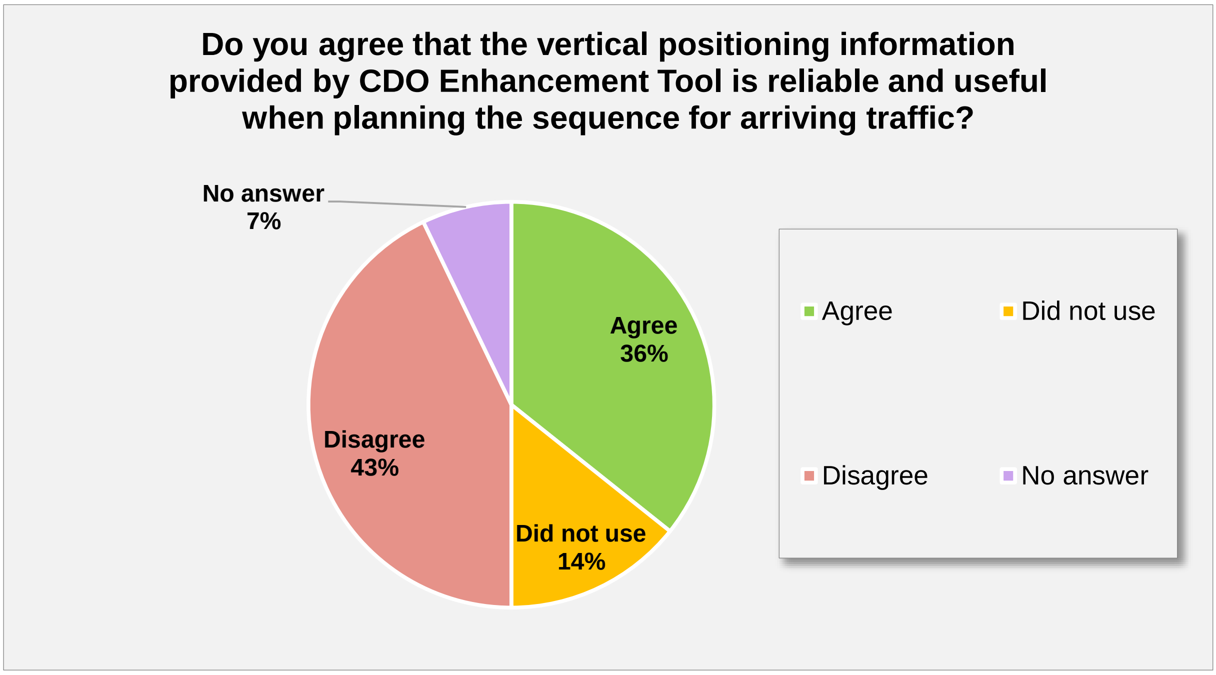
Purpose of the question to establish how in control the ATCOs have felt during the use of the CDO Enhancement Tool.
The majority of the ATCOs felt in control during the use of the CDO Enhancement Tool. The proportion of negative and positive answers shows some correlation with the traffic density question that means that in the high density traffic some ATCOs actually felt more in control using vectoring.



A.3.5.3 Do you agree that the vertical positioning information provided by CDO Enhancement Tool is reliable and useful when planning the sequence for arriving traffic?

The purpose of this question is to establish if the vertical positioning information provided by the CDO Enhancement Tool reliable and useful for the ATCOs.

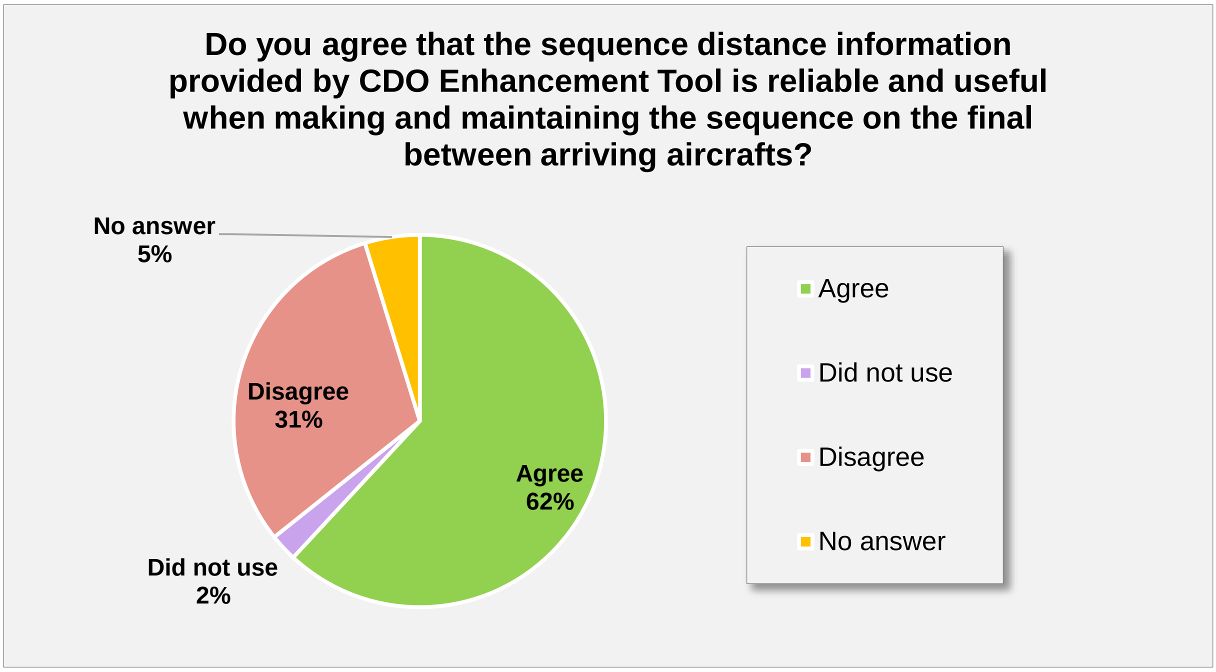
The answers were not consistent. During personal interviews some ATCOs expressed that the same information is available from other system too, however differently presented and that strong wind component, difference in aircraft types and dense traffic influences the reliability of the data. The strong wind component influences the ground speed of the aircraft moving from opposite direction to the same point. The aircraft with the strong headwind could be considerably slower than the one coming from the opposite direction with the tailwind. The different aircraft types that is those with turboprop engine and those with jet engine have different speeds during the procedures and as the CDO Enhancement Tool does not recognises this difference it provides unreliable data. If the number of arriving aircraft higher due to the long T-BAR some of them will be under other sector's control, so the ATCO cannot influence their movement. It was also mentioned that the graphical presentation of the CDO Enhancement Tool is quite useful.



A.3.5.4 Do you agree that the sequence distance information provided by CDO Enhancement Tool is reliable and useful when making and maintaining the sequence on the final between arriving aircrafts?

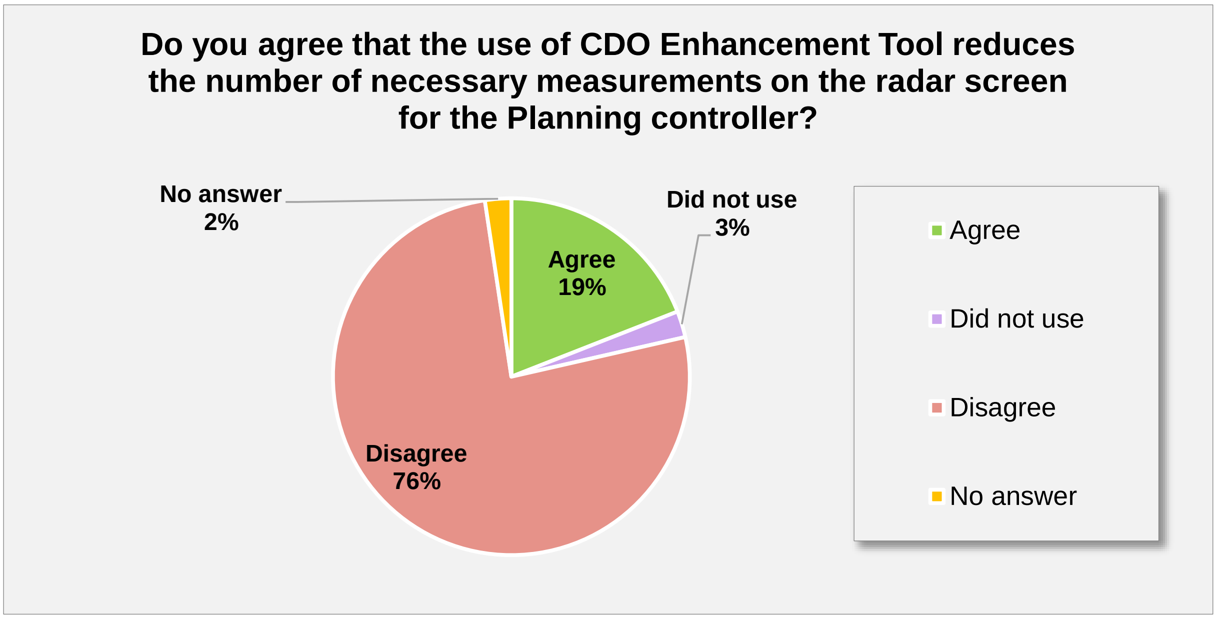
Purpose of this question is to establish if the sequence distance information provided by CDO Enhancement Tool is reliable and useful when making and maintaining the sequence on the final between arriving aircrafts.

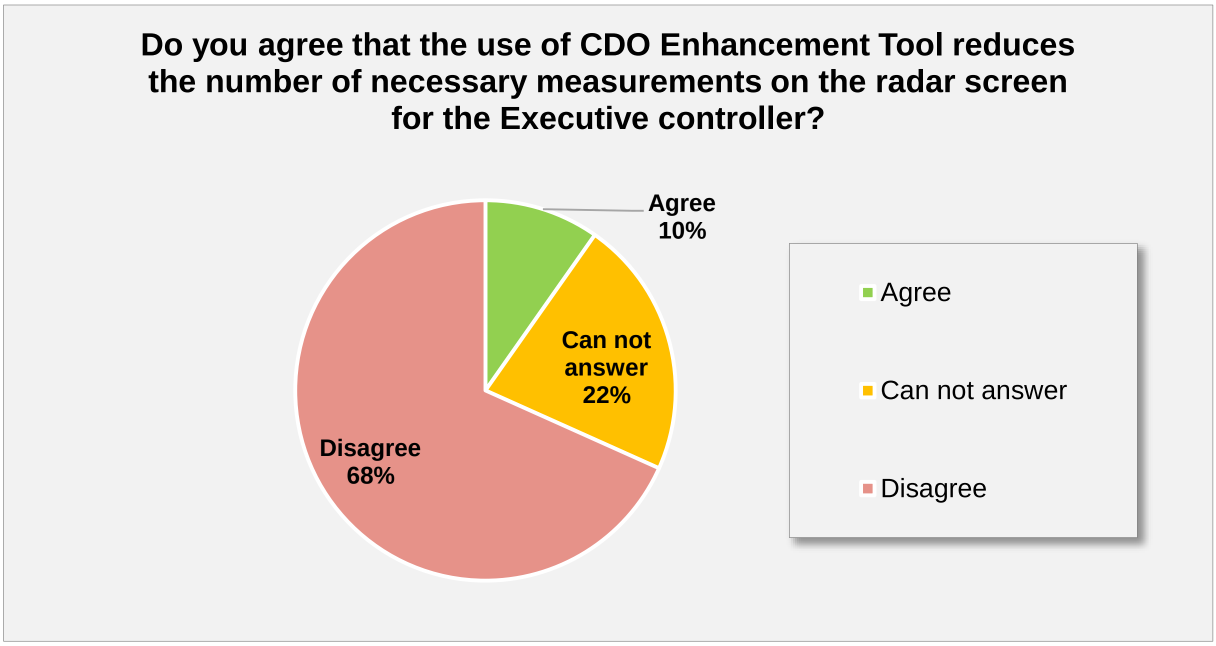
The majority of the ATCOs agree with the reliability and usefulness of the provided information. But it is mentioned during personal interviews that above a certain degree of traffic density the use of the CDO Enhancement Tool is difficult. The proportion off negative and positive answers show similarity with the traffic density related question.



A.3.5.5 Do you agree that the use of CDO Enhancement Tool reduces the number of necessary measurements on the radar screen for the controllers?

Purpose of this question is to establish if ATCOs agree with the statement that the use of CDO Enhancement Tool reduces the number of necessary measurements on the radar screen for the controller.
The majority of the ATCOs disagree with this statement.



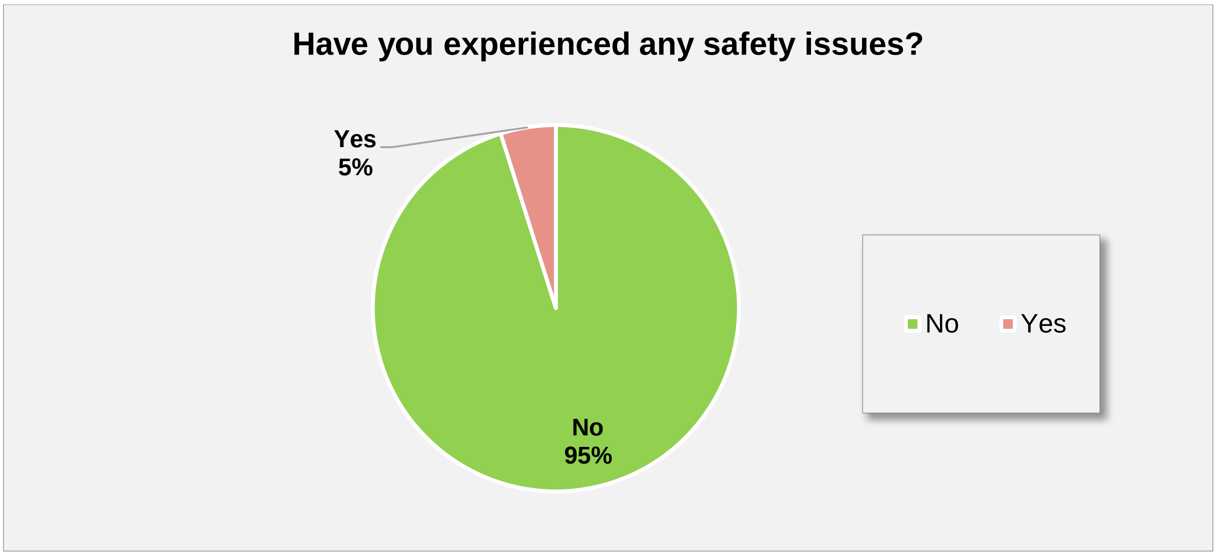


A.3.5.6 Have you experienced any safety issues?

Purpose of this question is to establish if ATCOs have experienced any safety issues.

Row Labels	Responds
No	39
Yes	2
Grand Total	**41**

The majority of the ATCOs has denied the existence of any safety issues relevant to this case. They have explained that due to the fact that the use of the CDO Enhancement Tool is not mandatory, so they can switch back to vectoring at any time they think is appropriate. Therefore, if they cope with the situation using CDO Enhancement Tool they can return to usual procedures.



A.3.6 ATCO Workshop results on CDO ACC Operations

On the 27th of July a workshop was organised jointly by HungaroControl and Slot Consulting to assess together the interim results of the survey with air traffic controllers.

In overall the followings were found:

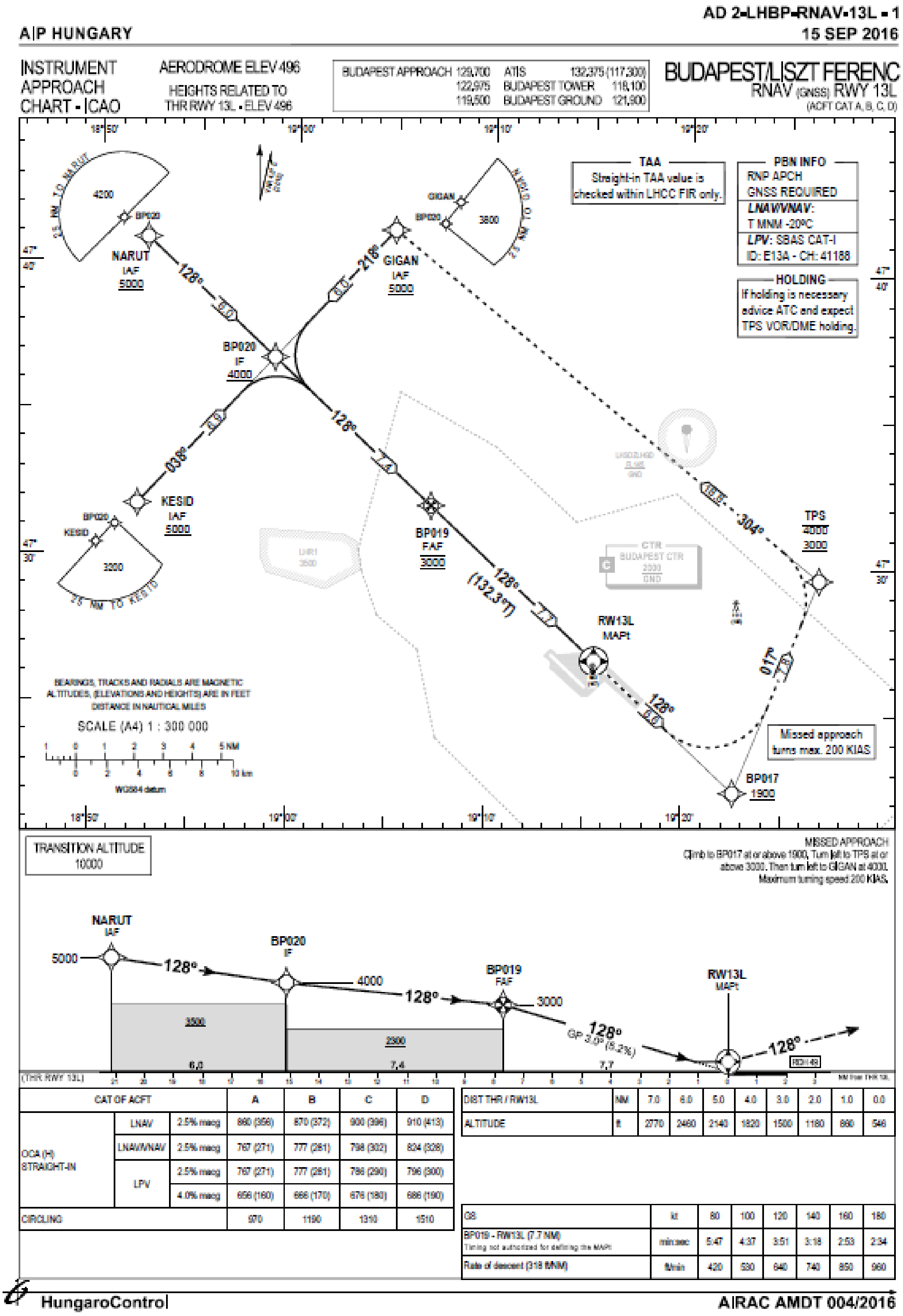
The ATCOs confirmed that the results to the survey are realistic and show their general feelings.

It seems to be obvious that ATCOs fall into two main categories: ones who are open for the new procedures, concepts and ones who are less open.

In terms of the CDO Enhancement Tool the majority of the ATCOs support the concept but most of them see the need for a lot of improvements before it can actually achieve what is meant for. Adding new functions and integration to the MATIAS system seem to be the key messages as needs from the ATCOs

Appendix B Procedure design packages

B.1 RNP APCH to RWY 13L LHBP



CAT OF ACFT			A	B	C	D
OCA (H) STRAIGHT-IN	LNAV	2.5% macg	860 (356)	870 (372)	900 (396)	910 (413)
	LNAV/VNAV	2.5% macg	767 (271)	777 (281)	798 (302)	824 (328)
	LPV	2.5% macg	767 (271)	777 (281)	786 (290)	796 (300)
		4.0% macg	656 (160)	666 (170)	676 (180)	686 (190)
CIRCLING			970	1190	1310	1510

DIST THR / RW13L	NM	7.0	6.0	5.0	4.0	3.0	2.0	1.0	0.0
ALTITUDE	ft	2770	2460	2140	1820	1500	1180	860	546

GS	kt	80	100	120	140	160	180
BP019 - RW13L (7.7 NM) Timing not authorized for defining the MAPt	min:sec	5:47	4:37	3:51	3:18	2:53	2:34
Rate of descent (318 ft/NM)	ft/min	420	530	640	740	850	960

WAYPOINT LIST

Procedure Name:	RNAV (GNSS) RWY13L	Version:	2.1

WP ID	Latitude	Longitude
NARUT	474052.8N	0185224.1E
GIGAN	474117.3N	0190458.0E
KESID	473147.2N	0185210.0E
BP020	473651.5N	0185859.1E
BP019	473154.7N	0190702.8E
RW13L	472643.52N	0191527.18E
BP017	472218.6N	0192234.5E
TPS	472935.7N	0192646.4E

CODING TABLES

Procedure Name: RNAV (GNSS) RWY13L **Version:** 2.1

Initial Waypoint name: NARUT

INSTRUMENT FLIGHT PROCEDURE FROM NARUT

PT	WP ID	OverFly	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF	RADIUS (NM)	ARC CTR ID
IF	NARUT		IAF		4.5					5000				RNP APCH		
TF	BP020		IF		4.5	132.1	TT		6	4000				RNP APCH		
TF	BP019		FAF		4.5	132.2	TT		7.4	3000	3000			RNP APCH		
TF	RW13L	Y	MAPt		4.5	132.3	TT		7.7	546			-3.0	RNP APCH		
TF	BP017		MATF		4.5	132.4	TT		6.6	1900		200		RNP APCH		
TF	TPS		MATF		4.5	21.3	TT		7.8	3000	4000	200		RNP APCH		
TF	GIGAN				4.5	308.5	TT		18.8	4000	4000	200		RNP APCH		

CODING TABLES

Procedure Name: RNAV (GNSS) RWY13L **Version:** 2.1

Initial Waypoint name: GIGAN

INSTRUMENT FLIGHT PROCEDURE FROM GIGAN

PT	WP ID	OverFly	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF	RADIUS (NM)	ARC CTR ID
IF	GIGAN		IAF		4.5					5000				RNP APCH		
TF	BP020		IF		4.5	222.4	TT		6	4000				RNP APCH		
TF	BP019		FAF		4.5	132.2	TT		7.4	3000	3000			RNP APCH		
TF	RW13L	Y	MAPt		4.5	132.3	TT		7.7	546			-3.0	RNP APCH		
TF	BP017		MATF		4.5	132.4	TT		6.6	1900		200		RNP APCH		
TF	TPS		MATF		4.5	21.3	TT		7.8	3000	4000	200		RNP APCH		
TF	GIGAN				4.5	308.5	TT		18.8	4000	4000	200		RNP APCH		

CODING TABLES

Procedure Name:	RNAV (GNSS) RWY13L	Version:	2.1

Initial Waypoint name:	KESID

INSTRUMENT FLIGHT PROCEDURE FROM KESID

PT	WP ID	OverFly	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF	RADIUS (NM)	ARC CTR ID
IF	KESID		IAF		4.5					5000				RNP APCH		
TF	BP020		IF		4.5	42.3	TT		6.9	4000				RNP APCH		
TF	BP019		FAF		4.5	132.2	TT		7.4	3000	3000			RNP APCH		
TF	RW13L	Y	MAPt		4.5	132.3	TT		7.7	546			-3.0	RNP APCH		
TF	BP017		MATF		4.5	132.4	TT		6.6	1900		200		RNP APCH		
TF	TPS		MATF		4.5	21.3	TT		7.8	3000	4000	200		RNP APCH		
TF	GIGAN				4.5	308.5	TT		18.8	4000	4000	200		RNP APCH		

Final Approach Segment - Datablock (FAS-DB)			
Procedure Name:	RNAV (GNSS) RWY13L	**Version:**	2.1

FAS-DB (CRC wrapped data)	
Operation type	0
SBAS provider ID	1
Airport identifier	LHBP
RWY	13L
Approach performance designator	0
Route indicator	
Reference path data selector	0
Reference path identifier	E13A
LTP/FTP latitude	472643.5200N
LTP/FTP longitude	0191527.1800E
LTP/FTP ellipsoidal height (m)	194.8
FPAP latitude	472521.7545N
FPAP longitude	0191739.2775E
Threshold crossing height (TCH)	15
TCH units	1
Glide path angle (degrees)	3.00
Course width at threshold (m)	105.00
Length offset (m)	40
Horizontal alert limit (m)	40.0
Vertical alert limit (m)	35.0
Computed Data Block	10 10 02 08 0C CD 00 00 01 33 31 05 80 82 5C 14 98 B2 43 08 9C 1B 35 81 FD 03 08 04 2C 81 2C 01 64 05 C8 AF 36 F8 33 69
Computed CRC	36F83369
FAS-DB (not CRC wrapped)	
ICAO code	LH
LTP/FTP Orthometric height (m)	151.3
FPAP Orhtometric height (m)	151.3

B.2 RNP APCH to RWY 13R LHBP

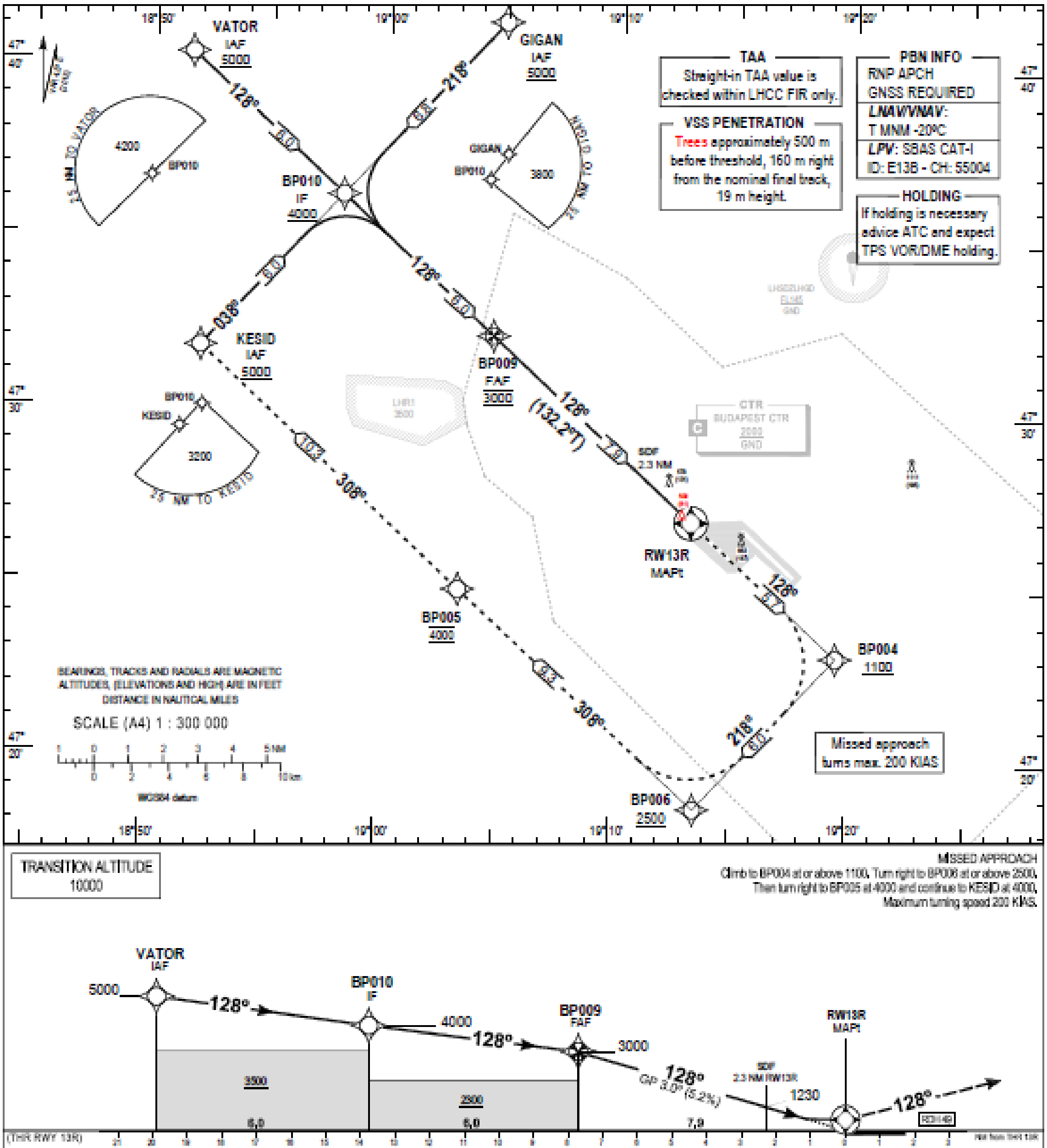
AD 2-LHBP-RNAV-13R - 1
AIP HUNGARY
15 SEP 2016

INSTRUMENT APPROACH CHART - ICAO

AERODROME ELEV 496
HEIGHTS RELATED TO THR RWY 13R - ELEV 448

BUDAPEST APPROACH 129,700 122,975 119,500 | ATIS 132,375 (117,300) | BUDAPEST TOWER 118,100 | BUDAPEST GROUND 121,900

BUDAPEST/LISZT FERENC
RNAV (GNSS) RWY 13R
(ACFT CAT A, B, C, D)



CAT OF ACFT			A	B	C	D
OCA (H) STRAIGHT-IN	LNAV	2.5% macg	900 (446)	920 (468)	940 (491)	960 (511)
		4.0% macg	830 (377)			
	LNAV/VNAV	2.5% macg	848 (400)	857 (409)	878 (430)	905 (457)
		4.0% macg	710 (262)	720 (272)	730 (282)	740 (292)
	LPV	2.5% macg	848 (400)	857 (409)	867 (419)	877 (429)
		4.0% macg	633 (185)	642 (194)	652 (204)	662 (214)
CIRCLING			970	1190	1310	1510

DIST THR / RW13R	NM	7.0	6.0	5.0	4.0	3.0	2.0	1.0	0.0
ALTITUDE	ft	2730	2410	2090	1770	1450	1130	820	497

GS	kt	80	100	120	140	160	180
BP009 - RW13R (7.9 NM) Timing not authorized for defining the MAPt	min:sec	5:54	4:43	3:56	3:22	2:57	2:37
Rate of descent (318 ft/NM)	ft/min	420	530	640	740	850	960

HungaroControl
AIRAC AMDT 004/2016

WAYPOINT LIST

Procedure Name: RNAV (GNSS) RWY13R — Version: 2.1

WP ID	Latitude	Longitude
VATOR	474015.8N	0185135.1E
GIGAN	474117.3N	0190458.0E
KESID	473147.2N	0185210.0E
BP010	473613.8N	0185809.0E
BP009	473212.4N	0190440.2E
RW13R	472655.34N	0191314.73E
BP004	472303.3N	0191929.6E
BP006	471837.5N	0191332.8E
BP005	472452.2N	0190322.1E

CODING TABLES																
Procedure Name:	RNAV (GNSS) RWY13R														**Version:**	2.1
Initial Waypoint name:	VATOR															

INSTRUMENT FLIGHT PROCEDURE FROM VATOR																
PT	**WP ID**	**OverFly**	**Fix role**	**TD**	**VAR**	**CRS Val (°)**	**CRS Type**	**TIME (s)**	**DIST (NM)**	**MNM ALT (ft)**	**MAX ALT (ft)**	**IAS MAX (kt)**	**VRT ANG**	**NAV PERF**	**RADIUS (NM)**	**ARC CTR ID**
IF	VATOR		IAF		4.5					5000				RNP APCH		
TF	BP010		IF		4.5	132.2	TT		6.0	4000				RNP APCH		
TF	BP009		FAF		4.5	132.3	TT		6.0	3000	3000			RNP APCH		
TF	RW13R	Y	MAPt		4.5	132.2	TT		7.9	497			-3.0	RNP APCH		
TF	BP004		MATF		4.5	132.3	TT		5.7	1100		200		RNP APCH		
TF	BP006		MATF		4.5	222.4	TT		6.0	2500		200		RNP APCH		
TF	BP005				4.5	312.1	TT		9.3	4000	4000	200		RNP APCH		
TF	KESID				4.5	312.4	TT		10.3	4000	4000			RNP APCH		

CODING TABLES

Procedure Name: RNAV (GNSS) RWY13R — **Version:** 2.1

Initial Waypoint name: GIGAN

INSTRUMENT FLIGHT PROCEDURE FROM GIGAN

PT	WP ID	OverFly	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF	RADIUS (NM)	ARC CTR ID
IF	GIGAN		IAF		4.5					5000				RNP APCH		
TF	BP010		IF		4.5	222.4	TT		6.8	4000				RNP APCH		
TF	BP009		FAF		4.5	132.3	TT		6.0	3000	3000			RNP APCH		
TF	RW13R	Y	MAPt		4.5	132.2	TT		7.9	497			-3.0	RNP APCH		
TF	BP004		MATF		4.5	132.3	TT		5.7	1100		200		RNP APCH		
TF	BP006		MATF		4.5	222.4	TT		6.0	2500		200		RNP APCH		
TF	BP005				4.5	312.1	TT		9.3	4000	4000	200		RNP APCH		
TF	KESID				4.5	312.4	TT		10.3	4000	4000			RNP APCH		

CODING TABLES

Procedure Name: RNAV (GNSS) RWY13R **Version:** 2.1

Initial Waypoint name: KESID

INSTRUMENT FLIGHT PROCEDURE FROM KESID

PT	WP ID	OverFly	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF	RADIUS (NM)	ARC CTR ID
IF	KESID		IAF		4.5					5000				RNP APCH		
TF	BP010		IF		4.5	42.3	TT		6.0	4000				RNP APCH		
TF	BP009		FAF		4.5	132.3	TT		6.0	3000	3000			RNP APCH		
TF	RW13R	Y	MAPt		4.5	132.2	TT		7.9	497			-3.0	RNP APCH		
TF	BP004		MATF		4.5	132.3	TT		5.7	1100		200		RNP APCH		
TF	BP006		MATF		4.5	222.4	TT		6.0	2500		200		RNP APCH		
TF	BP005				4.5	312.1	TT		9.3	4000	4000	200		RNP APCH		
TF	KESID				4.5	312.4	TT		10.3	4000	4000			RNP APCH		

Final Approach Segment - Datablock (FAS-DB)			
Procedure Name	RNAV (GNSS) RWY13R	**Version:**	2.1

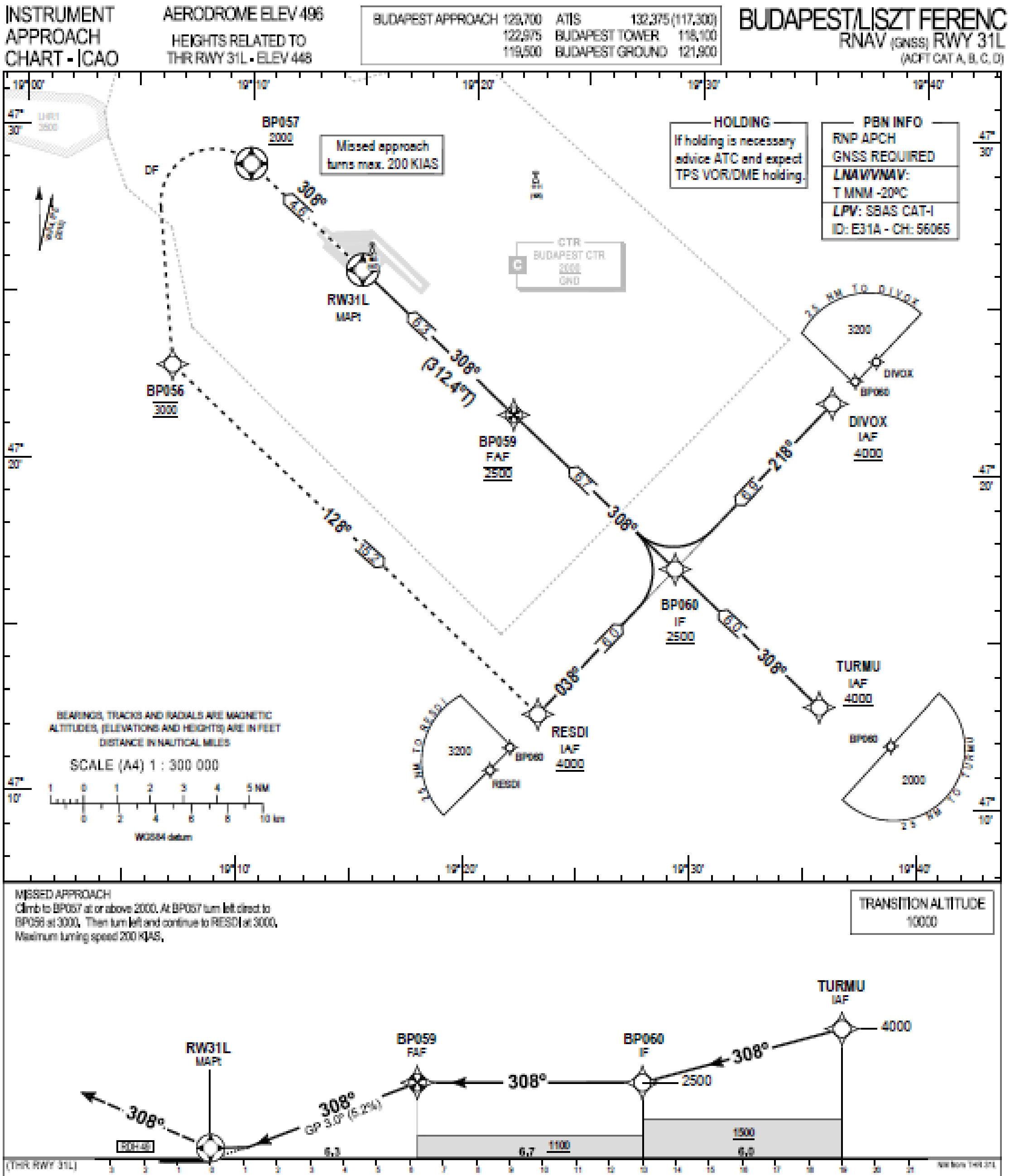
FAS-DB (CRC wrapped data)	
Operation type	0
SBAS provider ID	1
Airport identifier	LHBP
RWY	13R
Approach performance designator	0
Route indicator	
Reference path data selector	0
Reference path identifier	E13B
LTP/FTP latitude	472655.3400N
LTP/FTP longitude	0191314.7300E
LTP/FTP ellipsoidal height (m)	180.2
FPAP latitude	472548.1575N
FPAP longitude	0191503.4000E
Threshold crossing height (TCH)	15
TCH units	1
Glide path angle (degrees)	3.00
Course width at threshold (m)	105.00
Length offset (m)	72
Horizontal alert limit (m)	40.0
Vertical alert limit (m)	35.0
Computed Data Block	10 10 02 08 0C 4D 00 00 02 33 31 05 D8 DE 5C 14 D4 A7 3F 08 0A 1B 23 F3 FD FC 50 03 2C 81 2C 01 64 09 C8 AF 5B 89 E8 EF
Computed CRC	5B89E8EF
FAS-DB (not CRC wrapped)	
ICAO code	LH
LTP/FTP Orthometric height (m)	136.6
FPAP Orhtometric height (m)	136.6

B.3 RNP APCH to RWY 31L LHBP

AD 2-LHBP-RNAV-31L - 1

AIP HUNGARY

15 SEP 2016



CAT OF ACFT			A	B	C	D
OCA (H) STRAIGHT-IN	LNAV	2.5% macg	1050 (597)	1070 (621)	1100 (644)	1120 (664)
		4.0% macg	900 (450)			
	LNAV/VNAV	2.5% macg	951 (503)	961 (513)	982 (534)	1008 (560)
		4.0% macg	741 (293)	750 (302)	775 (327)	806 (358)
	LPV	2.5% macg	951 (503)	961 (513)	971 (523)	980 (532)
		4.0% macg	608 (160)	618 (170)	628 (180)	638 (190)
CIRCLING			970	1190	1310	1510

DIST THR / RW31L	NM	6.0	5.0	4.0	3.0	2.0	1.0	0.0
ALTITUDE	ft	2410	2090	1770	1450	1130	820	497

GS	kt	80	100	120	140	160	180
BP059 - RW31L (6.3 NM) Timing not authorized for defining the MAPt	min:sec	4:43	3:46	3:09	2:42	2:22	2:06
Rate of descent (318 ft/NM)	ft/min	420	530	640	740	850	960

HungaroControl

AIRAC AMDT 004/2016

WAYPOINT LIST			
Procedure Name:	RNAV (GNSS) RWY31L	**Version**	2.1

WP ID	Latitude	Longitude
TURMU	471300.0N	0193537.3E
DIVOX	472206.5N	0193557.5E
RESDI	471238.0N	0192311.1E
BP060	471703.4N	0192908.0E
BP059	472135.4N	0192151.1E
RW31L	472549.71N	0191500.89E
BP057	472856.5N	0190958.6E
BP056	472252N	0190641E

CODING TABLES																
Procedure Name:	RNAV (GNSS) RWY31L													**Version:**	2.1	
Initial Waypoint name:	TURMU															
INSTRUMENT FLIGHT PROCEDURE FROM TURMU																
PT	**WP ID**	**OverFly**	**Fix role**	**TD**	**VAR**	**CRS Val (°)**	**CRS Type**	**TIME (s)**	**DIST (NM)**	**MNM ALT (ft)**	**MAX ALT (ft)**	**IAS MAX (kt)**	**VRT ANG**	**NAV PERF**	**RADIUS (NM)**	**ARC CTR ID**
IF	TURMU		IAF		4.5					4000				RNP APCH		
TF	BP060		IF		4.5	312.6	TT		6.0	2500				RNP APCH		
TF	BP059		FAF		4.5	312.5	TT		6.7	2500	2500			RNP APCH		
TF	RW31L	Y	MAPt		4.5	312.4	TT		6.3	497			-3.0	RNP APCH		
TF	BP057	Y	MATF		4.5	312.4	TT		4.6	2000		200		RNP APCH		
DF	BP056		MATF		4.5					3000	3000	200		RNP APCH		
TF	RESDI				4.5	132.2	TT		15.2	3000	3000	200		RNP APCH		

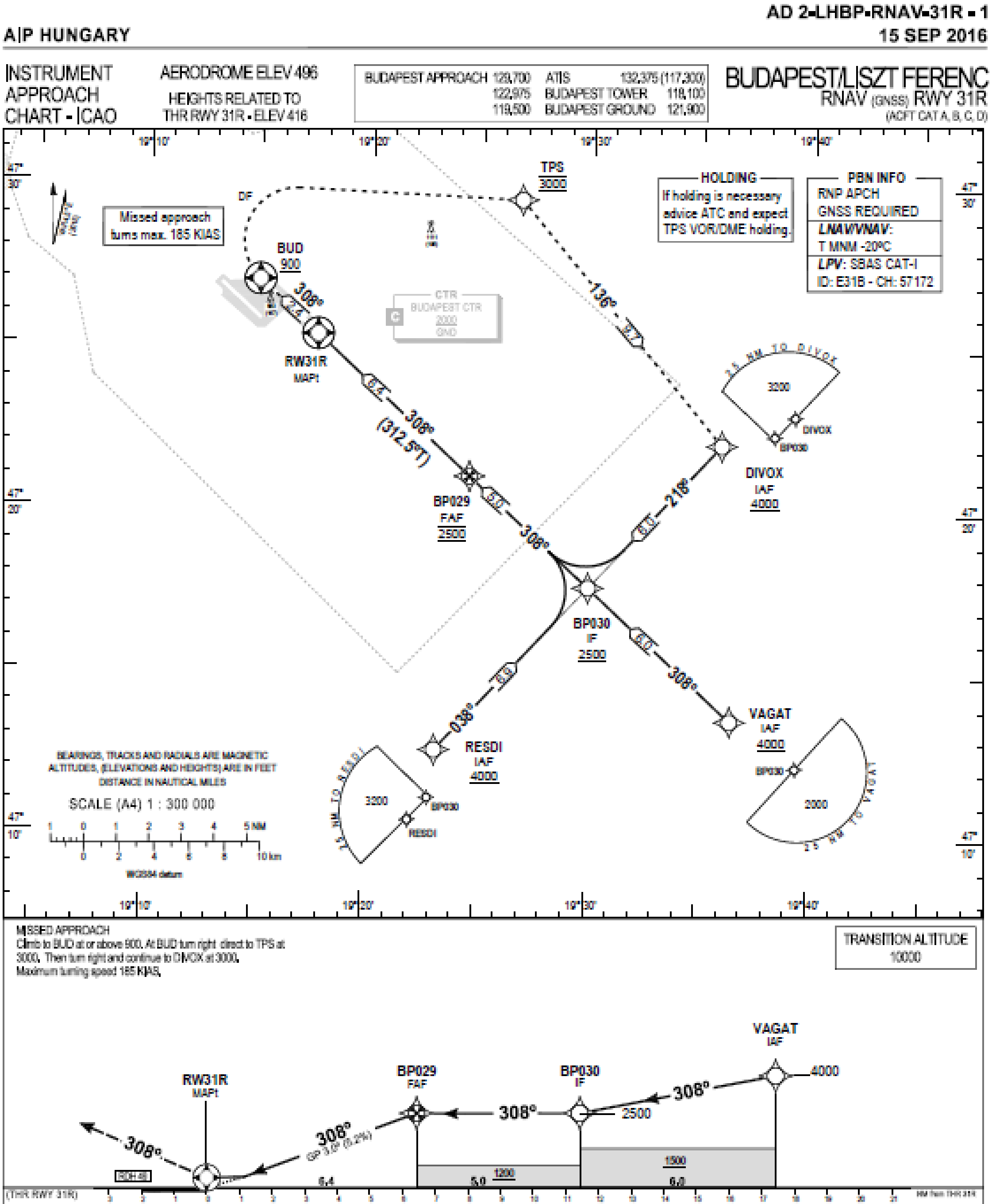
CODING TABLES																
Procedure Name:	RNAV (GNSS) RWY31L														**Version:**	2.1
Initial Waypoint name:	DIVOX															
INSTRUMENT FLIGHT PROCEDURE FROM DIVOX																
PT	**WP ID**	**OverFly**	**Fix role**	**TD**	**VAR**	**CRS Val (°)**	**CRS Type**	**TIME (s)**	**DIST (NM)**	**MNM ALT (ft)**	**MAX ALT (ft)**	**IAS MAX (kt)**	**VRT ANG**	**NAV PERF**	**RADIUS (NM)**	**ARC CTR ID**
IF	DIVOX		IAF		4.5					4000				RNP APCH		
TF	BP060		IF		4.5	222.6	TT		6.9	2500				RNP APCH		
TF	BP059		FAF		4.5	312.5	TT		6.7	2500	2500			RNP APCH		
TF	RW31L	Y	MAPt		4.5	312.4	TT		6.3	497			-3.0	RNP APCH		
TF	BP057	Y	MATF		4.5	312.4	TT		4.6	2000		200		RNP APCH		
DF	BP056		MATF		4.5					3000	3000	200		RNP APCH		
TF	RESDI				4.5	132.2	TT		15.2	3000	3000	200		RNP APCH		

CODING TABLES																
Procedure Name:	RNAV (GNSS) RWY31L													Version:	2.1	
Initial Waypoint name:	RESDI															
INSTRUMENT FLIGHT PROCEDURE FROM RESDI																
PT	WP ID	OverFly	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF	RADIUS (NM)	ARC CTR ID
IF	RESDI		IAF		4.5					4000				RNP APCH		
TF	BP060		IF		4.5	42.4	TT		6.0	2500				RNP APCH		
TF	BP059		FAF		4.5	312.5	TT		6.7	2500	2500			RNP APCH		
TF	RW31L	Y	MAPt		4.5	312.4	TT		6.3	497			-3.0	RNP APCH		
TF	BP057	Y	MATF		4.5	312.4	TT		4.6	2000		200		RNP APCH		
DF	BP056		MATF		4.5					3000	3000	200		RNP APCH		
TF	RESDI				4.5	132.2	TT		15.2	3000	3000	200		RNP APCH		

Final Approach Segment - Datablock (FAS-DB)			
Procedure Name	RNAV (GNSS) RWY31L	Version:	2.1

FAS-DB (CRC wrapped data)	
Operation type	0
SBAS provider ID	1
Airport identifier	LHBP
RWY	31L
Approach performance designator	0
Route indicator	
Reference path data selector	0
Reference path identifier	E31A
LTP/FTP latitude	472549.7100N
LTP/FTP longitude	0191500.8900E
LTP/FTP ellipsoidal height (m)	180.2
FPAP latitude	472655.5485N
FPAP longitude	0191314.3920E
Threshold crossing height (TCH)	15
TCH units	1
Glide path angle (degrees)	3.00
Course width at threshold (m)	105.00
Length offset (m)	16
Horizontal alert limit (m)	40.0
Vertical alert limit (m)	35.0
Computed Data Block	10 10 02 08 0C DF 00 00 01 31 33 05 1C DE 5A 14 34 E5 42 08 0A 1B 5D 02 02 FC BF FC 2C 81 2C 01 64 02 C8 AF CB 46 55 AB
Computed CRC	CB4655AB
FAS-DB (not CRC wrapped)	
ICAO code	LH
LTP/FTP Orthometric height (m)	136.7
FPAP Orhtometric height (m)	136.7

B.4 RNP APCH to RWY 31R LHBP



CAT OF ACFT			A	B	C	D
OCA (H) STRAIGHT-IN	LNAV	2.5% macg	1110 (686)	1130 (710)	1150 (734)	1170 (753)
		4.0% macg	770 (349)		780 (361)	790 (367)
	LNAV/VNAV	2.5% macg	979 (563)	989 (573)	1010 (594)	1036 (620)
		4.0% macg	650 (234)	660 (244)	669 (253)	687 (271)
	LPV	2.5% macg	979 (563)	989 (573)	999 (583)	1009 (593)
		4.0% macg	607 (191)	617 (201)	627 (211)	636 (220)
CIRCLING			970	1190	1310	1510

DIST THR / RW31R	NM	6.0	5.0	4.0	3.0	2.0	1.0	0.0
ALTITUDE	ft	2380	2060	1740	1420	1100	780	466

Timing not authorized for defining the MAPt

GS	kt	80	100	120	140	160	180
BP029 - RW31R (6.4 NM)	min:sec	4:47	3:50	3:12	2:44	2:24	2:08
Rate of descent (326.1 ft/NM)	ft/min	430	540	650	760	860	970

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WAYPOINT LIST			
Procedure Name:	RNAV (GNSS) RWY31R	Version:	2.1

WP ID	Latitude	Longitude
VAGAT	471338.1N	0193628.7E
DIVOX	472206.5N	0193557.5E
RESDI	471238.0N	0192311.1E
BP030	471741.5N	0192959.5E
BP029	472104.1N	0192434.4E
RW31R	472522.62N	0191737.88E
BUD	472701.60N	0191457.99E
TPS	472935.7N	0192646.4E

CODING TABLES

Procedure Name:	RNAV (GNSS) RWY31R	**Version:**	2.1
Initial Waypoint name:	VAGAT		

INSTRUMENT FLIGHT PROCEDURE FROM VAGAT

PT	WP ID	OverFly	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF	RADIUS (NM)	ARC CTR ID
IF	VAGAT		IAF		4.5					4000				RNP APCH		
TF	BP030		IF		4.5	312.6	TT		6.0	2500				RNP APCH		
TF	BP029		FAF		4.5	312.5	TT		5.0	2500	2500			RNP APCH		
TF	RW31R	Y	MAPt		4.5	312.5	TT		6.4	466			-3.0	RNP APCH		
TF	BUD	Y	MATF		4.5	312.4	TT		2.4	900		185		RNP APCH		
DF	TPS		MATF		4.5					3000	3000	185		RNP APCH		
TF	DIVOX				4.5	140.2	TT		9.7	3000	3000			RNP APCH		

CODING TABLES

Procedure Name: RNAV (GNSS) RWY31R **Version:** 2.1

Initial Waypoint name: DIVOX

INSTRUMENT FLIGHT PROCEDURE FROM DIVOX

PT	WP ID	OverFly	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF	RADIUS (NM)	ARC CTR ID
IF	DIVOX		IAF		4.5					4000				RNP APCH		
TF	BP030		IF		4.5	222.6	TT		6.0	2500				RNP APCH		
TF	BP029		FAF		4.5	312.5	TT		5.0	2500	2500			RNP APCH		
TF	RW31R	Y	MAPt		4.5	312.5	TT		6.4	466			-3.0	RNP APCH		
TF	BUD	Y	MATF		4.5	312.4	TT		2.4	900		185		RNP APCH		
DF	TPS		MATF		4.5					3000	3000	185		RNP APCH		
TF	DIVOX				4.5	140.2	TT		9.7	3000	3000			RNP APCH		

CODING TABLES

Procedure Name:	RNAV (GNSS) RWY31R	Version:	2.1

Initial Waypoint name: RESDI

INSTRUMENT FLIGHT PROCEDURE FROM RESDI

PT	WP ID	OverFly	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF	RADIUS (NM)	ARC CTR ID
IF	RESDI		IAF		4.5					4000				RNP APCH		
TF	BP030		IF		4.5	42.5	TT		6.9	2500				RNP APCH		
TF	BP029		FAF		4.5	312.5	TT		5.0	2500	2500			RNP APCH		
TF	RW31R	Y	MAPt		4.5	312.5	TT		6.4	466			-3.0	RNP APCH		
TF	BUD	Y	MATF		4.5	312.4	TT		2.4	900		185		RNP APCH		
DF	TPS		MATF		4.5					3000	3000	185		RNP APCH		
TF	DIVOX				4.5	140.2	TT		9.7	3000	3000			RNP APCH		

Final Approach Segment - Datablock (FAS-DB)			
Procedure Name	RNAV (GNSS) RWY31R	Version:	2.1

FAS-DB (CRC wrapped data)	
Operation type	0
SBAS provider ID	1
Airport identifier	LHBP
RWY	31R
Approach performance designator	0
Route indicator	
Reference path data selector	0
Reference path identifier	E31B
LTP/FTP latitude	472522.6200N
LTP/FTP longitude	0191737.8800E
LTP/FTP ellipsoidal height (m)	170.4
FPAP latitude	472644.3865N
FPAP longitude	0191525.7790E
Threshold crossing height (TCH)	15
TCH units	1
Glide path angle (degrees)	3.00
Course width at threshold (m)	105.00
Length offset (m)	40
Horizontal alert limit (m)	40.0
Vertical alert limit (m)	35.0
Computed Data Block	10 10 02 08 0C 5F 00 00 02 31 33 05 78 0A 5A 14 B0 AF 47 08 A8 1A CD 7E 02 F6 F7 FB 2C 81 2C 01 64 05 C8 AF D1 FF 45 66
Computed CRC	D1FF4566
FAS-DB (not CRC wrapped)	
ICAO code	LH
LTP/FTP Orthometric height (m)	126.9
FPAP Orhtometric height (m)	126.9

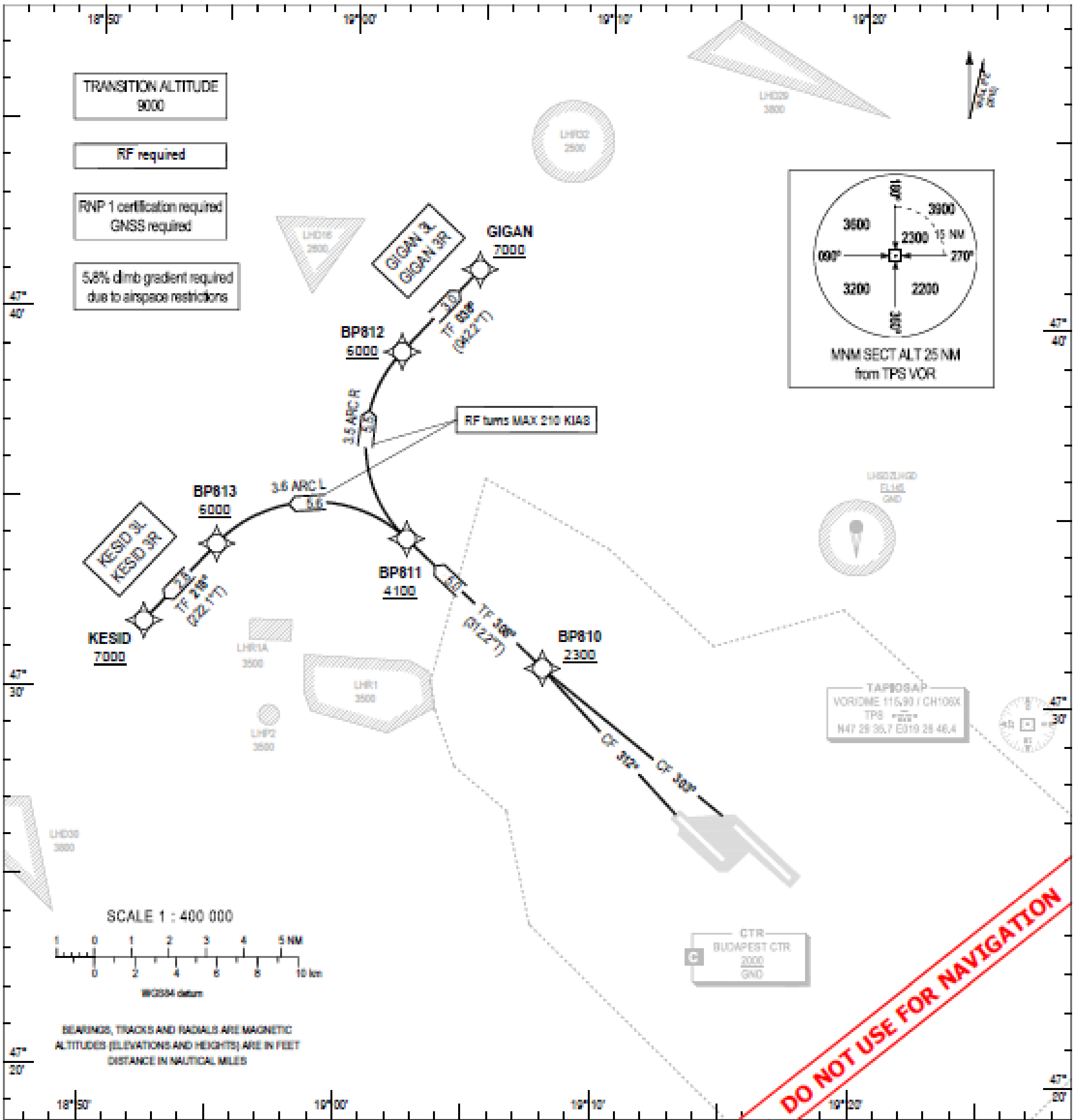
B.5 RNP-1 SID to RWY 31L

AIP HUNGARY — **AD 2-LHBP-SID-31L/R - 1**
XX XXX XXXX

STANDARD DEPARTURE CHART - INSTRUMENT (SID) - ICAO

BUDAPEST APP	129,700 122,975	ATIS	132,375 (117,300)
BUDAPEST DIRECTOR	119,500	BUDAPEST TOWER	118,100
		BUDAPEST GROUND	121,900

BUDAPEST/LISZT FERENC
SIDs RWY 31L/R - RNP 1
(ACFT CAT A, B, C, D)



GIGAN 3L
BP810[M312, A2300+]-BP811[K210-, A4100+]-BP812[R, 3.5, 473642.84N 0190549.36E, K210-, A6000+]-GIGAN[A7000+]
GIGAN 3R
BP810[M303, A2300+]-BP811[K210-, A4100+]-BP812[R, 3.5, 473642.84N 0190549.36E, K210-, A6000+]-GIGAN[A7000+]
KESID 3L
BP810[M312, A2300+]-BP811[K210-, A4100+]-BP813[L, 3.6, 473129.26N 0185849.70E, K210-, A6000+]-KESID[A7000+]
KESID 3R
BP810[M303, A2300+]-BP811[K210-, A4100+]-BP813[L, 3.6, 473129.26N 0185849.70E, K210-, A6000+]-KESID[A7000+]

BP810:	N47 30 47.19	E019 07 46.48	**BP811**:	N47 34 07.18	E019 02 20.80	**BP812**:	N47 39 03.92	E019 01 59.08
BP813:	N47 33 52.06	E018 54 56.31	**GIGAN**:	N47 41 17.33	E019 04 57.99	**KESID**:	N47 31 47.24	E018 52 09.95

Chart Version : 0.2

PILDO WESSEX LTD — **AIRAC AMDT XXX/XXXX**

WAYPOINT LIST			
Procedure Name:	RNAV SIDs RWY31L	Version:	0.2

WP ID	Latitude	Longitude
BP810	473047,19N	0190746,48E
BP811	473407,18N	0190220,80E
BP812	473903,92N	0190159,08E
BP813	473352,06N	0185456,31E
KESID	473147,24N	0185209,95E
GIGAN	474117,33N	0190457,99E
GIRFC	473642,84N	0190549,36E
KERFC	473129,26N	0185849,70E

CODING TABLES

Procedure Name: RNAV SID KESID RWY31L **Version:** 0.2

Initial Waypoint name: BP810

INSTRUMENT FLIGHT PROCEDURE FROM BP810

PT *	W/P ID *	OverFly *	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF (NM) *	RADIUS (NM)	ARC CTR ID
CF	BP810				4,5	316,2	TT			2300				RNP-1		
TF	BP811				4,5	312,2	TT		5,0	4100		210		RNP-1		
RF	BP813			L	4,5				5,6	6000		210		RNP-1	3,6	KERFC
TF	KESID				4,5	222,1	TT		2,8	7000				RNP-1		

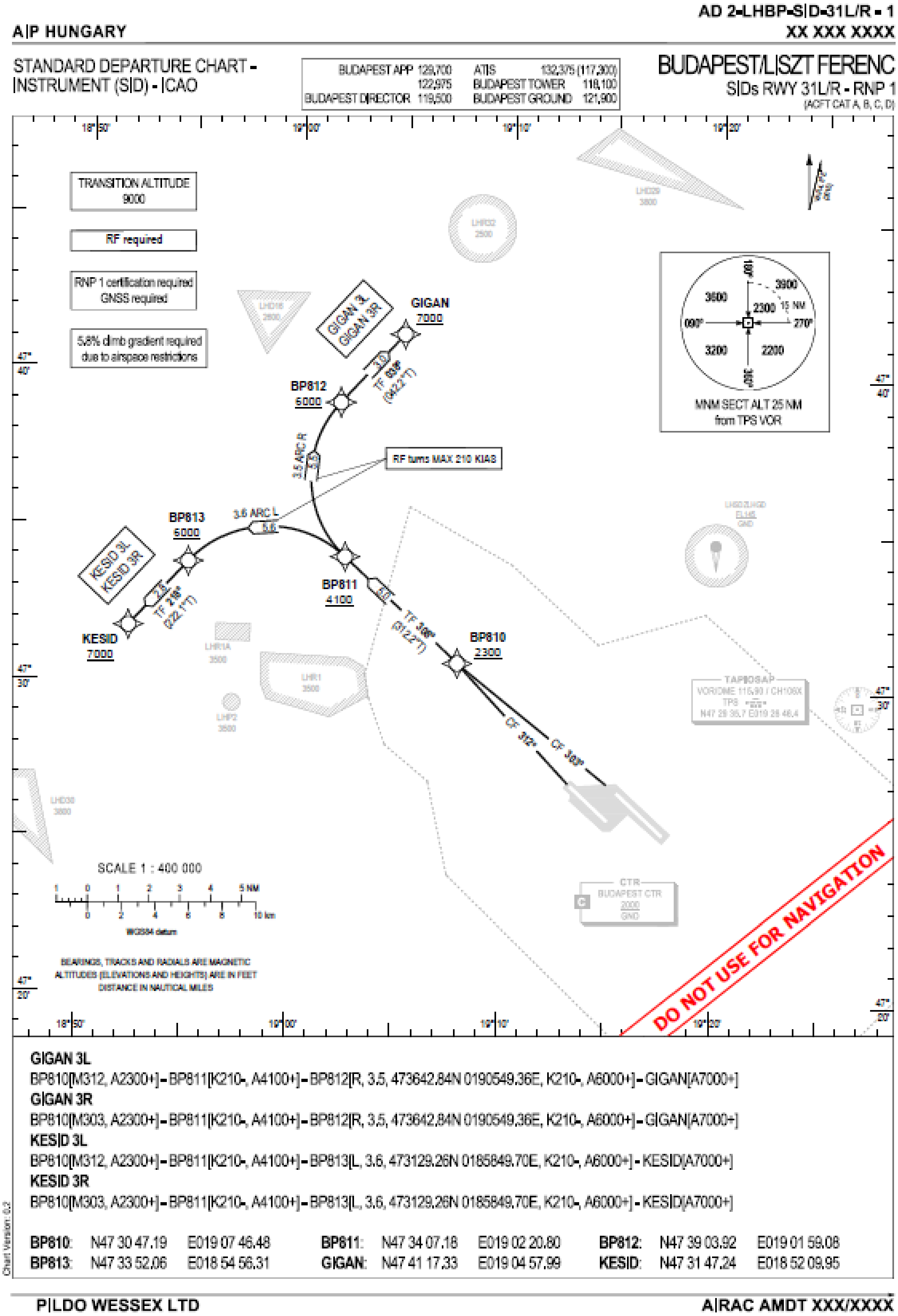
* mandatory fields

CODING TABLES															
Procedure Name:	RNAV SID GIGAN RWY31L												**Version:**	0.2	
Initial Waypoint name:	BP810														
INSTRUMENT FLIGHT PROCEDURE FROM BP810															
PT *	**W/P ID ***	**OverFly ***	**Fix role**	**TD**	**VAR**	**CRS Val (°)**	**CRS Type**	**TIME (s)**	**DIST (NM)**	**MNM ALT (ft)**	**MAX ALT (ft)**	**IAS MAX (kt)**	**VRT ANG**	**NAV PERF (NM) ***	**RADIUS (NM)**	**ARC CTR ID**

PT *	W/P ID *	OverFly *	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF (NM) *	RADIUS (NM)	ARC CTR ID
CF	BP810				4,5	316,2	TT			2300				RNP-1		
TF	BP811				4,5	312,2	TT		5,0	4100		210		RNP-1		
RF	BP812			R	4,5				5,5	6000		210		RNP-1	3,5	GIRFC
TF	GIGAN				4,5	42,2	TT		3,0	7000				RNP-1		

* mandatory fields

B.6 RNP-1 SID to RWY 31R



WAYPOINT LIST			
Procedure Name:	RNAV SIDs RWY31R	Version:	0.2

WP ID	Latitude	Longitude
BP810	473047,19N	0190746,48E
BP811	473407,18N	0190220,80E
BP812	473903,92N	0190159,08E
BP813	473352,06N	0185456,31E
KESID	473147,24N	0185209,95E
GIGAN	474117,33N	0190457,99E
GIRFC	473642,84N	0190549,36E
KERFC	473129,26N	0185849,70E

CODING TABLES

Procedure Name:	RNAV SID KESID RWY31R	Version:	0.2

Initial Waypoint name:	BP810

INSTRUMENT FLIGHT PROCEDURE FROM BP810

PT *	W/P ID *	OverFly *	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF (NM) *	RADIUS (NM)	ARC CTR ID
CF	BP810				4,5	308,0	TT			2300				RNP-1		
TF	BP811				4,5	312,2	TT		5,0	4100		210		RNP-1		
RF	BP813			L	4,5				5,6	6000		210		RNP-1	3,6	KERFC
TF	KESID				4,5	222,1	TT		2,8	7000				RNP-1		

* mandatory fields

CODING TABLES

Procedure Name:	RNAV SID GIGAN RWY31R	Version:	0.2

Initial Waypoint name: BP810

INSTRUMENT FLIGHT PROCEDURE FROM BP810

PT *	W/P ID *	OverFly *	Fix role	TD	VAR	CRS Val (°)	CRS Type	TIME (s)	DIST (NM)	MNM ALT (ft)	MAX ALT (ft)	IAS MAX (kt)	VRT ANG	NAV PERF (NM) *	RADIUS (NM)	ARC CTR ID
CF	BP810				4,5	308,0	TT			2300				RNP-1		
TF	BP811				4,5	312,2	TT		5,0	4100		210		RNP-1		
RF	BP812			R	4,5				5,5	6000		210		RNP-1	3,5	GIRFC
TF	GIGAN				4,5	42,2	TT		3,0	7000				RNP-1		

* mandatory fields

Appendix C Evaluation of EXE-02.10-D-003

C.1 Basic information on the survey

TERM	DEFINITION	
Demonstration exercise	EXE-02.10-D-003.1	Single RWY Remote Tower - operations
Scenario	SCN-02.10-004	IFR flights arriving at, and departing from, an aerodrome
	SCN-02.10-005	VFR flights arriving at, and departing from, an aerodrome
	SCN-02.10-006	Remote Provision of ATS during good visibility conditions
	SCN-02.10-007	Remote Provision of ATS during limited visibility conditions
	SCN-02.10-008	Remote Provision of ATS during hours of darkness
	SCN-02.10-009	Ground surface movements at an aerodrome - vehicles and aircraft
	SCN-02.10-010	Simultaneous service provision of aircraft in flight and on the manoeuvring area by the ATCO
Corresponding objectives	OBJ-02.10-08	Setting up a Remote TWR ops room with all the capabilities needed for live trials (including visualization)
	OBJ-02.10-09	Demonstrating technical capabilities and boundaries of using camera technologies for visual observation of the airport traffic in order to maintain safe ATS provision
	OBJ-02.10-10	Demonstrating technical possibilities and limitations of enhancing visual observation by camera technologies during limited visibility conditions (occurring within the demonstration time of period) in order to maintain safe ATS provision.
	OBJ-02.10-11	Demonstrating what level of situation awareness can be reached compared to a conventional TWR ops room
Methodology	Paper-based questionnaire	
Respondents	68 responds from 13 Air Traffic Controllers of HungaroControl	
Period of data collection	25th Jul – 19th Aug, 2016	

C.1.1 Infrastructure related questions – video wall evaluation

As part of the rTWR equipment a video wall was mounted to provide a visual reference for the ATCOs. The following questions are related to the video wall usability as a technical solution and as a tool that should support the work process.

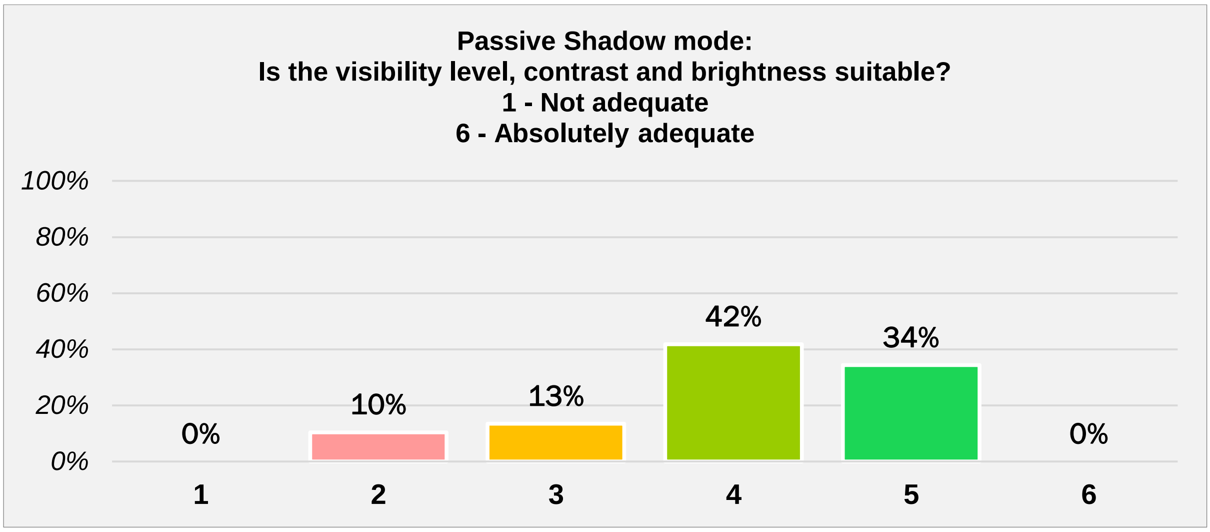
C.1.1.1 View

The first set of questions is related to the quality of the visual solution.

Is the visibility level, contrast and brightness suitable?

The question is aimed at the quality of the visual information transmitted by the cameras. The ATCOs had to evaluate the visibility level, brightness and contrast of the image of the video wall and rate it on the scale from 1 to 6 where the 1 value meant that visibility is not adequate and 6 meant that the visibility is absolutely good.

Most of the ATCOs evaluated the visibility as being adequate, however none of them considered the visibility perfect and only 23 percent of them was disappointed with the visibility.

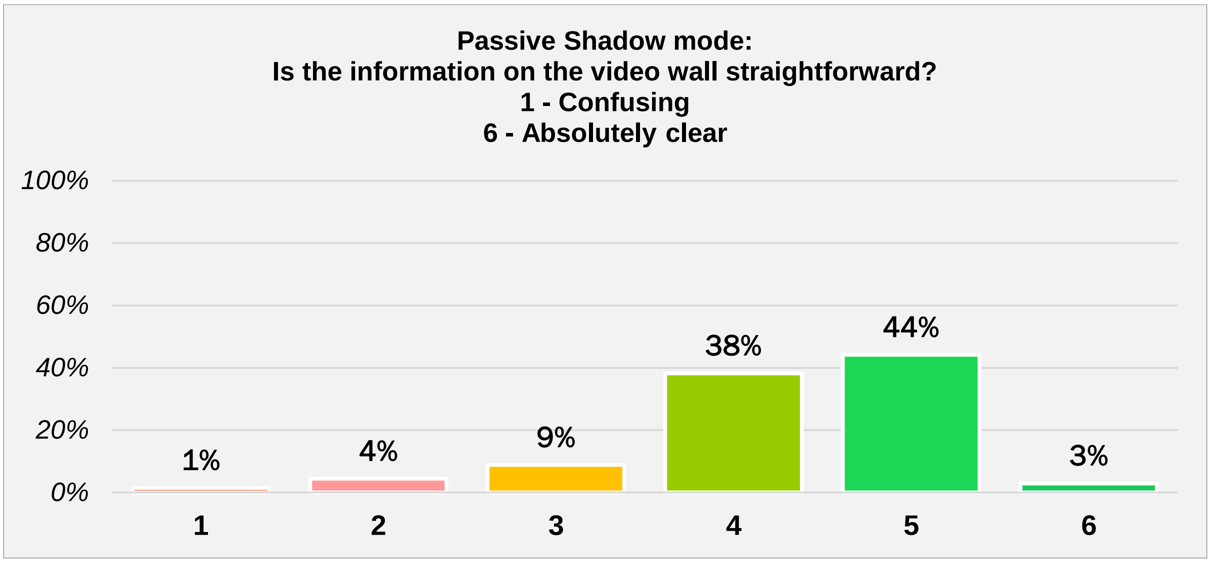


C.1.1.2 Information on the video wall

Is the information on the video wall straightforward?

The question was targeting the lucidity of the information presented on the video wall. The ATCOs had to evaluate the intelligibility of the information presented on the video wall and rate it on the scale from 1 to 6 where the 1 meant that the information presented is not clear and 6 meant that the information presented is unequivocal.

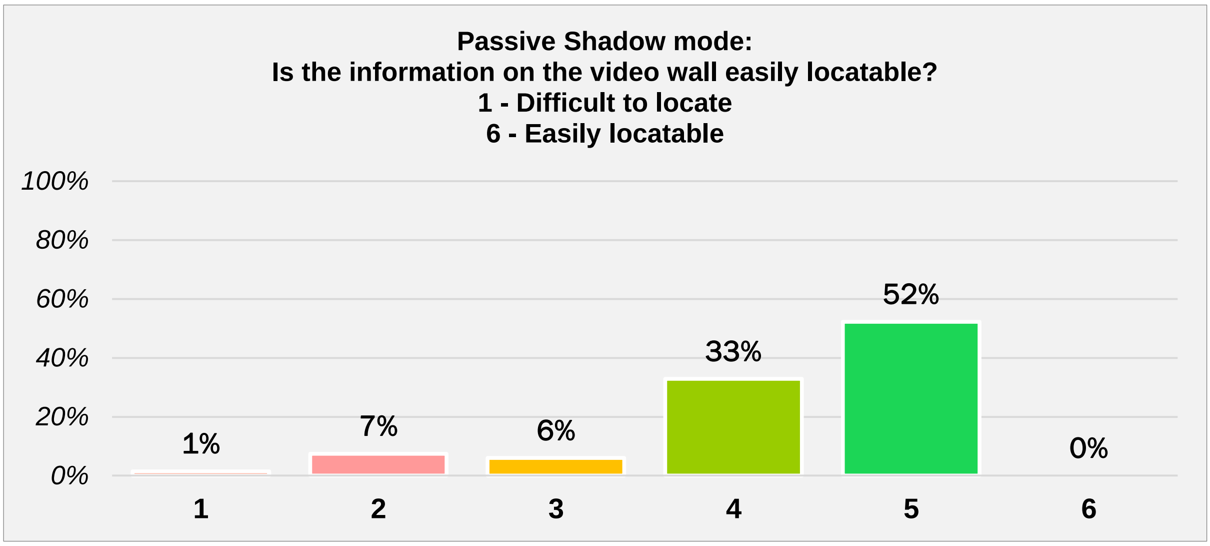
The majority of the ATCOs, that is 82 percent, evaluated it as clear and 3 percent considered it as absolutely clear.



Is the information on the video wall easily locatable?

It was asked from the ATCOs how easily can an ATCO find the information presented on the video wall. The ATCOs had to evaluate the level of difficulty of locating the information presented on the video wall and rate it on the scale from 1 to 6 where the 1 meant that the information presented is difficult to locate and 6 meant that the information is easily located.

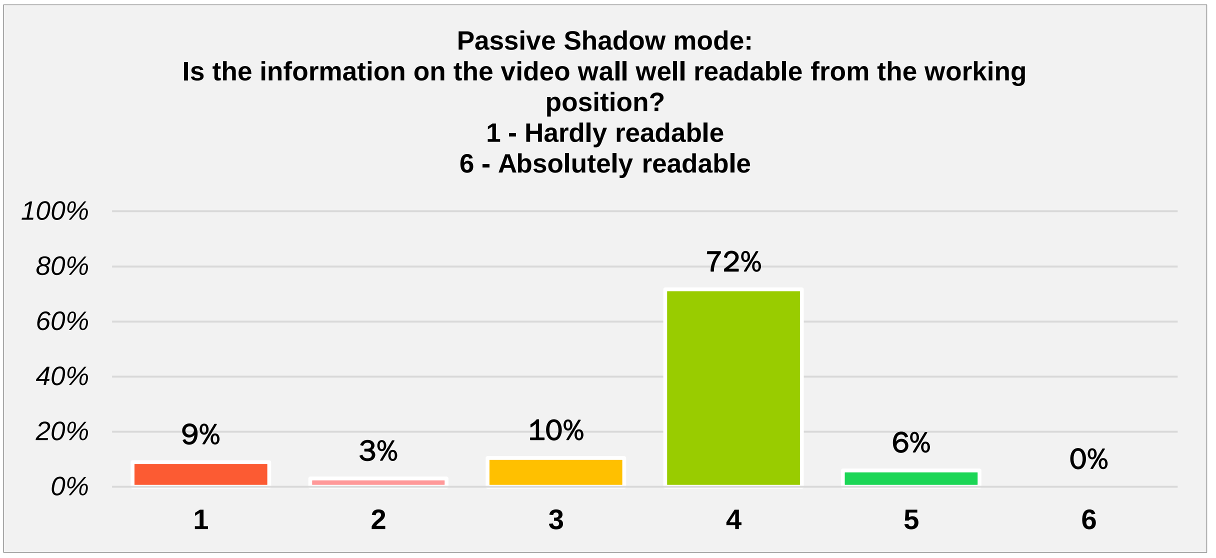
Majority of the ATCOs (85 percent) evaluated it as easily locatable and 6 percent considered it absolutely easy to locate.



Is the information on the video wall well readable from the working position?

This question was aiming at establishing if the information on the video wall is well readable. The ATCOs were asked to evaluate readability and rate it on a scale from 1 to 6 where 1 meant hardly readable and 6 meant absolutely readable.

72 percent of ATCOs voted for relatively good readability (4), 22 percent were less satisfied with the readability and only 6 percent voted for better than average readability.

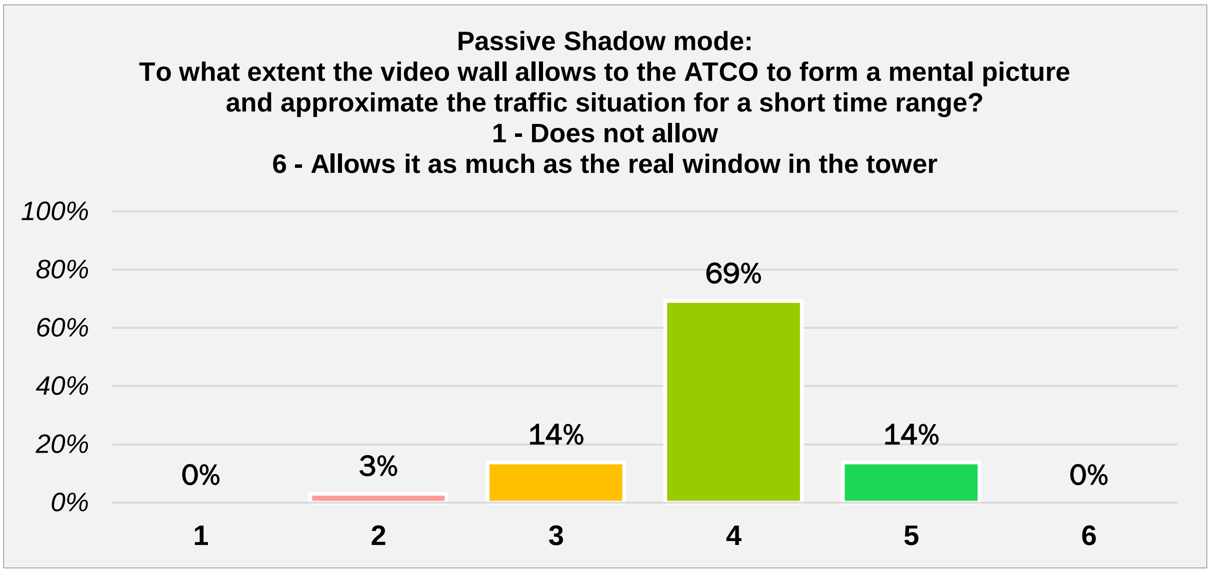


C.1.1.3 Usability of the video wall

To what extent the video wall allows to the ATCO to form a mental picture and approximate the traffic situation for a short time range?

This question is aimed at establishing if the video wall allows ATCOs to form mental picture and approximate the traffic situation for a short time range. The ATCOs were required to evaluate this on the scale from 1 to 6 where 1 correspond to "does not allow" and 6 to "allows it as much as the real window in the tower".

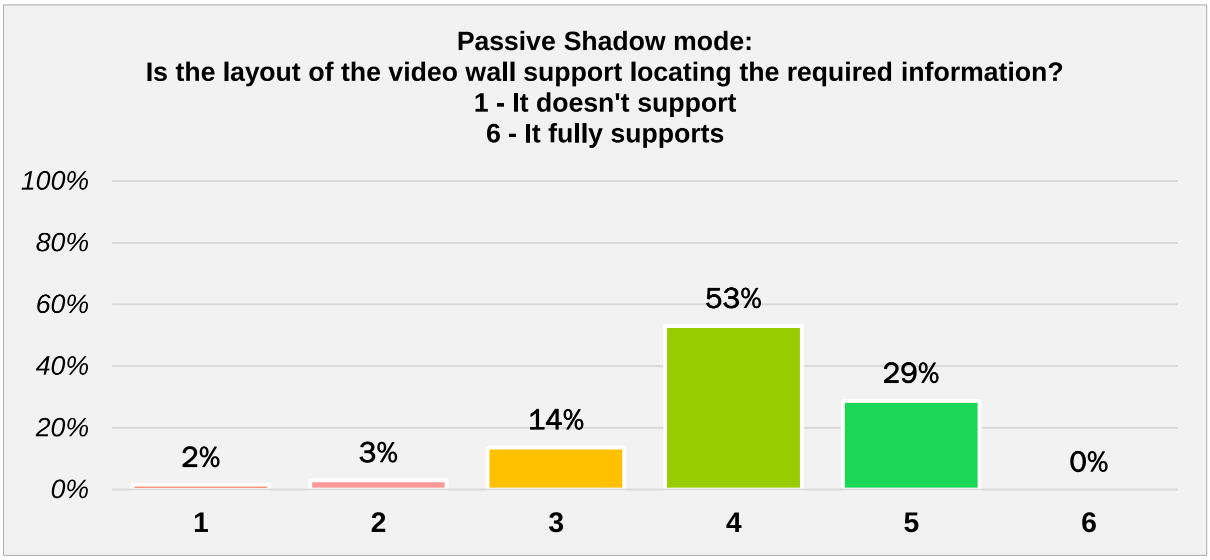
Most of the ATCOs evaluated the question positively (83%) and only 17 percent rated it negatively, however none of them voted to for the negative or positive ends.



Is the layout of the video wall support locating the required information?

The question is aimed at the how extensively supports the video wall locating of information. The ATCOs had to evaluate the level of support locating the required information by the video wall and rate it on the scale from 1 to 6 where the 1 meant that it does not support it and 6 meant that it fully supports it.

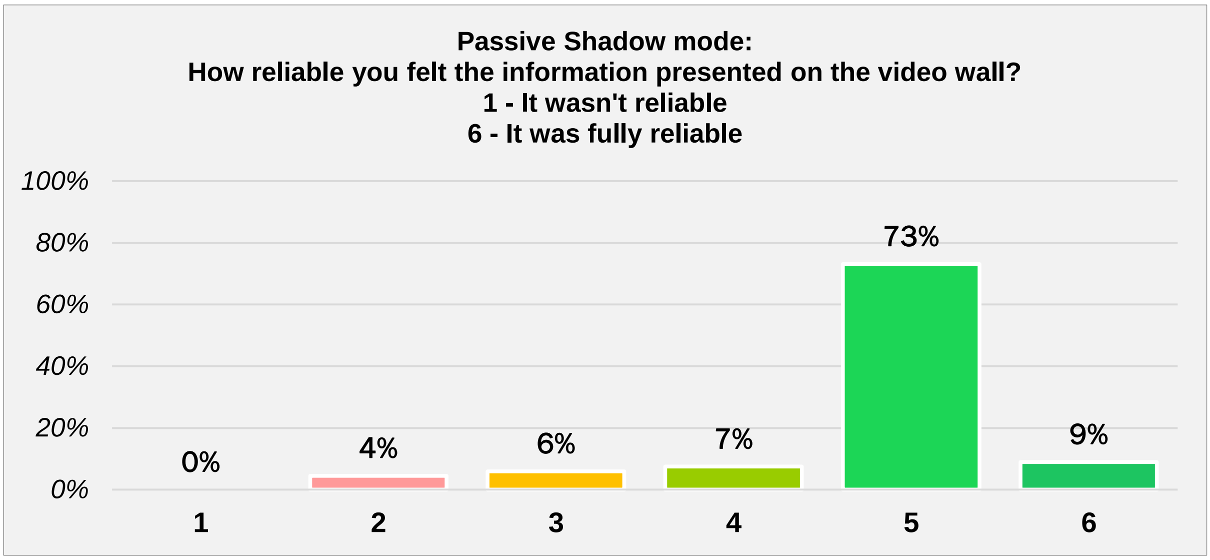
Majority of the ATCOs that is 82 percent was satisfied with the provided support, however, none of them felt that it fully supports the locating of the required information with set up available during the passive shadow mode tests.



How reliable you felt the information presented on the video wall?

The question is aimed at the reliability of the information presented on the video wall. The ATCOs had to evaluate reliability and rate that said reliability on the scale from 1 to 6 where 1 meant not reliable and 6 meant absolutely reliable.

10 percent of the ATCOs were not satisfied with the reliability of the provided information 80 percent were satisfied with reliability and only 9 percent was fully satisfied with the provided reliability.

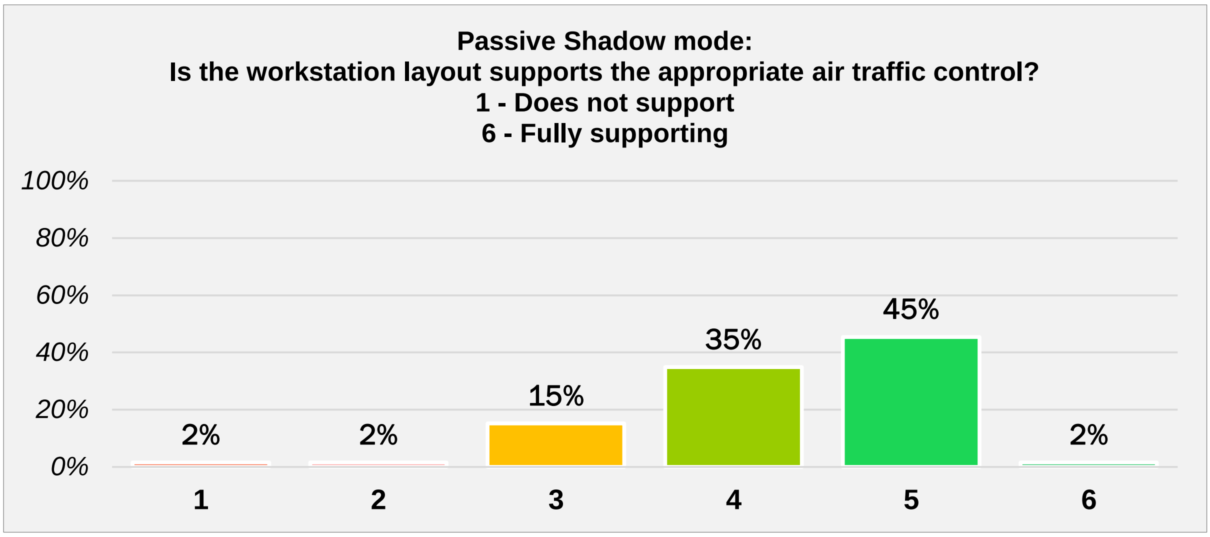


C.1.2 Infrastructure related questions – workstation evaluation

Is the workstation layout supports the appropriate air traffic control?

The question is about the layout of the video wall and if it supports the appropriate air traffic control. The ATCOs had to evaluate the layout of the video wall and if it supports the appropriate air traffic control and rate the support provided on the scale from 1 to 6 where 1 meant does not support and 6 meant fully supporting.

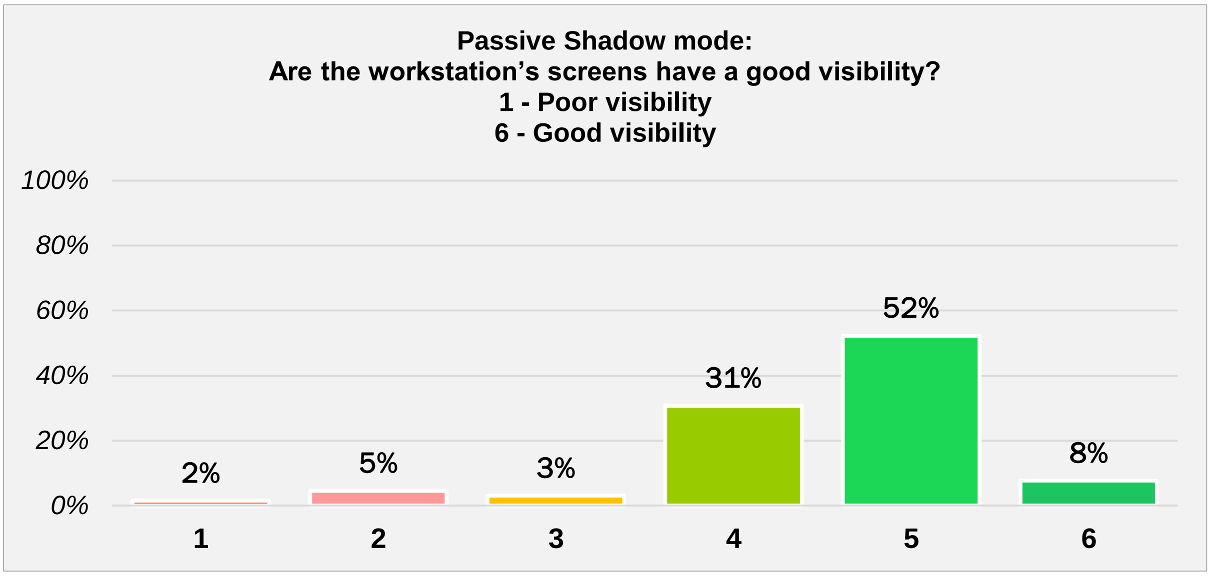
The results are: 80 percent evaluated positively the video wall support, 19 percent of the ATCOs evaluated the video wall support negatively, and only 2 percent evaluated the video wall support as fully supporting.



Are the workstation's screens have a good visibility?

The question targets the visibility of the video wall's screens. The ATCOs had to evaluate the visibility of the video wall's screens and rate the visibility on the scale from 1 to 6 where 1 meant poor visibility and 6 meant good visibility.

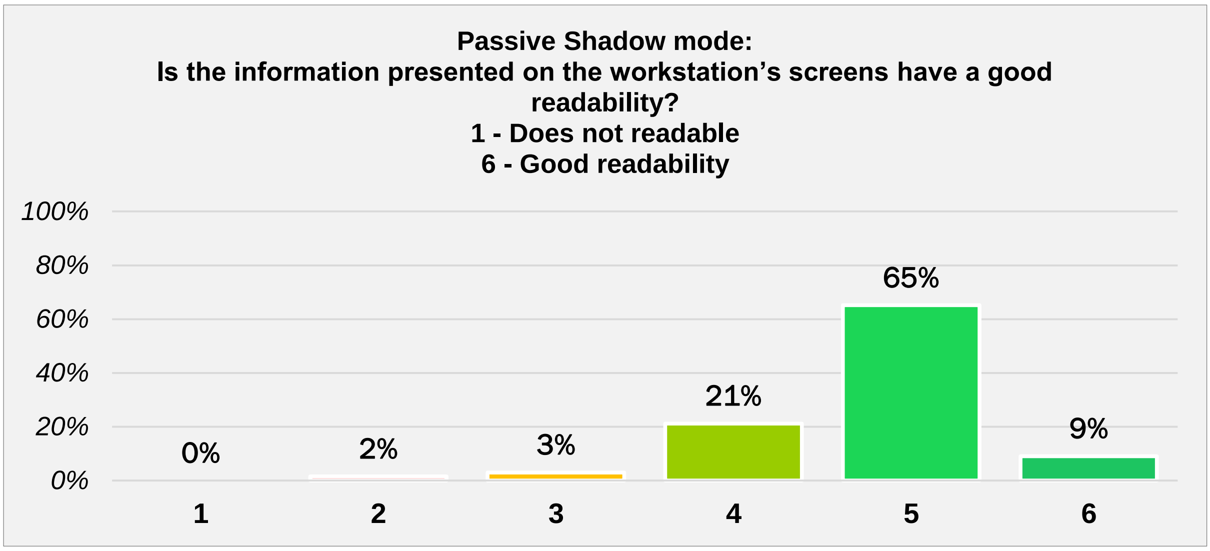
The results are the following: 10 percent of the ATCOs evaluated the visibility negatively, 83 percent evaluated the visibility positively.



Is the information presented on the workstation's screens have a good readability?

The question is aimed at the readability of the information presented on the video wall. The ATCOs had to evaluate the readability of the information and rate it on the scale from 1 to 6 where 1 meant does not readable and 6 meant good readability.

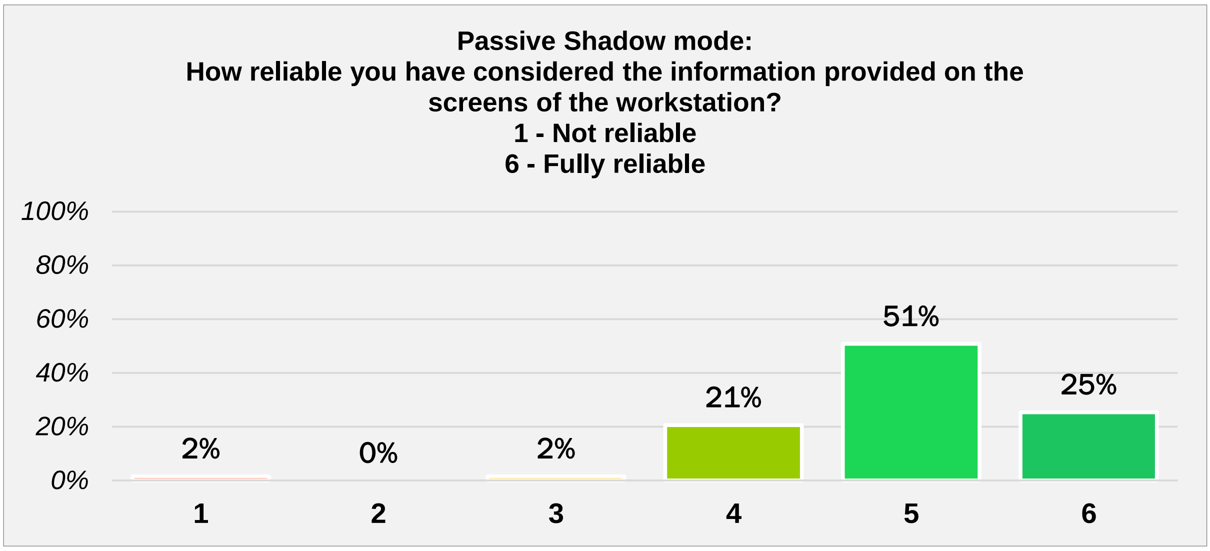
The results are: 5 percent of the ATCOs evaluated the readability negatively, 86 percent evaluated the readability positively and 9 percent evaluated the readability as excellent.



How reliable you have considered the information provided on the screens of the workstation?

The question is aimed at the reliability of the presented on the screens information. The ATCOs had to evaluate to what extent the information provided is reliable and rate it on the scale from 1 to 6 where 1 meant not reliable and 6 meant fully reliable.

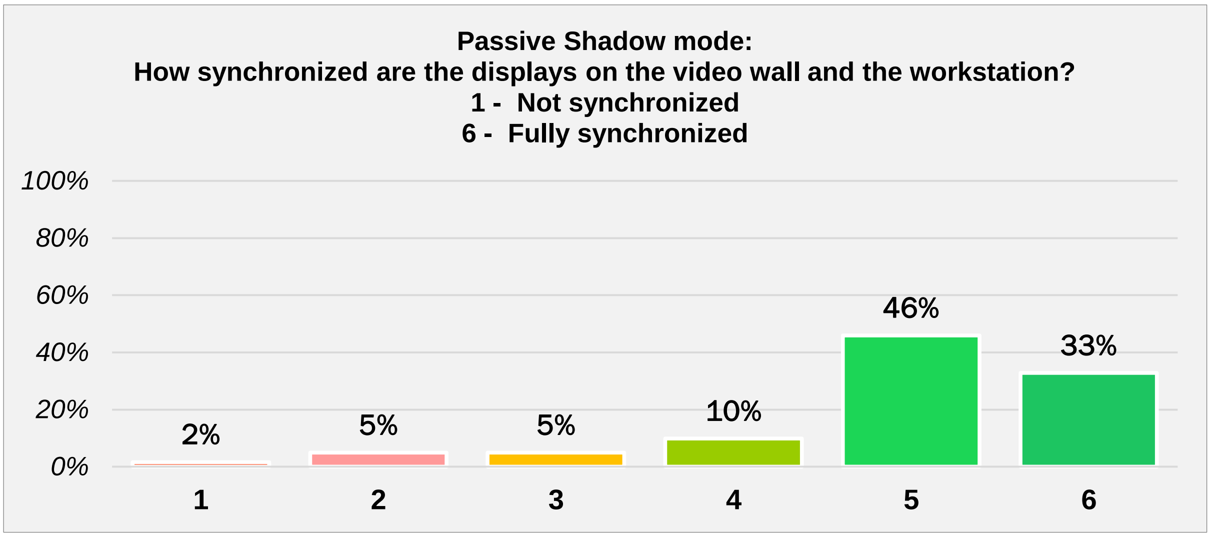
The results are: only 4 percent of the ATCOs evaluated the reliability negatively, majority evaluated the reliability positively out of which 25 percent rated it as fully reliable.



How synchronized are the displays on the video wall and the workstation?

The question asked about the synchronisation of the video wall data and the workstation data. The ATCOs had to evaluate to synchronicity of video wall and the workstation data and rate the synchronicity on the scale from 1 to 6 where 1 meant not synchronized and 6 meant fully synchronized.

According to the results 12 percent of the ATCOs evaluated the question negatively, 89 percent evaluated the question positively of which 33 percent evaluated the question fully positively that is the data are fully synchronised.



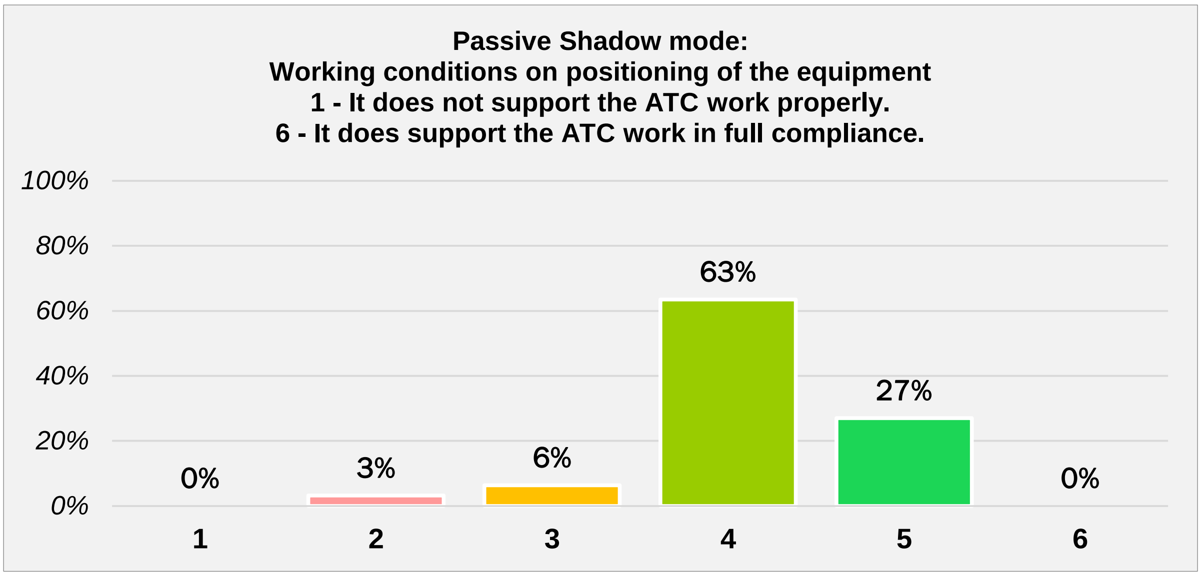
C.1.3 Infrastructure related questions – air traffic control environment and area evaluation

C.1.3.1 How the working conditions at rTWR area support the air traffic control?

Positioning of the equipment

The question is aimed at the positioning of the equipment at work area. The ATCOs had to evaluate how the positioning of the equipment at the work area supports the air traffic control and rate the positioning of the equipment on the scale from 1 to 6 where 1 meant It does not support the ATC work properly and 6 meant It does support the ATC work in full compliance.

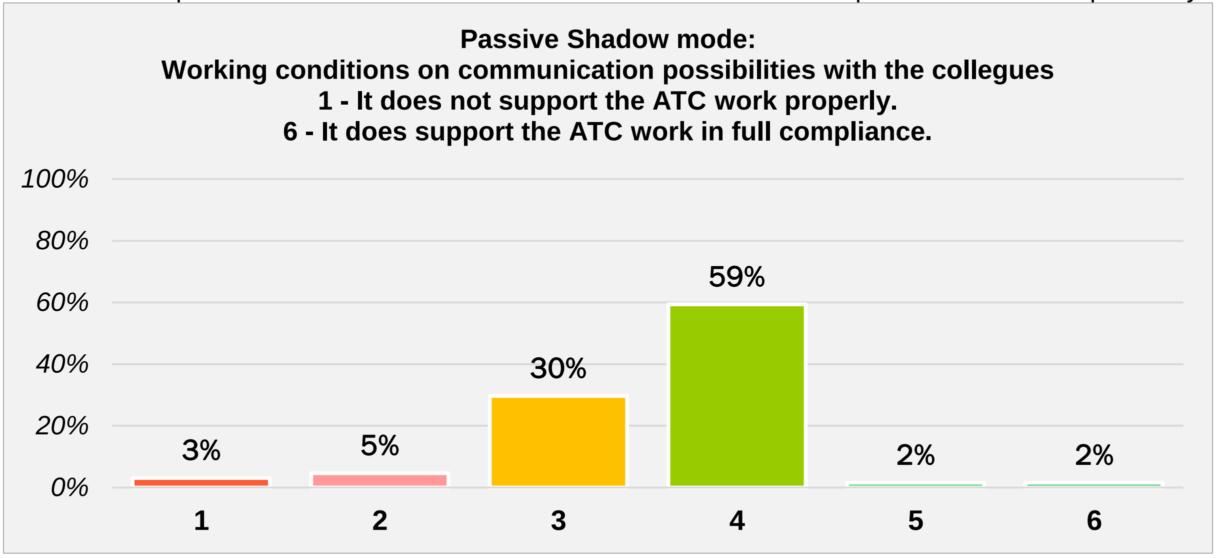
According to the results 9 percent of the ATCOs evaluated the question negatively, 91 percent evaluated the question positively.



Communication possibilities with the colleagues

The question was bout the communication possibilities with the colleagues at the work area. The ATCOs had to evaluate how the communication possibilities with the colleagues at the work area supports the air traffic control and rate the communication possibilities on the scale from 1 to 6 where 1 meant It does not support the ATC work properly and 6 meant It does support the ATC work in full compliance.

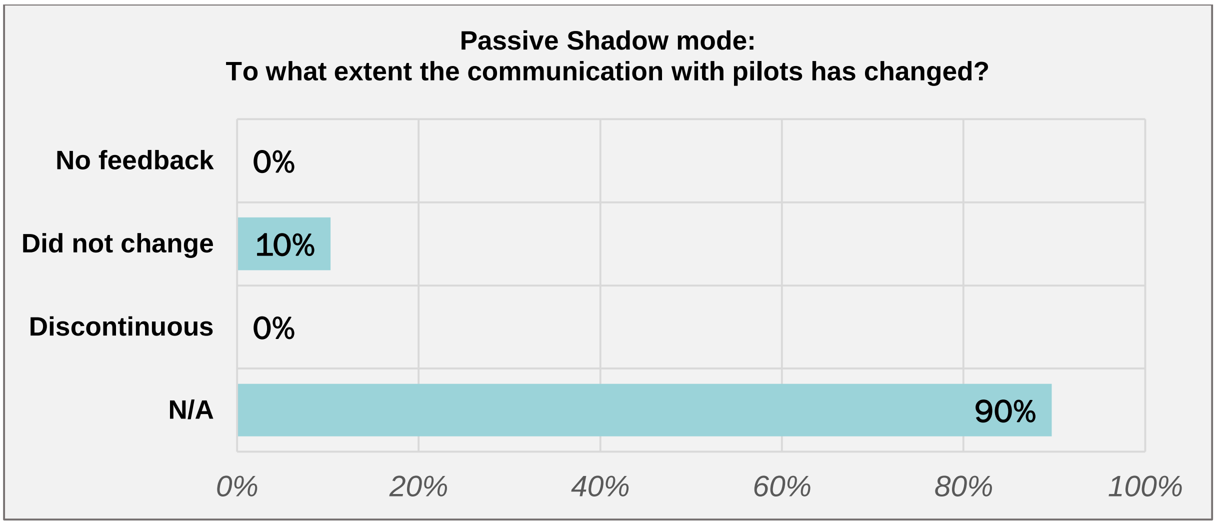
The evaluation of the answers show that 37 percent of the ATCOs evaluated the question negatively, 63 percent evaluated the question positively.



To what extent the communication with pilots has changed?

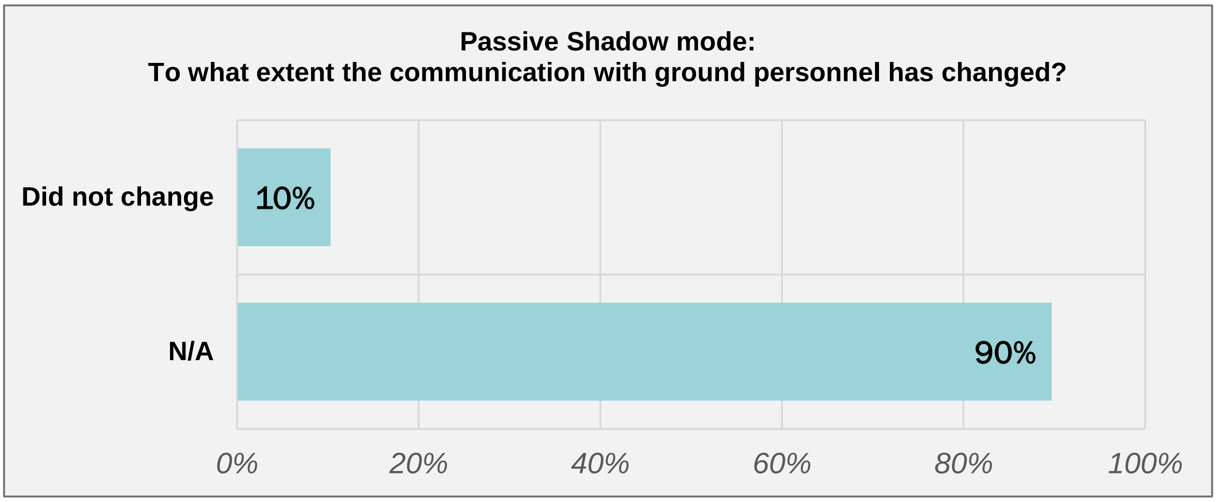
The question is aimed at the communication with pilots in the rTWR during the air traffic control. The ATCOs had to evaluate the change in the communication with pilots during the air traffic control in the rTWR on the multiple choice question were the default answer was no changes and they had a possibility to input free text as remark.

According to the results 10 percent of the ATCOs felt that the communication hasn't changed and 90 percent answered N/A that is not applicable which means no change as well.



To what extent the communication with ground personnel has changed?
The question was about the communication with ground personnel in the rTWR during the air traffic control. The ATCOs had to evaluate the change in the communication with ground personnel during the air traffic control in the rTWR on the multiple choice question were the default answer was no changes and they had a possibility to input free text as remark.

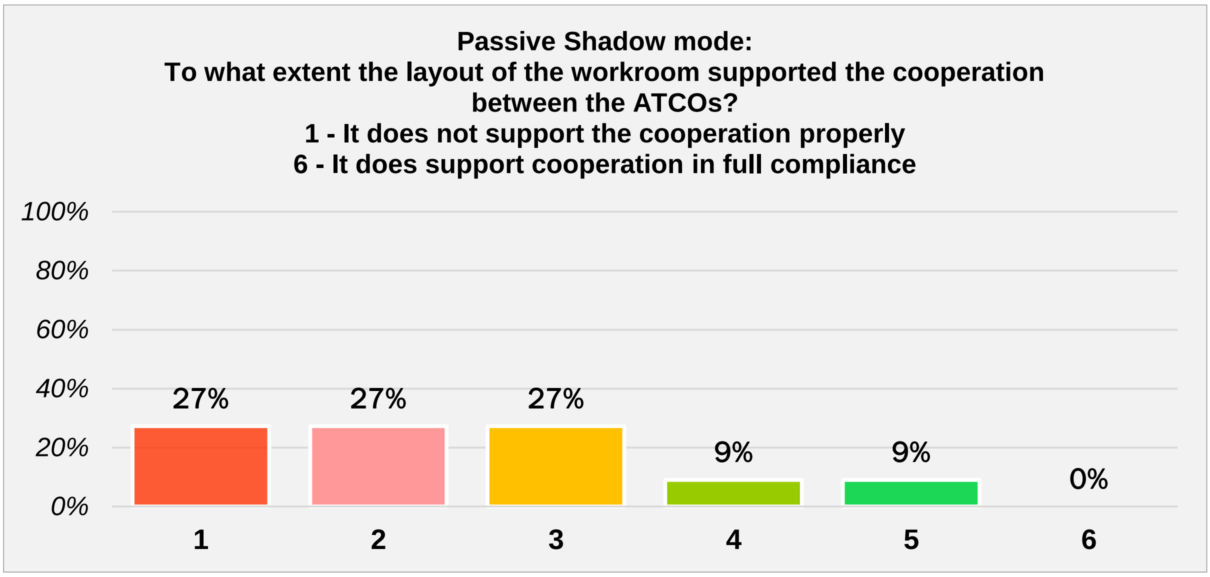
According to the results 10 percent of the ATCOs felt that the communication hasn't changed and 90 percent answered N/A that is not applicable which could be interpreted as no change as well.



To what extent the layout of the workroom supported the cooperation between the ATCOs?

The question was about the cooperation possibilities with the colleagues at the work area. The ATCOs had to evaluate how the work area layout supports cooperation possibilities with the colleagues at the air traffic control and rate the level of support on the scale from 1 to 6 where 1 meant "It does not support the cooperation properly" and 6 meant "It does support cooperation in full compliance".

As the results show 81 percent of the ATCOs evaluated the question negatively, 19 percent evaluated the question positively.



C.2 Basic information on the survey

TERM	DEFINITION	
Demonstration exercise	EXE-02.10-D-003.2	Dual RWY Remote Tower - operations
Scenario	SCN-02.10-004	IFR flights arriving at, and departing from, an aerodrome
	SCN-02.10-005	VFR flights arriving at, and departing from, an aerodrome
	SCN-02.10-006	Remote Provision of ATS during good visibility conditions
	SCN-02.10-007	Remote Provision of ATS during limited visibility conditions
	SCN-02.10-008	Remote Provision of ATS during hours of darkness
	SCN-02.10-009	Ground surface movements at an aerodrome - vehicles and aircraft
	SCN-02.10-010	Simultaneous service provision of aircraft in flight and on the manoeuvring area by the ATCO
Corresponding objectives	OBJ-02.10-08	Setting up a Remote TWR ops room with all the capabilities needed for live trials (including visualization)
	OBJ-02.10-09	Demonstrating technical capabilities and boundaries of using camera technologies for visual observation of the airport traffic in order to maintain safe ATS provision
	OBJ-02.10-10	Demonstrating technical possibilities and limitations of enhancing visual observation by camera technologies during limited visibility conditions (occurring within the demonstration time of period) in order to maintain safe ATS provision.
	OBJ-02.10-11	Demonstrating what level of situation awareness can be reached compared to a conventional TWR ops room
Methodology	Paper-based questionnaire	
Respondents	68 responds from 13 Air Traffic Controllers of HungaroControl	
Period of data collection	22th Aug – 9th Sept, 2016	

C.2.1 Infrastructure related questions – video wall evaluation

As part of the rTWR equipment a video wall was mounted to provide as realistic as possible view for the ATCOs. The following questions are related to the video wall usability as a technical solution and as a tool that should support the work process

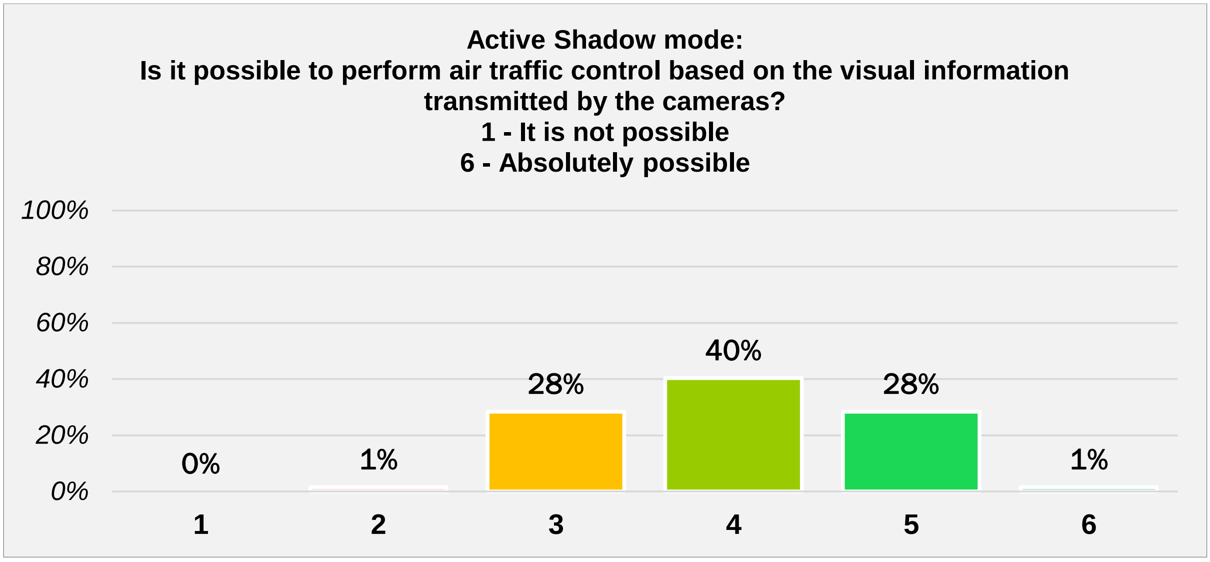
C.2.1.1 View

The first set of questions is related to the quality of the visual solution.

Is it possible to perform air traffic control based on the visual information transmitted by the cameras?

The question was about the possibility of performing air traffic control based on the visual information transmitted by the cameras. The ATCOs had to evaluate the possibility and rate it on the scale from 1 to 6 where the 1 value meant that it is not possible and 6 meant that it is absolutely possible.

As it can be seen from this table above and the graph below the majority of the ATCOs evaluated 3 to 5 out of 6 which shows that they are not absolutely confident in the possibility of performing air traffic control based on the visual information provided by the video wall.

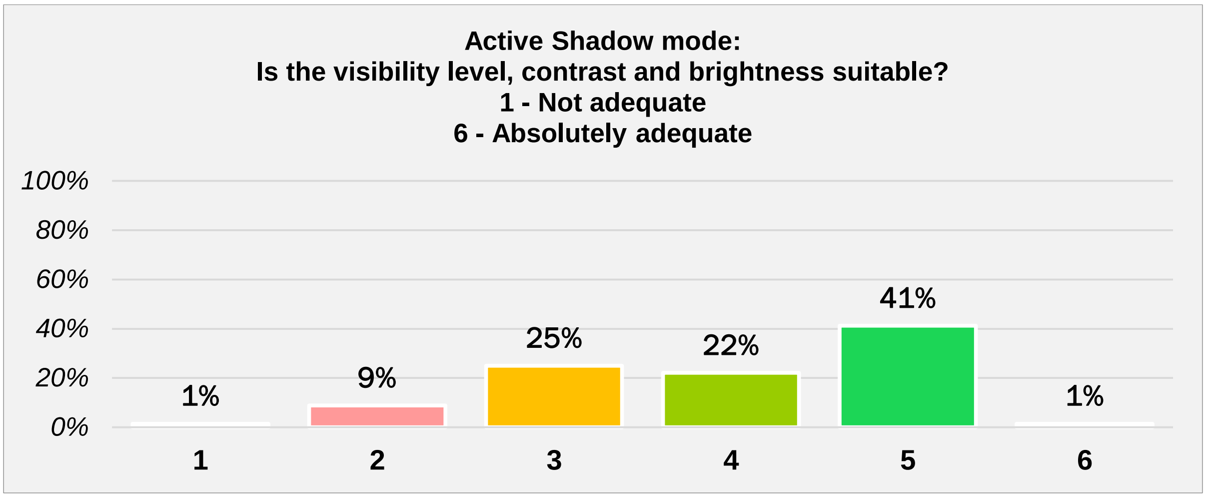


Compared to the shadow mode the results are more spread around 3, 4 and 5 that means that the ATCO are still not fully confident in the possibility of the performing the air traffic control based on visual information transmitted by the cameras.

Is the visibility level, contrast and brightness suitable?

The question is aimed at the quality of the visual information transmitted by the cameras. The ATCOs had to evaluate the visibility level, brightness and contrast of the image of the video wall and rate it on the scale from 1 to 6 where the 1 value meant that visibility is not adequate and 6 meant that the visibility is absolutely good.

Most of the ATCOs evaluated the visibility adequate, however none of them considered the visibility perfect and 45 percent of them were disappointed with the visibility.



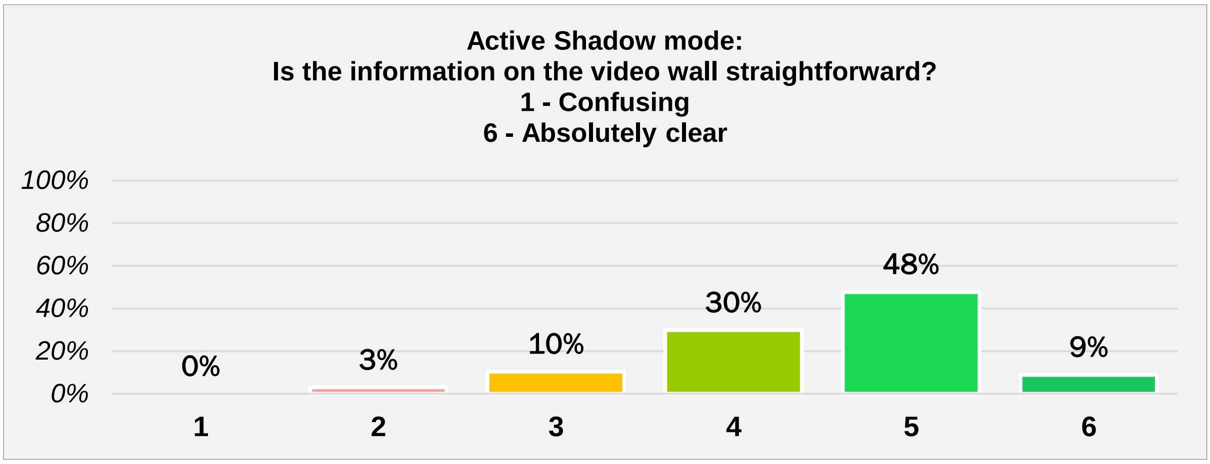
Compared to the shadow mode the results are a bit worse than before.

C.2.1.2 Information on the video wall

Is the information on the video wall straightforward?

The ATCOs were asked about the lucidity of the information presented on the video wall. The ATCOs had to evaluate the intelligibility of the information presented on the video wall and rate it on the scale from 1 to 6 where the 1 meant that the information presented is not clear and 6 meant that the information presented is unequivocal.

None of the ATCOs evaluated the information presented on the video wall as confusing, majority of the ATCOs that is 87 percent evaluated it as clear and only 3 percent considered it absolutely clear.

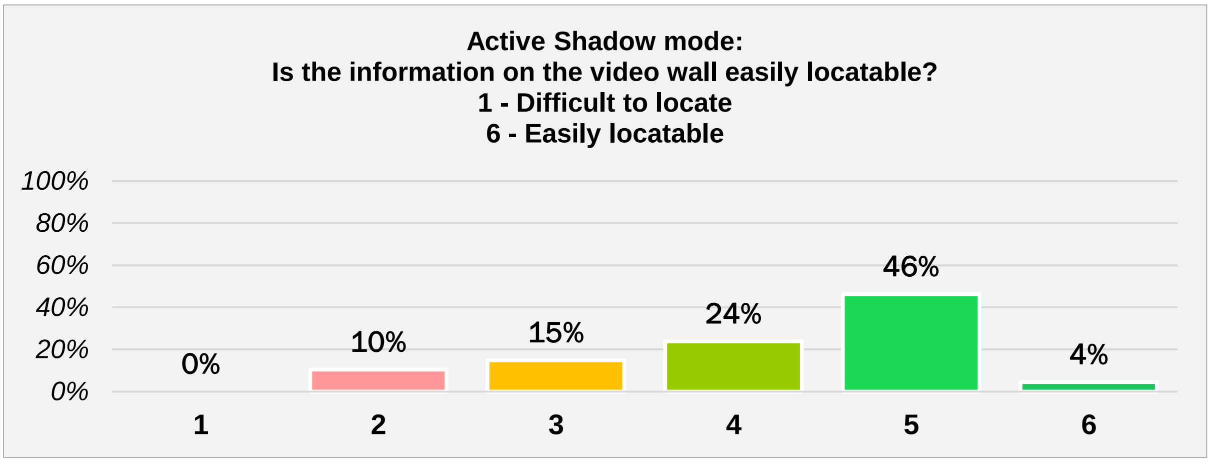


Compared to the shadow mode the results are a bit better considering that in shadow mode only 82 percent of the ATCOs evaluated the topic positively and only 3 percent have evaluated the information absolutely straightforward.

Is the information on the video wall easily locatable?

The question is aimed at the how easily can ATCO find the information presented on the video wall. The ATCOs had to evaluate the level of difficulty of locating the information presented on the video wall and rate it on the scale from 1 to 6 where the 1 meant that the information presented is difficult to locate and 6 meant that the information is easily located.

None of the ATCOs considered the information presented on the video wall difficult to locate, majority of the ATCOs that is 70 percent evaluated it as easily locatable.

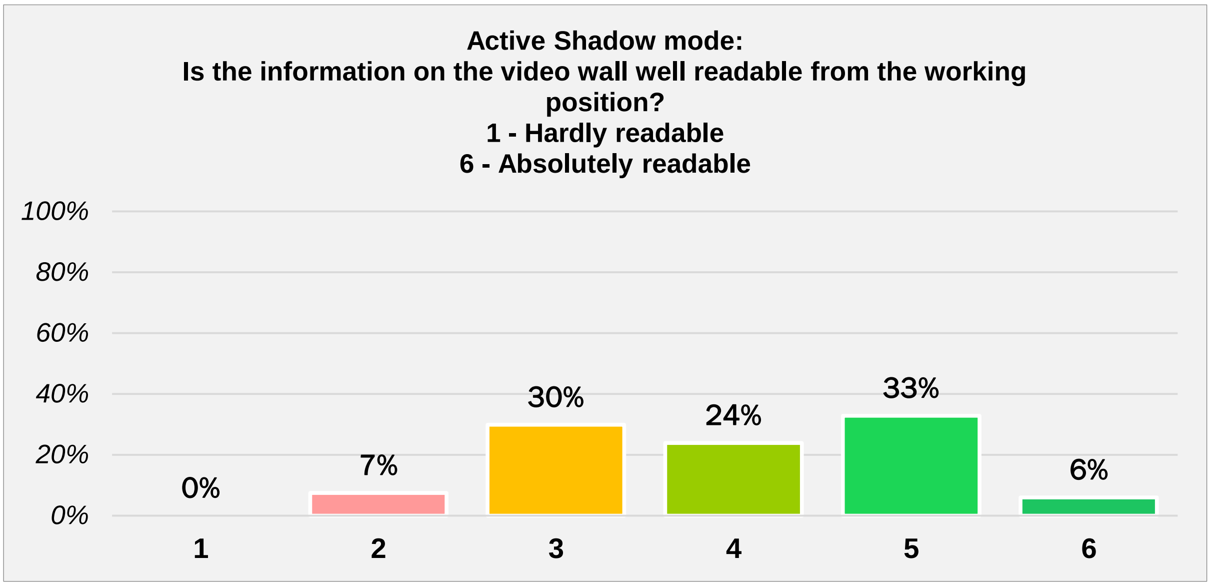


Compared to the shadow mode the results are a bit negative, but this is probably due to the increased pressure of the live controlling.

Is the information on the video wall well readable from the working position?

This question targets if the information on the video wall is well readable. The ATCOs were asked to evaluate readability and rate it on a scale from 1 to 6 where 1 meant hardly readable and 6 meant absolutely readable.

24 percent of ATCOs voted for relatively good readability (4) 37 percent were less satisfied with the readability and 39 percent voted for better than average readability.



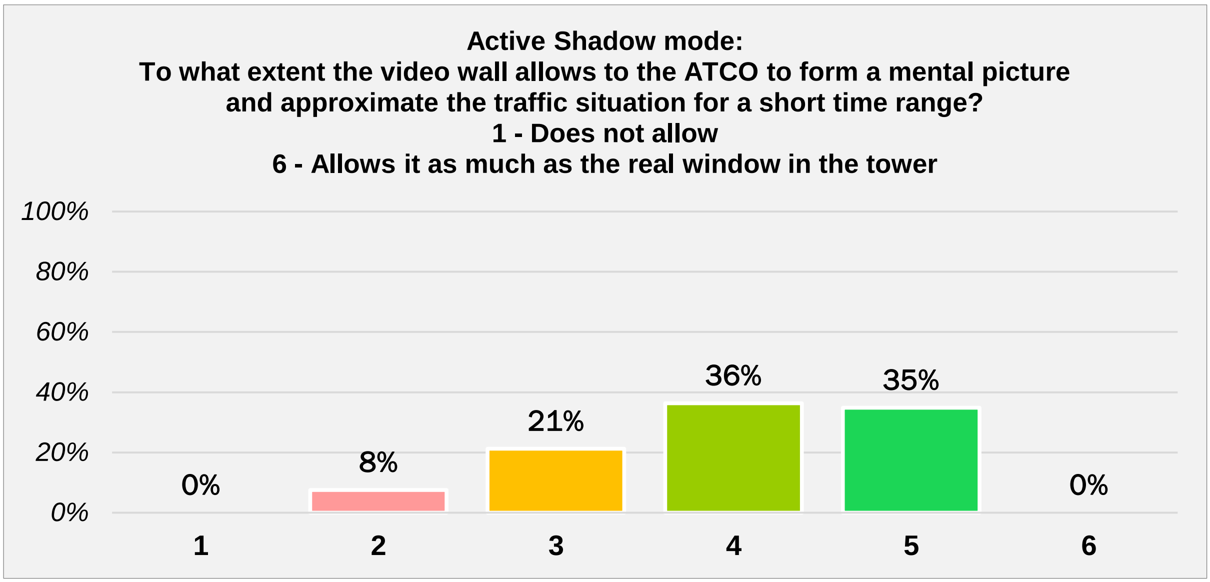
Compared to the shadow mode the results are more spread. 57 percent voted for good readability, 22 percent still not satisfied and 6 percent considered it absolutely readable which was 0 in shadow mode.

C.2.1.3 Usability of the video wall

To what extent the video wall allows to the ATCO to form a mental picture and approximate the traffic situation for a short time range?

This question is aimed at establishing if the video wall allows ATCOs to form mental picture and approximate the traffic situation for a short time range. The ATCOs were required to evaluate this on the scale from 1 to 6 where 1 correspond to "does not allow" and 6 to "allows it as much as the real window in the tower".

Most of the ATCOs evaluated the question positively (71%) and only 29 percent rated it negatively, however none of them voted 6.

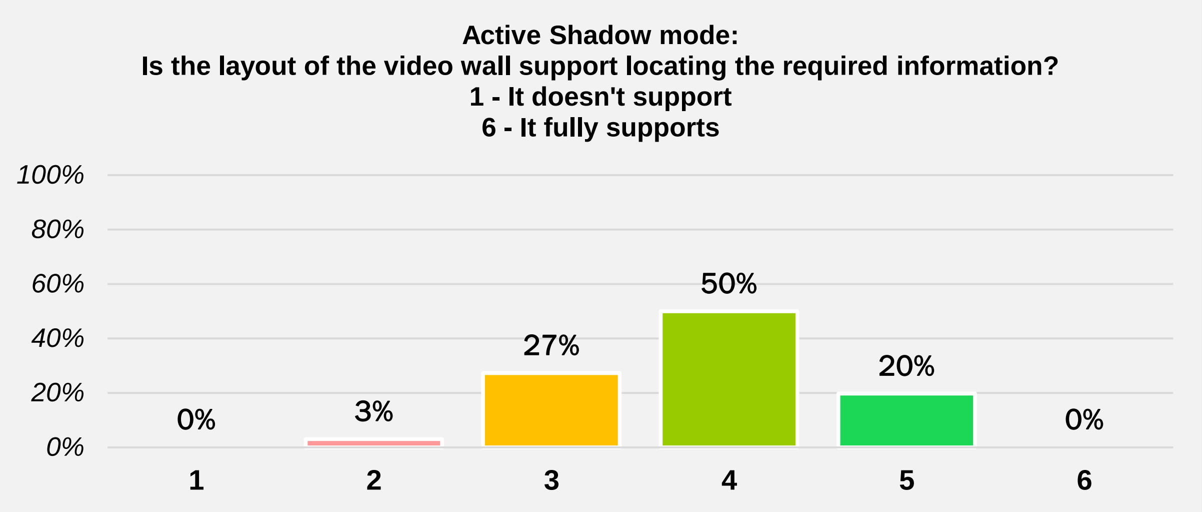


Compared to the shadow mode the results are bit lower than in the shadow mode.

Is the layout of the video wall support locating the required information?

The question was about how extensively supports the video wall the locating of the information. The ATCOs had to evaluate the level of support locating the required information by the video wall and rate it on the scale from 1 to 6 where the 1 meant that it does not support it and 6 meant that it fully supports it.

The results are: 30 percent of the ATCOs evaluated the support locating the required information negatively, majority of the ATCOs that is 70 percent was satisfied with the provided support, however, none of the felt that it fully supports the locating of the required information.

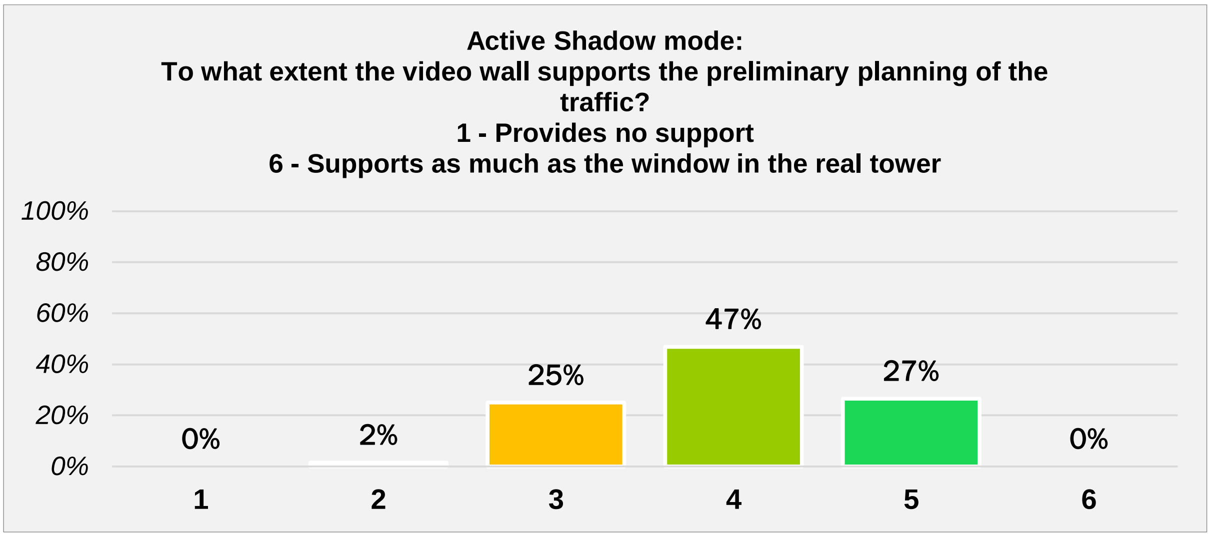


Compared to the shadow mode the results are a bit lower probably due to the pressure of the live session.

To what extent the video wall supports the preliminary planning of the traffic?

The question targets the support that the video wall provides for the preliminary planning of the traffic. The ATCOs had to evaluate the support that the video wall provides for the preliminary planning of the traffic and rate that said support on the scale from 1 to 6 where 1 meant provides no support and 6 meant supports as much as the window in the real tower.

27 percent of the ATCOs evaluated the support negatively and roughly 74 percent considered the provided support positively.

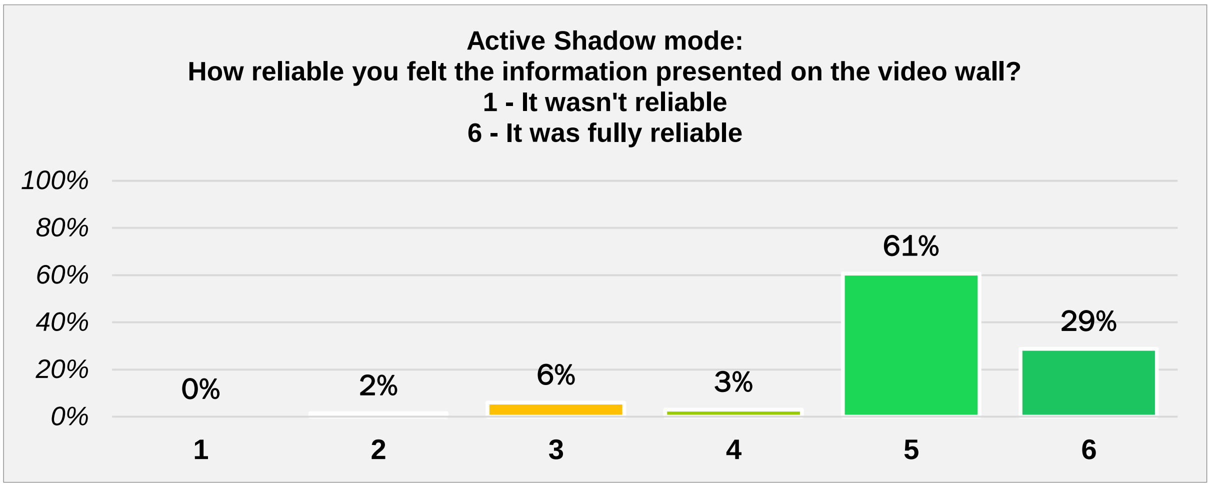


Compared to the shadow mode the results are a bit different, none of the ATCOs voted for “Provides no support”. 25 percent graded it as 3 instead of 9 percent and 74 percent were still satisfied.

How reliable you felt the information presented on the video wall?

The question is aimed at the reliability of the information presented on the video wall. The ATCOs had to evaluate reliability and rate that said reliability on the scale from 1 to 6 where 1 meant not reliable and 6 meant absolutely reliable.

The evaluation of the results show that only 8 percent of the ATCOs were not satisfied with the reliability of the provided information roughly 93 percent were satisfied with reliability.

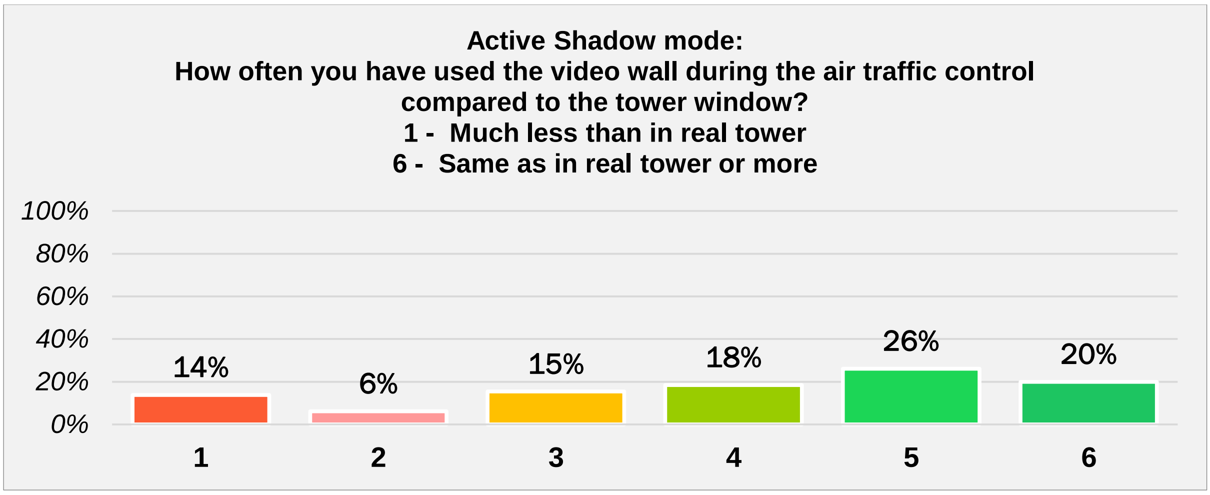


Compared to the shadow mode the results are better as negative evaluation went down from 10 to 8 percent and the positive evaluation is also shifted from 73 percent of grade 5 and 9 percent of grade 6 to 61 percent of grade 5 and 29 percent of grade 6.

How often you have used the video wall during the air traffic control compared to the tower window?

The question was about the frequency of the video wall usage by the ATCOs. The ATCOs had to evaluate how often they have used the video wall compared to the real windows in the tower during the air traffic control and rate the frequency on the scale from 1 to 6 where 1 meant much less and 6 meant same as in real tower or more.

According to the results 35 percent of the ATCOs used the video wall less the real tower window, 54 percent used it nearly as much as the real window and 20 percent indicated that they have used the video wall same quantity or more.



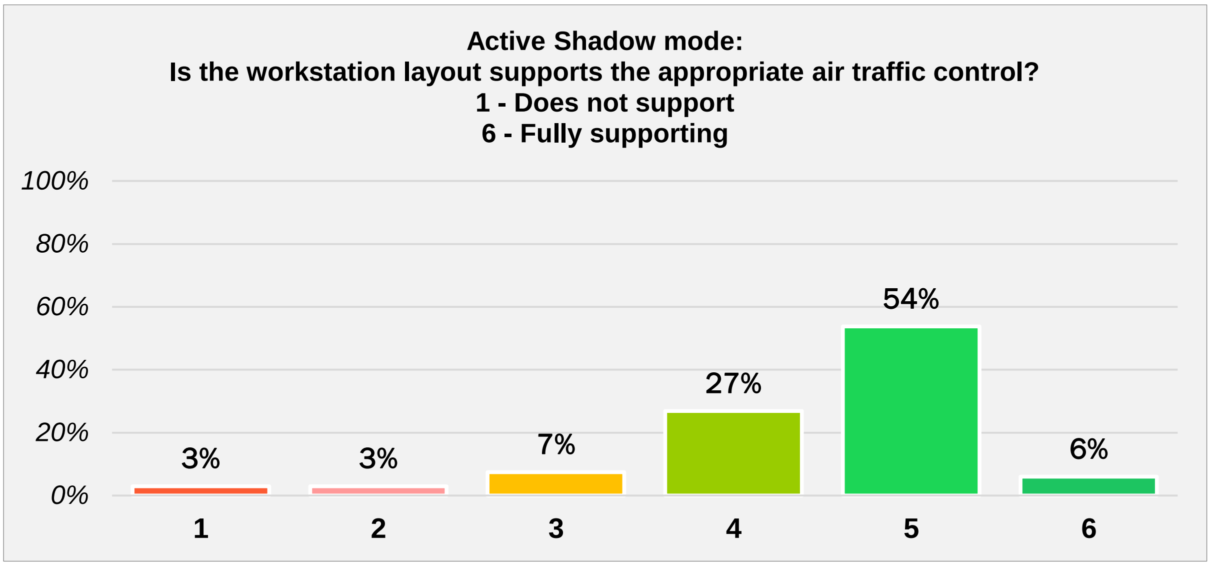
Compared to the shadow mode the results are more levelled. The ATCOs voted for all grades, however most grades are below 20 percent. The overall picture though still the same namely 35 percent of ATCOs used the video wall less that the window in the tower and 64 percent used it more.

C.2.2 Infrastructure related questions – workstation evaluation

Is the workstation layout supports the appropriate air traffic control?

The question is aimed at the layout of the video wall and if it supports the appropriate air traffic control. The ATCOs had to evaluate the layout of the video wall and if it supports the appropriate air traffic control and rate the support provided on the scale from 1 to 6 where 1 meant does not support and 6 meant fully supporting.

The evaluation results show that 13 percent of the ATCOs evaluated the video wall support negatively, 81 percent evaluated the video wall support and only 6 percent evaluated the video wall support as fully supporting.

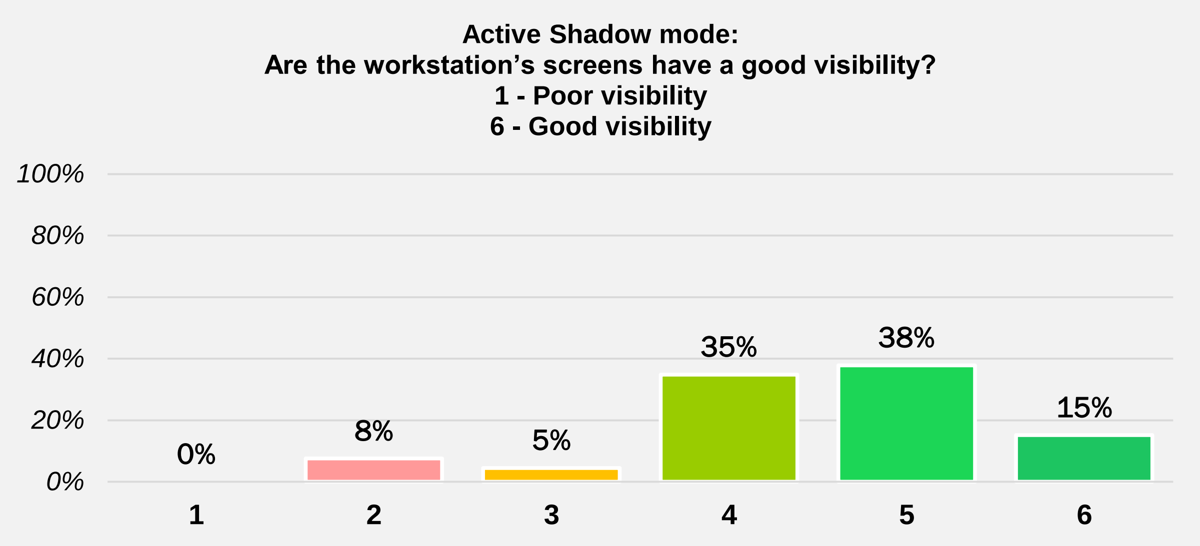


Compared to the shadow mode the results are basically the same yet you can see the confidence in video wall supporting the air traffic control is stronger than in shadow mode as votes for grade 5 are grow almost 10 percent and for grade 6 by 4 percent.

Are the workstation's screens have a good visibility?

The question was about the visibility of the video wall's screens. The ATCOs had to evaluate the visibility of the video wall's screens and rate the visibility on the scale from 1 to 6 where 1 meant poor visibility and 6 meant good visibility.

According to the results 13 percent of the ATCOs evaluated the visibility negatively, approximately 88 percent evaluated the visibility positively of which 15 percent evaluated the visibility as very good.

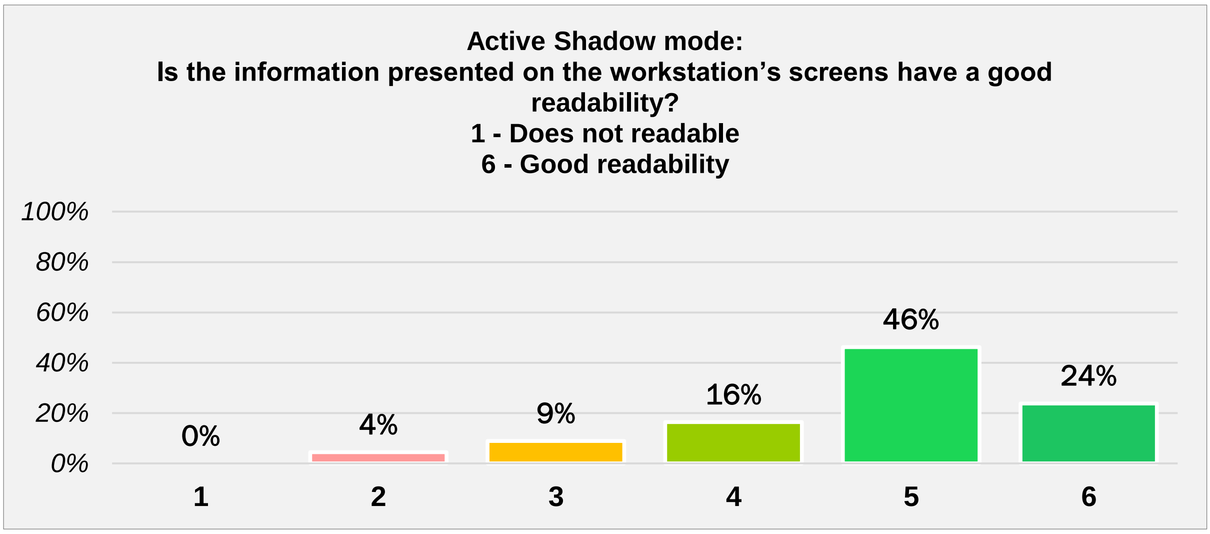


Compared to the shadow mode the results are more levelled yet the ATCOs voted for the grade 6 "Good visibility" 7 percent more.

Is the information presented on the workstation's screens have a good readability?

The question is aimed at the readability of the information presented on the video wall. The ATCOs had to evaluate the readability of the information and rate it on the scale from 1 to 6 where 1 meant does not readable and 6 meant good readability.

According to the results 13 percent of the ATCOs evaluated the readability negatively, approximately 86 percent evaluated the readability positively and only 9 percent evaluated the readability as excellent.

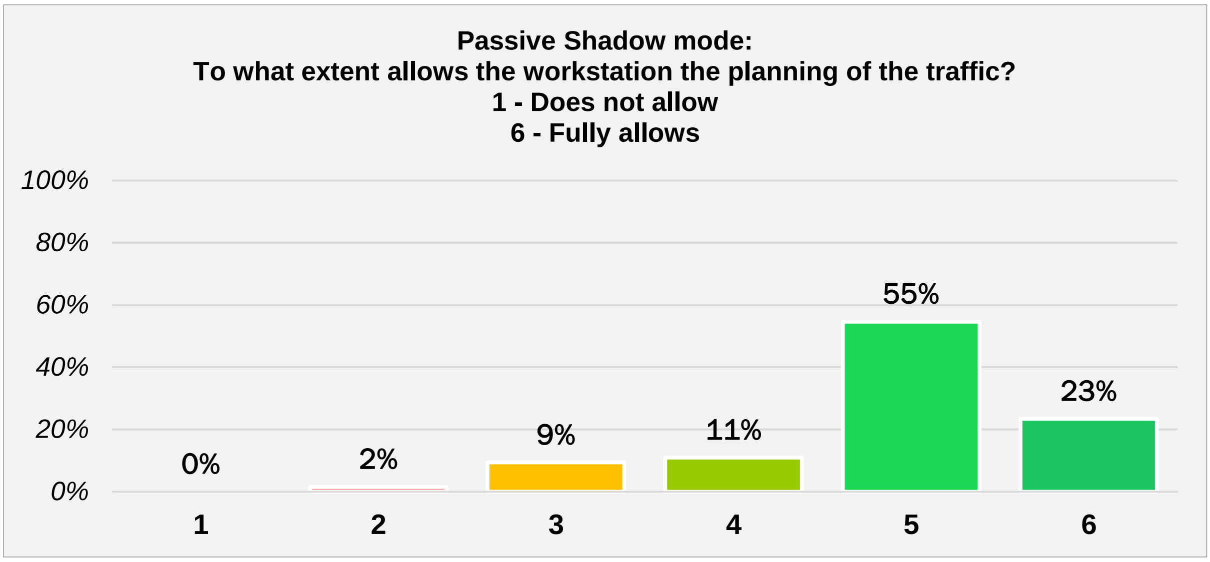


Compared to the shadow mode the results are more levelled and votes for reliability grade 6 grow by 15 percent.

To what extent allows the workstation the planning of the traffic?

The question was about the traffic planning. The ATCOs had to evaluate to what extent the workstation allows planning of the traffic and rate it on the scale from 1 to 6 where 1 meant does not allow and 6 meant fully allows.

The results are: 11 percent of the ATCOs evaluated the question negatively, 66 percent evaluated the question positively and 23 percent evaluated the question fully positively.

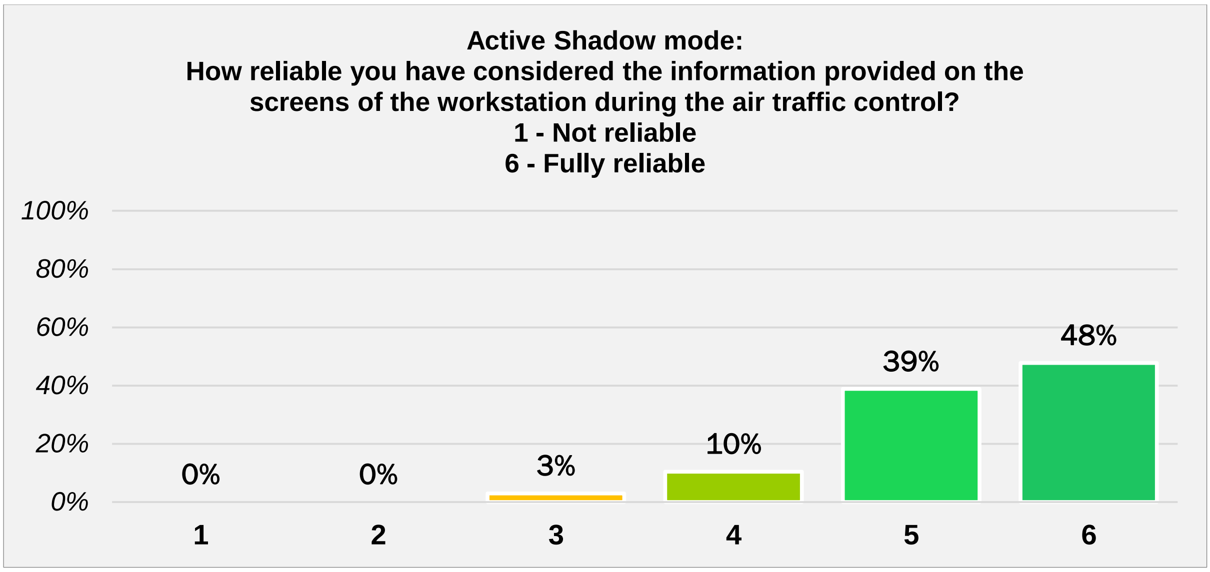


Compared to the shadow mode the results are more positive as although the negative evaluation are still at 11 percent yet the positive evaluations are shifted to the more positive end of the scale.

How reliable you have considered the information provided on the screens of the workstation during the air traffic control?

The question is aimed at the reliability of the presented on the screens information. The ATCOs had to evaluate to what extent the information provided is reliable and rate it on the scale from 1 to 6 where 1 meant not reliable and 6 meant fully reliable.

According to the results 3 percent of the ATCOs evaluated the reliability negatively, 97 percent evaluated the reliability positively of which 48 percent rated it as fully reliable.

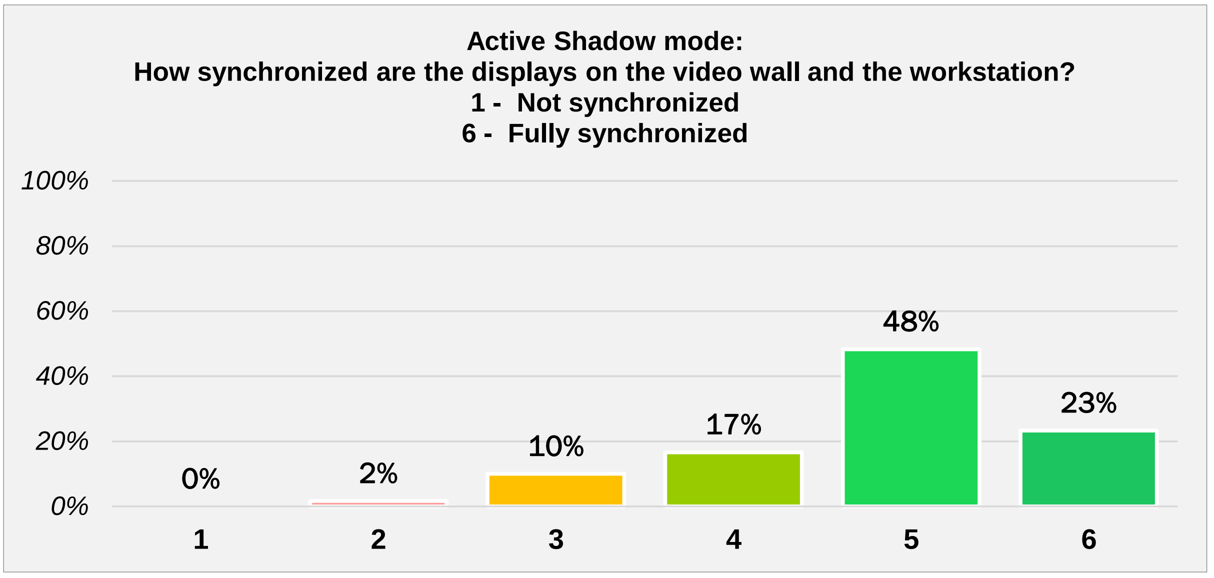


Compared to the shadow mode the results are more positive as although the negative evaluation are still at 3 percent yet the positive evaluations are shifted to the more positive end of the scale and 6 grade has the biggest percentage.

How synchronized are the displays on the video wall and the workstation?

The question is aimed at the synchronisation of the video wall data and the workstation data. The ATCOs had to evaluate to synchronicity of video wall and the workstation data and rate the synchronicity on the scale from 1 to 6 where 1 meant not synchronized and 6 meant fully synchronized.

According to the results 12 percent of the ATCOs evaluated the question negatively, 88 percent evaluated the question positively of which 23 percent evaluated the question fully positively that is the data are fully synchronised.



Compared to the shadow mode the results are more positive as although the negative evaluation are still at 12 percent yet the evaluations are shifted to the more middle of the scale.

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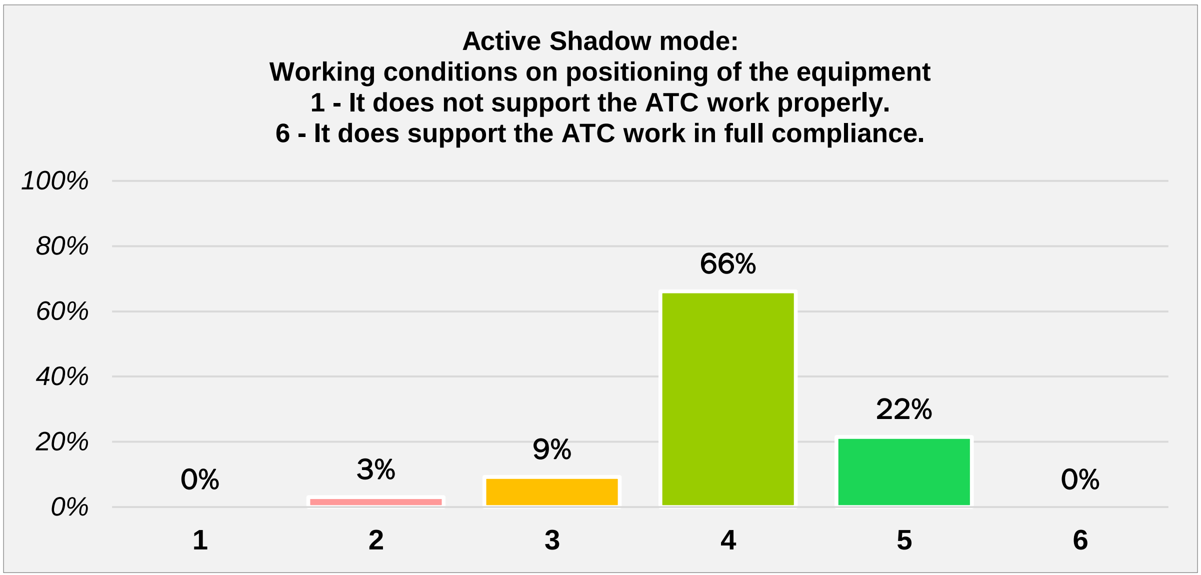
C.2.3 Infrastructure related questions – air traffic control environment and area evaluation

How the working conditions at rTWR area support the air traffic control? Positioning of the equipment

The question is aimed at the positioning of the equipment at work area. The ATCOs had to evaluate how the positioning of the equipment at the work area supports the air traffic control and rate the positioning of the equipment on the scale from 1 to 6 where 1 meant It does not support the ATC work properly and 6 meant It does support the ATC work in full compliance.

According to the results 12 percent of the ATCOs evaluated the question negatively, 88 percent evaluated the question positively.

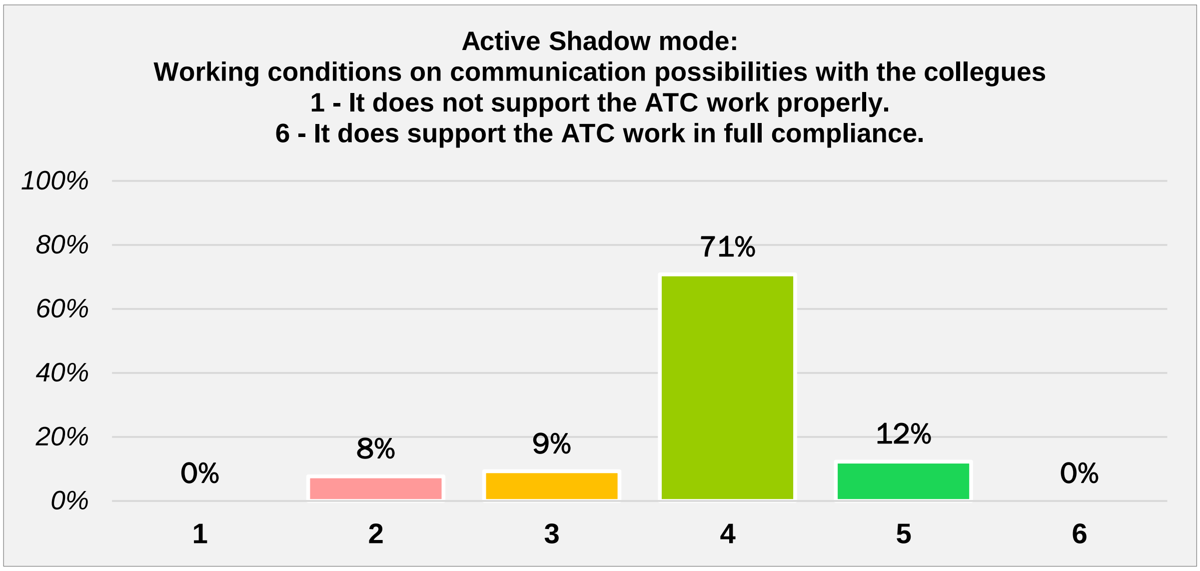


Compared to the shadow mode the results are more negative yet the votes are concentrated on the middle section of the scale.

Communication possibilities with the colleagues

The question is aimed at the communication possibilities with the colleagues at the work area. The ATCOs had to evaluate how the communication possibilities with the colleagues at the work area supports the air traffic control and rate the communication possibilities on the scale from 1 to 6 where 1 meant It does not support the ATC work properly and 6 meant It does support the ATC work in full compliance.

According to the results 17 percent of the ATCOs evaluated the question negatively, 83 percent evaluated the question positively.



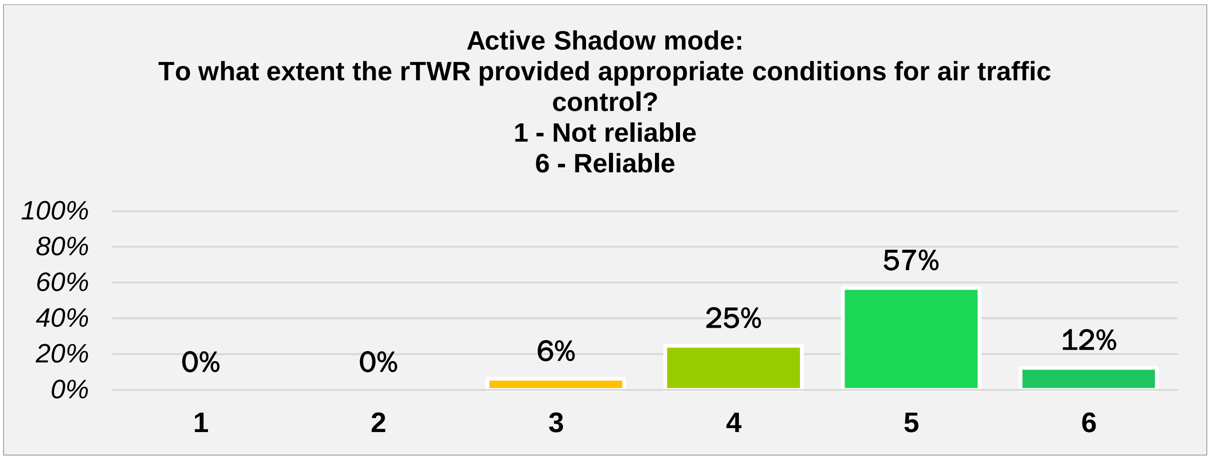
Compared to the shadow mode the results are more positive most of the votes (71%) placed on 4th grade yet the votes are concentrated on the middle section of the scale.

C.2.4 General working and ergonomic conditions

To what extent the rTWR provided appropriate conditions for air traffic control?

The question was about at the provided work conditions at the rTWR. The ATCOs had to evaluate if the reliable working conditions are provided at the rTWR and rate working conditions on the scale from 1 to 6 where 1 meant not reliable and 6 meant reliable.

The results show that 6 percent of the ATCOs evaluated the question negatively, 94 percent evaluated the question positively.

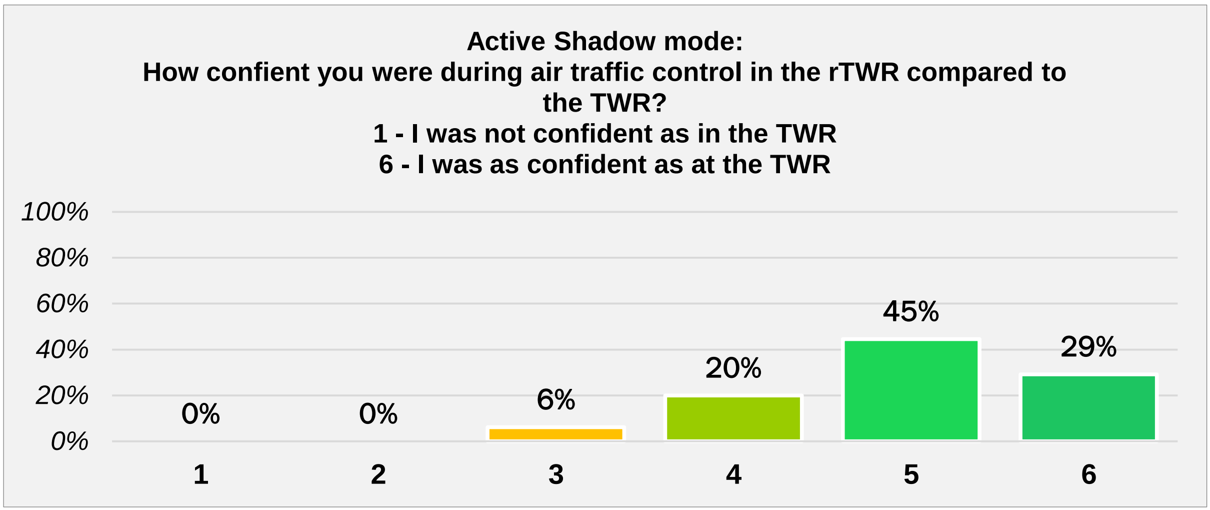


Compared to the shadow mode the results are much more positive and the votes are concentrated on the positive section of the scale.

Compared to the TWR how confident you were during the air traffic control at the rTWR?

The question is aimed at the confidence of the ATCOs during the air traffic control. The ATCOs had to evaluate how confident they are during the air traffic control in the rTWR compared to the TWR and rate their confidence on the scale from 1 to 6 where 1 meant I was not confident as in the TWR and 6 meant I was as confident as at the TWR.

According to the results 6 percent of the ATCOs were less confident that at the TWR, 94 percent were as much confident as at the TWR.

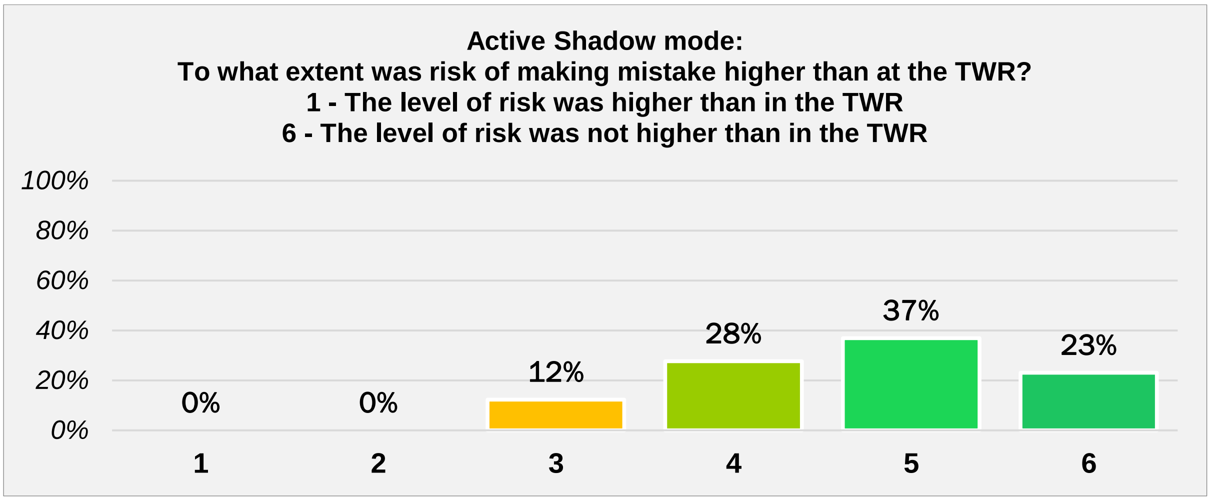


Compared to the shadow mode the results are much more positive and the votes are concentrated on the positive section of the scale.

To what extent was risk of making mistake higher than at the TWR?

The question is aimed at the level of risk of making a mistake during the air traffic control. The ATCOs had to evaluate level of risk of making a mistake during the air traffic control in the rTWR compared to the TWR and rate the level of risk on the scale from 1 to 6 where 1 meant the level of risk was higher than in the TWR and 6 meant the level of risk was not higher than in the TWR.

According to the results 12 percent of the ATCOs considered the level of risk as higher and 88 percent considered the level of risk similar to TWR.

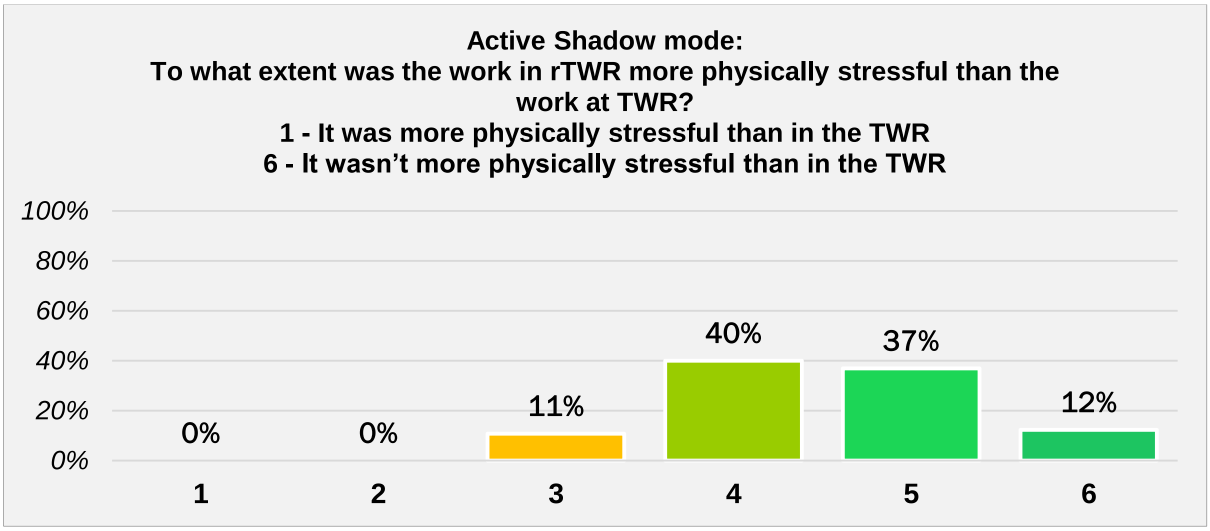


Compared to the shadow mode the results are much more positive and the votes are concentrated on the positive section of the scale.

To what extent was the work in rTWR more physically stressful than the work at TWR?

The question was about the physical stress of the ATCOs during the air traffic control. The ATCOs had to evaluate how physically stressful was the air traffic control in the rTWR compared to the TWR and rate the physical stress on the scale from 1 to 6 where 1 meant it was more physically stressful than in the TWR and 6 meant it wasn't more physically stressful than in the TWR.

The evaluation of the questionnaires show that 11 percent of the ATCOs considered that it was physically more stressful than in the TWR, 89 percent of the ATCOs considered that it wasn't physically more stressful than in the TWR.

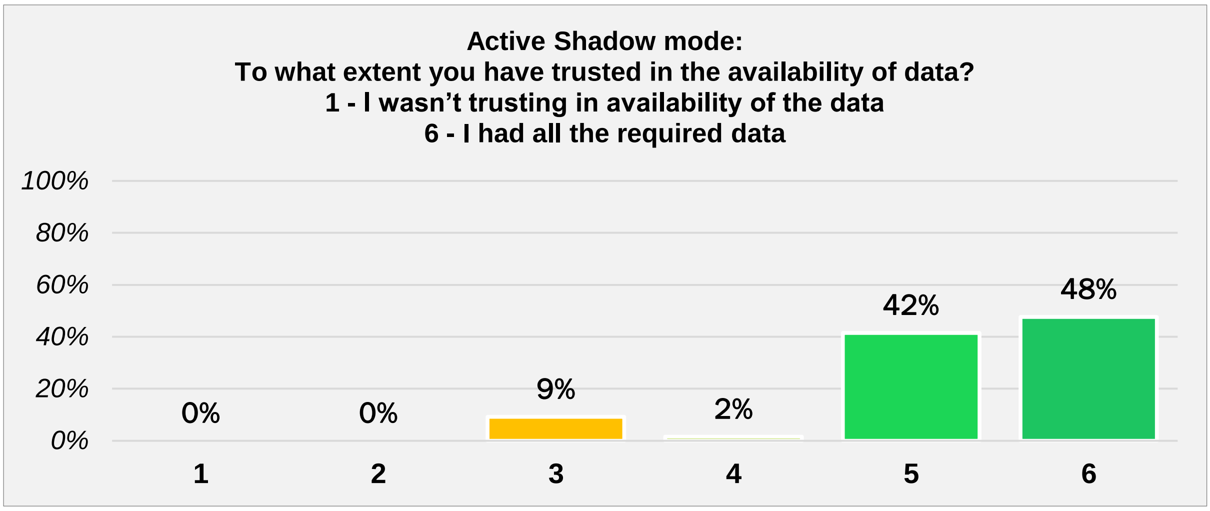


Compared to the shadow mode the results are much more positive and the votes are concentrated on the positive section of the scale.

To what extent you have trusted in the availability of data?

The question was about the ATCOs trust in the availability of data during the air traffic control. The ATCOs had to evaluate level of trust in availability of the during the air traffic control in the rTWR and rate the level of availability on the scale from 1 to 6 where 1 meant I wasn't trusting in availability of the data and 6 meant I had all the required data.

The results are: 9 percent of the ATCOs were not trusting into availability of the required data and 92 percent of the ATCOs considered that they had all the required data, however 48 percent of them were fully confident in this.

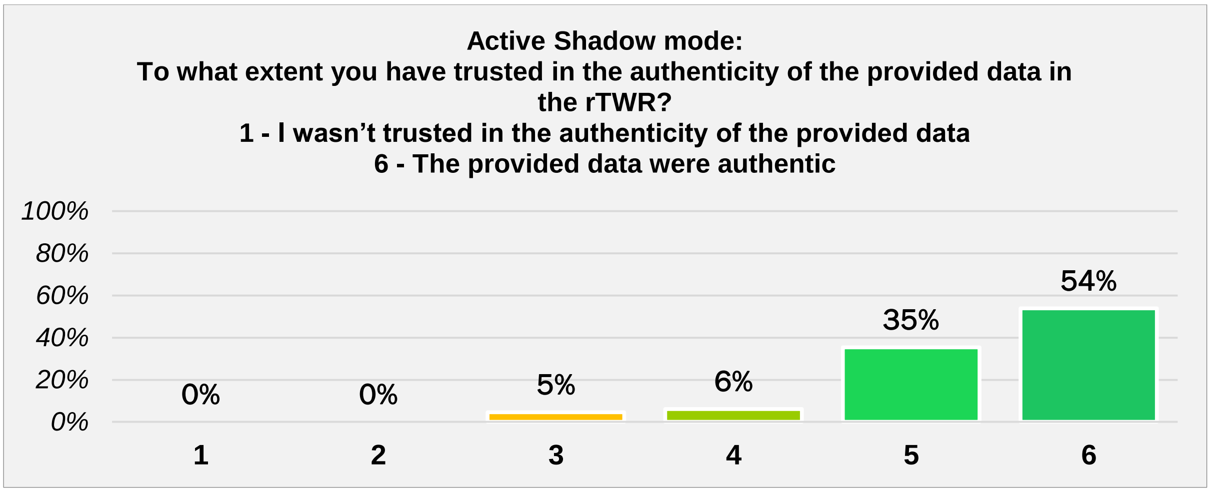


Compared to the shadow mode the results are much more positive and the votes are concentrated on the positive section of the scale.

To what extent you have trusted in the authenticity of the provided data in the rTWR?

The ATCOs were asked about the authenticity of the provided data in the rTWR during the air traffic control. The ATCOs had to evaluate the level of trust in the authenticity of the provided data during the air traffic control in the rTWR and rate the level of trust on the scale from 1 to 6 where 1 meant I wasn't trusted in the authenticity of the provided data and 6 meant the provided data were authentic.

The results are: 5 percent of the ATCOs wasn't trusted in the authenticity of the provided data, 95 percent of the ATCOs considered that the provided data were authentic.

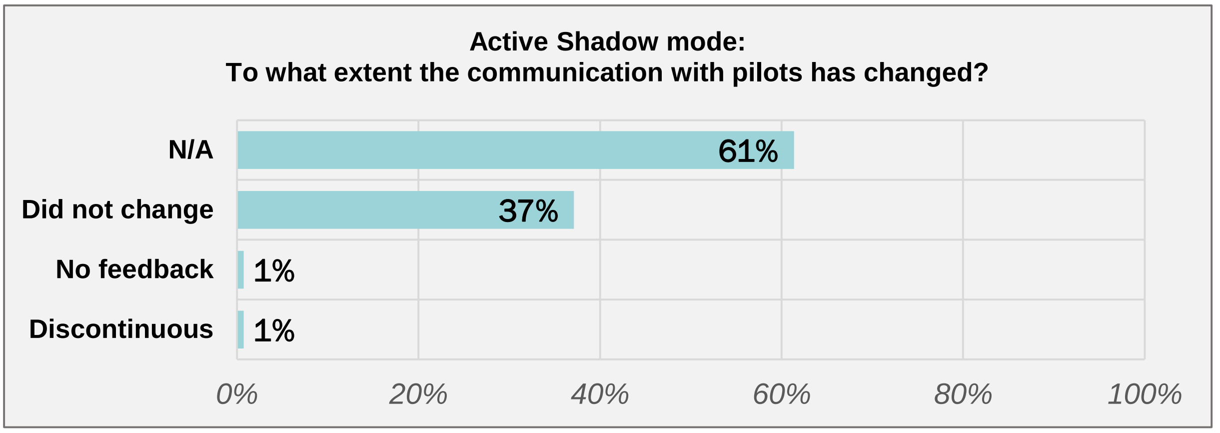


Compared to the shadow mode the results are much more positive and the votes are concentrated on the positive section of the scale.

To what extent the communication with pilots has changed?

The question is aimed at the communication with pilots in the rTWR during the air traffic control. The ATCOs had to evaluate the change in the communication with pilots during the air traffic control in the rTWR on the multiple choice question were the default answer was no changes and they had a possibility to input free text as remark.

According to the results 37 percent of the ATCOs felt that the communication hasn't changed and 61 percent answered N/A as not applicable that means no change as well.



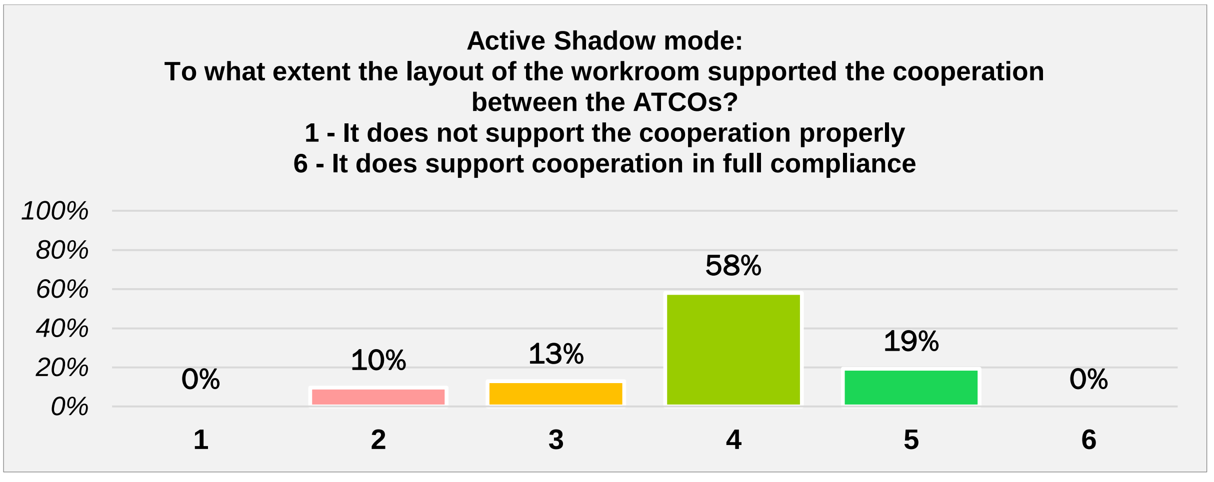
To what extent the communication with ground personnel has changed?

The question is aimed at the communication with ground personnel in the rTWR during the air traffic control.

To what extent the layout of the workroom supported the cooperation between the ATCOs?

The question is aimed at the cooperation possibilities with the colleagues at the work area. The ATCOs had to evaluate how the work area layout supports cooperation possibilities with the colleagues at the air traffic control and rate the level of support on the scale from 1 to 6 where 1 meant It does not support the cooperation properly and 6 meant It does support cooperation in full compliance.

According to the results 23 percent of the ATCOs evaluated the question negatively, 77 percent evaluated the question positively.



Compared to the shadow mode the results are much more positive and the votes are concentrated on the positive section of the scale.

Appendix D Communication activities

Implementation of the Hungarian "virtual" tower has begun

HungaroControl has just launched its "virtual" tower implementation project (Remote Tower, rTWR), which will enable providing location independent aerodrome control service. According to the contract that was signed by the managements of the Hungarian air navigation service provider (ANSP) and INDRA Navia AS, a complete Advanced Surface Movement Guidance and Control System (A-SMGCS) will be set up by INDRA Navia AS until March 2016 to implement a remote tower at Budapest. The integrated radar and camera system will be provided by the Norwegian company and the Canadian SeaRidge Technologies as subcontractor as part of the 4.9 million dollars agreement.

According to forecasts, the number of flights over Europe might reach 16.9 million by 2030. Air navigation systems have to keep up with the enormously growing traffic and with its inherent safety and capacity challenges. HungaroControl's concept of the virtual tower (rTWR) enables the fulfillment of airport control services at medium or large sized airports. By 2017, departing and arriving traffic of Budapest Airport (BUD) may already be navigated by Hungarian air traffic control officers (ATCO) from a "virtual" tower.

According to the contract, INDRA Navia AS shall install a complete Advanced Surface Movement Guidance and Control System (A-SMGCS), which is required to implement the concept of rTWR at Budapest. The Norwegian company will also set up a camera system provided by SeaRidge Technologies from Canada, a video wall and further equipment. The visualization of the aprons and both runways of Budapest Airport, as well as the flight information coming from A-SMGCS on the video wall will be tailored to meet the ATCOs' needs.

"Next year we will also demonstrate our rTWR infrastructure on live traffic as part of a SESAR Large Scale Demonstration (Budapest 2.0) project. By achieving this, HungaroControl will be the first in the world to test and demonstrate air traffic control from a remote tower at an airport the size of Budapest Airport," – said Mr. Kornél Szepessy, CEO of HungaroControl.

In the last five years, there have been numerous improvements and significant investments in the remote tower industry. The implementation of the Hungarian concept is based on the duplication of the current air traffic management systems and navigation procedures, which will provide safe air navigation services of appropriate capacity on the long term. HungaroControl's concept fully exploits the opportunities of modern technologies: including the use of infrared cameras in order to further extend its technical infrastructure.

Figure 9-3: News published in HungaroControl's website

Figure 9-4: News published in Pildo's twitter account

First EGNOS-based approaches implemented in Hungary

Last 15th September, the first EGNOS-based approaches implemented in Hungary became effective at Budapest Airport thanks to the work performed by Pildo Labs, HungaroControl and JetStream in the framework of BUDAPEST 2.0 Project.

The new PBN approach includes also a GPS non-precision approach (LNAV) and an approach with barometric vertical guidance (LNAV/VNAV), whilst the LPV procedures are based on EGNOS LPV-200 service level. The procedures have been designed by Pildo Labs and validated in July 2016 in a flight validation campaign organized by HungaroControl in coordination with the airport.

A Cessna C-650 Citation III operated by Jetstream was used for the flight validation of the procedures. The aircraft was temporarily equipped with PLATERO, Pildo Labs flight validation system which provided the guidance to the pilots for validating all the approaches. The project was also strongly supported by Emirates airline, who performed simulator evaluations. Pilots' feedback was very positive.

Once validated, the procedures were submitted to the AIS department of HungaroControl for publication in their National AIP and are operationally available since September 15th.

The flight campaign took place in the framework of the BUDAPEST 2.0 project funded by SESAR Joint Undertaking with the main objective of demonstrating that the implementation of new solutions and concepts can contribute to improve operations and provide most cost-effective business models for small/medium airport stakeholders and airspace users.

< Prev post

Figure 9-5: News published in Pildo's website

PildoLabs move smart | SESAR JOINT UNDERTAKING *today's partners for tomorrow's aviation*

First EGNOS-based approaches implemented in Hungary

Last 15th September, the first EGNOS-based approaches implemented in Hungary became effective at Budapest Airport thanks to the work performed by Pildo Labs, HungaroControl and JetStream in the framework of BUDAPEST 2.0 Project.

Four new PBN approaches have been implemented in Budapest Airport including a GPS non-precision approach (LNAV), an approach with barometric vertical guidance (LNAV/VNAV), and LPV procedures based on EGNOS LPV-200 service level. The procedures have been designed by Pildo Labs and validated in July 2016 in a flight validation campaign organized by HungaroControl in coordination with the airport.

A Cessna C-650 Citation III operated by Jetstream was used for the flight validation of the procedures. The aircraft was temporarily equipped with PLATERO, Pildo Labs flight validation system which provided the guidance to the pilots for validating all the approaches.

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BUDAPEST 2.0 Consortium Members

Founded in 2001 and based in Barcelona (Spain), **Pildo Labs** is recognized as one of the global players in the development of advanced Air Navigation products and services.
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Figure 9-6: Press Release intended to be published in SESAR's e-news bulletin

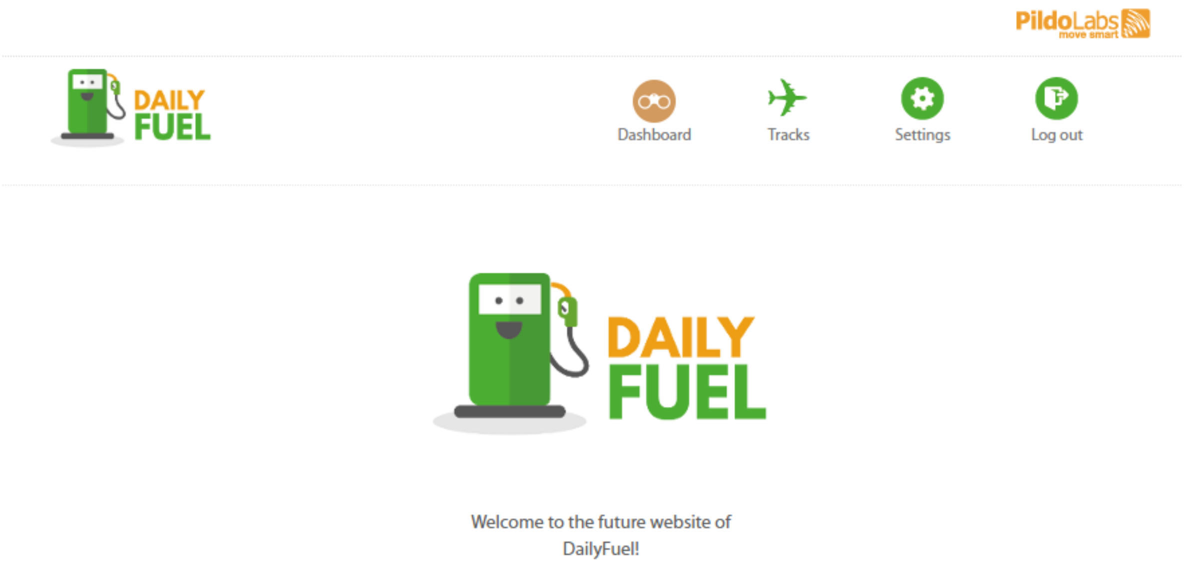

Figure 9-7: Showroom overview

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