Demonstration Report (B1)

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Abstract

This document is the Demonstration Report of PROuD project.
It provides an overview of the project, in terms of context of the demonstration and programme management, and describes in details all demonstration activities performed during the lifetime of the project and the relevant results obtained.
PinS RNP APCH to LPV minima and helicopter RNP AR APCH procedures, PinS departure procedures, low level IFR route segments and related transitions are evaluated as effective solutions to improve HEMS operations in European scenarios, challenging for weather conditions, visibility limitations and geographical configuration.
Conclusions of PROuD flight campaigns are pointed out as well as recommendations for future activities to improve rotorcraft operations in challenging environment and in adverse weather conditions.
This document also provides a summary of the communication activities performed during the project execution.

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This deliverable consists of SJU foreground.

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Executive summary

The PROuD (PBN Rotorcraft Procedures under Demonstration) project started on 6th October 2014 and executed through the cooperation of five entities forming the PROuD Consortium: IDS Ingegneria Dei Sistemi S.p.A (IDS), Swiss Air-Rescue Rega (REGA), Norsk Luftambulanse (NLA); Skyguide; Deep Blue (DBL). EHA (European Helicopter Association) and EHAC (European HEMS & Air Ambulance Committee) endorsed the PROuD project activities, providing guidance, feedback and a supporting interface with European regulators.

The PROuD purpose was to demonstrate improvements in rotorcraft operations, particularly for HEMS (Helicopter Emergency Medical Services) and SAR (Search and Rescue), through the implementation of Performance Based Navigation (PBN) procedures for approach, departure and Low Level IFR Routes (LLR) in European scenarios, challenging for weather conditions, visibility limitations or geographical configuration.

RNP APCH to LPV minima and helicopter RNP AR APCH procedures, PinS departure procedures, low level IFR route segments and related transitions were evaluated as effective solutions to improve HEMS operations in the challenging selected scenarios analysed in the PROuD project:

- Samedan (Engadin airport - ICAO code LSZS) - situated in the Engadine valley, surrounded by a mountainous region wherein the flight procedures and aircraft performances are very strongly affected by the natural obstacles. The Engadin airport is the highest elevated airport in Europe (elevation 5.600ft AMSL). For this scenario, the implementation of a PinS "non-standard" departure and a helicopter RNP AR APCH has been identified by REGA (supported by SKYGUIDE and IDS) as effective solutions to overcome the currently existing limitations in terms of safety and airport capacity/accessibility and to have benefit from operational point of view.
- Chur (ICAO code LSHC) hospital - the hospital is situated in the Churer Rhine valley and is surrounded by a mountainous region, wherein the flight procedures are very strongly affected by natural obstacles. In terms of number of HEMS movements, Chur hospital ranks among the top 2 hospitals in Switzerland (756 landings in 2015). For this scenario, the implementation of a PinS departure and a PinS RNP APCH to LPV minima has been identified by REGA as effective solutions to overcome the currently existing limitations in terms of safety and site capacity/accessibility.
- Lørenskog (heliport - ICAO code ENLX) and Ullevål heliport (ICAO code ENUH) – Lørenskog heliport is located in the Southern of Norway where a low level routing structure exists for use by the Norwegian Air Ambulance to connect hospital heliports throughout the region. Together with Ullevål heliport, serves approximately 35% of the Norwegian population when it comes to severe injuries. The implementation of a PinS RNP APCH to LPV minima (at ENLX and ENUH) and PinS departure (at ENLX) procedures has been identified by NLA as effective solutions to overcome the currently existing limitations in terms of safety and heliport capacity/accessibility. For the Norwegian approaches, also the related procedures with LNAV minima have been considered.

PROuD, through campaigns for a total of approximately 80 test flights performed in Switzerland and Norway, demonstrated in a live trial environment, how the adoption of PBN flight procedures improves the safety and reliability of operations and landing site accessibility in challenging environments such as in adverse weather conditions or mountainous areas. It implies significant improvements for the general population in the experience of medical assistance by air.

Routes and procedures flown in the PROuD live trials were considered as a starting point for future operational implementation, as soon as the local regulation allows it. The Norwegian CAA has already approved the approach procedures with LNAV and LPV minima for operational use by Norsk Luftambulanse. NLA has received a temporary approval based on the PinS departure criteria together with some other company approval based on the ICAO DOC 8168 Vol. 2.

Today, the RNP AR design criteria as stipulated in the current first edition of ICAO Doc 9905 RNP AR Manual only cover aircraft categories A to E, i.e. fixed wing aircraft. The Helicopter Working Group of the ICAO IFP Panel is already proposing a Corrigendum which will add the general statement that rotorcraft may be used to fly category A RNP AR procedures, if the helicopter and crew are accordingly certified and meet the AR requirements. However, in particular the procedure design activities in the Samedan scenario have shown that this may not always be sufficient. In order to enable the provision of IFR procedures with operationally beneficial approach minima or climb performance requirements in even the most demanding terrain environments, the option to design the following types of procedures would be of interest:

- Adoption of CAT H specific procedure design parameters such as speeds, climb/descent gradients and height loss to Doc 9905 RNP AR Manual.
- Extension of the scope of the RNP AR navigation specification to encompass the departure phase of flight and the development of the respective procedure design criteria.
- Extension of the Point-in-Space concept to encompass "PinS RNP AR" approach and departure procedures and the development of the respective procedure design criteria.

PROuD highlighted the following high level benefits:

- Guarantee the continuity of vital services such as patient transport and mountain rescue, enhancing safety and saving costs for communities;
- Improve the reliability and safety of helicopter operations, in particular at night and/or adverse weather conditions;
- Increase operational efficiency and reduce costs;
- Improve landing site accessibility.

This document represents the official deliverable D02 (Edition 00.01.00) of PROuD Execution Phase and includes:

- The context of the PROuD demonstration;
- The definition of the PROuD programme management;
- The operational, technical and safety aspects took into account during the preparation and execution of the preliminary and core parts of the project;
- The overall outcomes of the demonstration exercise performed in PROuD;
- The detailed report of demonstration campaigns starting in June 2015 and completed in April 2016;
- The communication activities performed for the PROuD project, both within SESAR and external to the Programme;
- The description of the necessary steps for implementation of the demonstrated solutions;
- Additional material and outcomes linked to PROuD activities that contribute to the completion of the project.

1 Introduction

1.1 Purpose of the document

This document provides the Demonstration Report for LSD.LOT2.09 – PROuD Project. It describes the results of demonstration exercises defined in the PROuD Demonstration Plan, Edition 00.02.00, delivered the 24th March 2015 and how they have been conducted.

1.2 Intended readership

This document is addressed to two categories of readers:

- readers with active/reviewers/approval role;
- readers, who should be informed about the PROuD plan and might be willing to follow and benefit from the project results.

Reviewing/Approval readers:

- the SESAR Joint Undertaking to allow for an evaluation of the project's working programme;
- the PROuD stakeholders, who will have a role in the different phases of the project:
    - Consortium Members (IDS Ingegneria Dei Sistemi S.p.A; Swiss Air-Rescue Rega; Norsk Luftambulanse; Skyguide; Deep Blue) personnel;
    - EHA – European Helicopter Association;
    - EHAC – European HEMS & Air Ambulance Committee;
- SESAR OFA02.01.01 "Optimised 2D/3D Routes" Coordinator;
- SESAR P04.10 "GA and Rotorcraft Operations" Project Manager.

Other targeted readers:

- SESAR Large Scale Demonstration - Project Managers;
- Airport/Heliport Operators;
- Norwegian CAA;
- Norwegian health care authorities;
- Swiss Federal Office of Civil Aviation (FOCA);
- Regulatory authorities (including other European CAAs);
- EASA;
- ICAO IFPP Helicopter WG;
- ICAO Helicopter Subgroup;
- International Helicopter Safety Team (IHST);
- Commission on Accreditation of Medical Transport Systems (CAMTS);
- International Federation of Helicopter Associations (IFHA);
- Participants to Nordic PINS Symposium (armed forces, police and HEMS operators);
- SESAR ENB 01.01.04 "Navigation";
- Relevant SESAR Projects in WP4, WP5, WP6 and WP9;
- Transversal Projects, relevant for human performances and safety assessment, e.g. WP16 L3 Projects;

- OEM AgustaWestland and Airbushelicopter.

1.3 Structure of the document

The document's structure complies with the Demonstration Report template provided by the SJU.

The PROuD Demonstration Report document is organised as follows:

Chapter 1 is this introduction;

Chapter 2 provides the context of the demonstration presenting at a high-level the exercises under the scope of the Demonstration Report;

Chapter 3 details the Programme management;

Chapter 4 provides the context of the demonstration exercises, giving an overview of the exercises preparation and execution, together with an explanation of the deviations from the planned activities;

Chapter 5 provides an overview of the exercises results: a summary of performed exercises and the list of choice of metrics and indicators used to evaluate the performance;

Chapter 6 details the conduction of each demonstration exercise: firstly the exercise scope is introduced, secondly each steps of the exercise conduction is explained (exercise preparation, execution and its related deviations from the planned activity), finally the exercise results and conclusions & recommendations close the section;

Chapter 7 reports a summary of the Communication Activities performed during the PROuD project;

Chapter 8 provides the next steps for the implementation of the demonstrated solutions;

Chapter 9 contains the References (Applicable and Reference documents list);

Appendix A presents the KPA results;

Appendix B reports the Demonstration Scenarios;

Appendix C reports the Demonstration Objectives;

Appendix D reports the Communication material produced during the PROuD project;

Appendix E presents the Swiss Local Safety Assessments;

Appendix F presents the Norwegian Local Safety Assessments;

Appendix G reports the PROuD questionnaires;

Appendix H contains the minima used for weather data analysis;

Appendix I reports the traceability between PROuD Objectives, Phases of Flight, KPA, Exercises and Scenarios;

Appendix J presents the Denmark procedures and related outcomes derived from pilots' feedback.

Appendix K contains the reference to the final flight inspection reports related to the first and the second Samedan campaigns.

1.4 Glossary of terms

Term	Definition	Source
ADS-B	Automatic Dependent Surveillance – Broadcast. A means by which aircraft, can automatically transmit and /or receive data such as identification, position and additional data, as appropriate, in a broadcast mode via a data link to increase the situational awareness.	ICAO
AFIS	AFIS is the Aerodrome Flight Information Service provided by an AFISO (Aerodrome Flight Information Service Officer).	EUROCONTROL AFIS Manual

Term	Definition	Source
ATS	ATS (Air Traffic Service) is a generic term for the three services Flight Information Service (FIS), Alerting Service (ALRS) and Air Traffic Control Service (ATC). In this document, when the term ATS is used, it is usually referring to AFIS.	EUROCONTROL AFIS Manual
CHIPS	**CHIPS** **ch** = Swiss: Switzerland-wide **implementation programme** for **SESAR** related activities and objectives. Not oriented towards one specific locality. Promote further development of the existing Swiss aviation system. **i** = Implementation: Demonstrate the will for implementation. Gradual approach. Applied research and development topics. **P** = programme. Set priorities. Gradual progress **s** = SESAR oriented activities and technologies. Not only will the objectives of SESAR and the ATM master plan be taken into account, but other innovative solution approaches and concepts will also be picked up.	http://www.skyguide.ch/de/chips-aero/chips/
LPV	LPV – Localiser Performance with Vertical Guidance: the minima-line based on SBAS performances that can be used by aircraft approved according to AMC 20-28 or equivalent.	EUR RNP APCH Guidance Material
RNAV	Area Navigation (formerly: Random Navigation): A navigation specification based on area navigation that does not include the requirement for on-board performance monitoring and alerting, designated by the prefix RNAV, e.g. RNAV 5, RNAV 1.	ICAO PBN Manual 9613
RNP	Required Navigation Performance: A navigation specification based on area navigation that includes the requirement for on-board performance monitoring and alerting, designated by the prefix RNP, e.g. RNP 4, RNP APCH.	ICAO PBN Manual 9613
RNP-AR	Required Navigation Performance Authorisation Required. RNP AR APCH operations are classified as approach procedures with vertical guidance (APVs)— This type of operation requires a positive vertical navigation (VNAV) guidance system for the final approach segment (FAS). Current RNP AR APCH implementations utilize a barometric vertical navigation system (BARO-VNAV) meeting specified airworthiness requirements. Obstacle clearance is based on a statistical assessment of all the component errors referred to as a vertical	ICAO DOC 9905 FAA Advisory Circular 90-101A EASA AMC 20-26

Term	Definition	Source
	error budget (VEB). Other suitably accurate vertical guidance may be implemented provided equivalent accuracy, integrity and containment can be assured.	
Point-in-Space (PinS) Approach	Point-in-space approach is an approach procedure designed for helicopters only that includes both a visual and an instrument segment.	ICAO PANS OPS 8168
Point-in-Space (PinS) Departures	Point-in-space departure is a departure procedure designed for helicopters only that includes both a visual and an instrument segment.	ICAO PANS OPS 8168
Navigation specification	A set of aircraft and aircrew requirements needed to support performance-based navigation operations within a defined airspace. RNAV and RNP are the two kinds of navigation specifications.	ICAO PBN Manual 9613
Operational Scenario	Within the context of an operational scenario is a description of how a future system could work in the operational context. Each scenario describes the behaviour of users and the future system, interaction between the two, and the wider context of use. From a detailed scenario the ATM Stakeholders are able to identify user requirements and potential applicable business cases.	
EGNOS	The European Geostationary Navigation Overlay Service. This is the European Satellite-Based Augmentation System (SBAS). A wide coverage augmentation system in which the user receives augmentation information from a satellite-based transmitter.	EUR RNP APCH Guidance Material
Low Level IFR Routes	Low Level IFR Routes dedicated to rotorcraft integration in dense / constrained airspace or remote area specific Low Level IFR routes network using RNP 1 or RNP 0.3. The integration in dense and constraint airspace or remote mountains areas is due to the rotorcraft peculiar flight characteristics and type of operation conducted, such as: • Helicopters not pressurised: the maximum allowed altitude by regulation and helicopter capabilities (The maximum altitude is defined by the country´s regulation and the helicopter/type limitations) • Helicopters without de-icing capability	ICAO Documentation FAA AC20-138

Term	Definition	Source
	– Risk of encountering icing conditions increases with altitude. Typically standard IFR FL are often too high • HEMS flights: Enable helicopter emergency medical flights also through areas with deteriorated weather conditions (IMC) in order to provide life-saving treatment through a significant reduction of the therapy-free interval and/or a fast transport to start a definitive treatment at a specialized hospital as soon as possible to improve the overall medical result of emergency patients. Such includes also inter-hospital transfers, e.g. from a regular hospital to a specialized hospital (e.g. trauma centre) • Safety and environment Low Level IFR Routes avoid visual flights at very low altitudes (500 ft. or sometimes less) to stay below clouds in marginal weather conditions, as such VFR flights are a frequent accident cause and also impact the environment (e.g. noise footprint) negatively.	

1.5 Acronyms and Terminology

Term	Definition
ADS-B	Automatic Dependent Surveillance – Broadcast
AFIS	Aerodrome Flight Information Service
AFISO	Aerodrome Flight Information Service Operator
AFP	Actual Flight Path
AGL	Above Ground Level
AIM	Aeronautical Information Management
ALRS	Alerting Service
AMSL	Above Mean Sea Level

Term	Definition
AOM	Airspace Organisation & Management
APM	Approach Path Monitor
APV	Approach Procedure with Vertical Guidance
ASI	Italian Space Agency
ATC	Air Traffic Control
ATCO	ATC Operator
ATM	Air Traffic Management
ATS	Air Traffic Service
CAA	Civil Aviation Authority
CFIT	Controlled Flight into Terrain
CHIPS	Swiss (CH) Implementation Programme SESAR
COTS	Commercial Off-The-Shelf
DA/H	Decision Altitude/Height
DBL	Deep Blue
DFP	Defined Flight Path
DOD	Detailed Operational Description
EASA	European Aviation Safety Agency
EGNOS	European Geostationary Navigation Overlay Service
EHA	European Helicopter Association
EHAC	European HEMS & Air Ambulance Committee
EM	ElectroMagnetic
EMC	ElectroMagnetic Compatibility
EMI	Electromagnetic Interference
ENAV	Ente Nazionale di Assistenza al Volo (the Italian Air Navigation Services Provider)
ENGM	Location indicator for Gardermoen airport
ENLX	Location indicator for Lørenskog heliport

Term	Definition
ENUH	Location indicator for Ullevål heliport
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology
ESSP	European Satellite Services Provider
FAF	Final Approach Fix
FCS	Flight Calibration Services
FFS	Full Flight Simulator
FHA	Functional Hazard Assessment
FIS	Flight Information Service
FISO	Flight Information Services Officer
FIZ	Flight Information Zone
FL	Flight Level
FMS	Flight Management System
FPDAM	Flight Procedure Design & Airspace Management
FPDO	Flight Procedure Design Organization
FPDO	Flight Procedure Design Organization
FPSAT	Flight Procedure Satellite Analysis Tool
FTE	Flight Technical Error
GBAS	Ground Based Augmentation System
GLS	GBAS Landing System
GNOME	GNSS Operative Monitoring Equipment
GNSS	Global Navigation Satellite System
GPA	Glide Path Angle
GPS	Global Positioning Satellite
HDOP	Horizontal Dilution of Precision
HEMS	Helicopter Emergency Medical Service
HF	Human Factor(s)

Term	Definition
HP	Human Performance
IAC	Instrument Approach Chart
ICAO	International Civil Aviation Organization
IDS	IDS Ingegneria Dei Sistemi S.p.A.
IFP	Instrumental Flight Procedure
IFPP	ICAO Instrument Flight Procedure Panel
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
KOM	Kick Off Meeting
KPA	Key Performance Area
KPI	Key Performance Indicator
LLR	Low Level IFR Routes
LPV	Localiser Performance with Vertical Guidance
LSHC	Location indicator for Chur hospital landing site
LSZS	Location indicator for Samedan airport
MA	Missed Approach
MC	Management Committee
MDA	Minimum Descent Altitude
METAR	Meteorological Terminal Air Report
MLS	Microwave Landing System
MTBF	Mean Time Between Failures
NLA	Norsk Luftambulanse
NSA	National Supervisory Authority
NSE	Navigation System Error
OAS	Obstacle Assessment Surfaces
OEI	One Engine Inoperative

Term	Definition
OEM	Original Equipment Manufacturer
OFA	Operational Focus Area
OI	Operational Improvement
OPS	Operations
OSED	Operational Service and Environment Definition
PBN	Performance Based Navigation
PC	Proficiency Check
PCM	Project Configuration Manager
PDG	Procedure Design Gradient
PinS	Point-in-Space
PM	Project Manager
PPR	Prior Permission Required
PQM	Project Quality Manager
PROuD	PBN Rotorcraft Operations under Demonstration
PSSA	Preliminary System Safety Assessment
QMS	Quality Management System
RAIM	Receiver Autonomous Integrity Monitoring
RF	Radius to Fix
RNAV	Area navigation
RNP	Required Navigation Performance
RNPAPCH	Required Navigation Performance Approach (navigation specification)
RNP AR APCH	Required Navigation Performance Authorisation Required Approach (navigation specification)
SA	Situational Awareness
SAM	Safety Assessment Methodology
SBAS	Satellite Based Augmentation System
SESAR	Single European Sky ATM Research Programme

Term	Definition
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SID	Standard Instrument Departures
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SKYGUIDE	Swiss air navigation services
SMS	Safety Management Service
SPO	Specialised Operations
SSA	System Safety Assessment
STAR	Standard Instrument Arrival
STC	Supplemental Type Certificate
SW	Software
SWIM	System Wide Information Management
TCAS	Traffic Collision Avoidance System
TSE	Total System Error
VDOP	Vertical Dilution of Precision
VFR	Visual Flight Rules
VIS	Visibility
VMC	Visual Meteorological Conditions
WAM	Wide Area Multilateration
WBS	Work Breakdown Structure
WP	Work Package
XLS	(x = G, I, M) includes GLS, ILS, MLS

2 Context of the Demonstrations

The PROuD project promoted the execution of a significant number of demonstration activities addressing the implementation of satellite based procedures for rotorcraft HEMS operations.

In this context the implementation of PBN IFR routes, approaches and departures tailored for helicopter operations was the right solution to overcome the existing limitations taking into account the maturity of key enablers, such as:

- RNAV navigation;
- GPS and EGNOS augmentation systems;
- ICAO Standards: ICAO Annex 14 Vol II, ICAO PANS-OPS 8168 Vol. II - Helicopter PinS procedures;
- High percentage of helicopter fleet certified for IFR operations;
- PBN (Performance Based Navigation) navigation specification intended for use by helicopters (e.g. RNP 0.3, RNP APCH).

The scope of the project was focused on:

- Implementation of IFR PinS departure and approach procedures based on GPS/EGNOS navigation;
- Link between IFR departure and approach segments based on GNSS and helicopter Low Level IFR Routes for a full IFR connection.

The PROuD project main objectives were:

- Demonstrate how helicopter PinS RNP APCH to LPV minima and RNP APCH AR approach procedures allow the implementation of IFR operations in small non-IFR airports/heliports located in challenging environment;
- Demonstrate how helicopter RNP PinS departure procedures allow the implementation of IFR operations in small non-IFR airports/heliports located in challenging environment;
- Demonstrate how helicopter PinS RNP APCH to LPV minima and RNP APCH AR approach procedures allow to overcome operational constraints in adverse meteorological conditions, in small not IFR airports and heliports, where precision facilities are not installed;
- Demonstrate how helicopter RNP PinS departures allow to overcome operational constraints in adverse meteorological conditions, in small non-IFR airports and heliports, where precision facilities are not installed;
- Demonstrate the operational benefits coming from the implementation of PinS RNP APCH to LPV minima and RNP APCH AR approach procedures, in small non-IFR airports and heliports;
- Demonstrate the operational benefits coming from the implementation of departure procedures based on GNSS, in small non-IFR airports and heliports;
- Evaluate the improvement in overall airspace usage, of heliport-to-hospital rotorcraft IFR flights, connecting the PinS departure and approach segments with the relevant en-route low level flight segments;
- Provide input to related SESAR/SESAR 2020 projects and initiatives focused rotorcraft operations;
- Contribute to the evolution and standardization of ICAO PANS OPS amendments for flight procedure design criteria for LPV PinS approach procedures (GPA > 6.3°);
- Contribute to adopt RNP 0.3 in all phases of flights (except on final approach segment for LPV/LP operation) and share the outcomes with other European RNP 0.3 implementation projects.

The above objectives have been demonstrated through the execution of the flight campaigns in Switzerland and in Norway.

2.1 Scope of the demonstration and complementarity with the SESAR Programme

The scope of the demonstration is encompassing flight trials organized as follows:

- A set of flight trials (approximately 60) executed in Switzerland, encompassing flight trials for:
  - validation of newly designed procedures for Low Level IFR Routes, PinS approach and PinS departure and helicopter RNP AR APCH,
  - operational flights of the validated flight procedures,
  - simulated IFR flights in VFR/VMC for heliport-to-hospital demonstrations (Note that in PROuD context, simulated IFR in VFR/VMC means that the flight trials will execute IFR procedures in VFR/VMC conditions);
- A set of flight trials (28) executed in Norway, encompassing flight trials for:
  - validation of newly designed procedures for PinS departure, STAR and PinS approaches,
  - operational flights of the validated flight procedures,
  - additional operational IFR flights executed for HEMS procedures in the project lifetime and contributing to the set of demonstrations of the project.

The benefits of implementing rotorcraft IFR PinS departure and approach procedures have been evaluated, including their connection with Low Level IFR Routes for a fully improved IFR heliport-to-hospital flight.

In the scope of the project demonstrations PinS RNP APCH to LPV minima procedures, using SBAS (EGNOS) augmentation, have been designed and flown in Chur, Lørenskog and Ullevål.

SBAS vertical guidance allows a precise height control throughout the final descent and the reduction of the risk of collision with terrain (CFIT), particularly at night and/or in adverse weather conditions.

Moreover, with steep approach procedures (up to 6.3°), it is easier to fulfil the required obstacle clearance in the final approach segment through the adoption of SBAS Obstacle Assessment Surfaces (OAS). Indeed, these procedures are similar to those used for ILS approaches, especially in obstacle rich environments.

Due to extremely challenging environment, in Samedan airport, helicopter RNP AR APCH procedure have been designed and flown.

As shown in Figure 1, the following types of approach procedures have been addressed within the PROuD project:

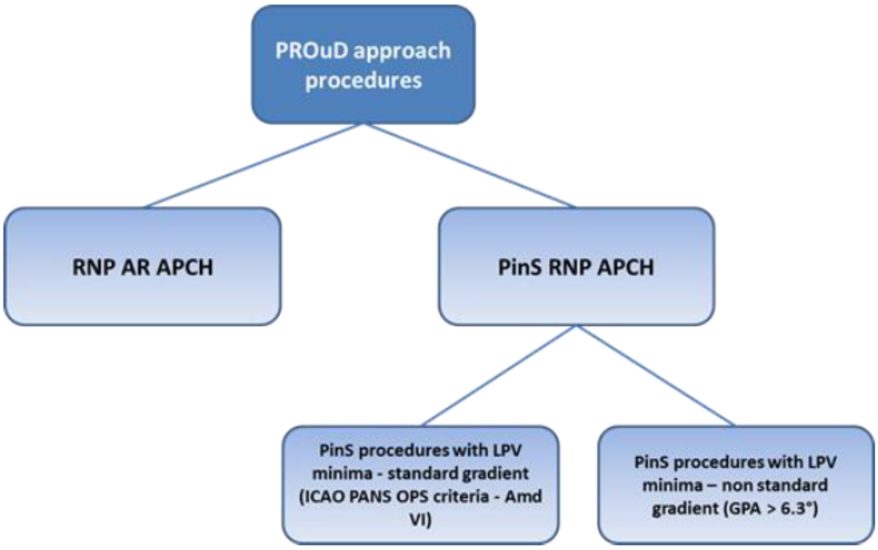


Figure 1: PROuD PinS approach procedures

The following tables summarise the relevant information for each exercise, including the reference to operational concepts, SESAR OFAs and capabilities that will be evaluated in the scope of the listed PROuD demonstration exercises:

Demonstration Exercise ID and Title	EXE-02.09-D-001 : RNP AR APCH procedure at Samedan airport
Leading organization	Rega
Demonstration exercise objectives	Assess the benefits coming from the implementation of RNP AR APCH procedure at Samedan Airport, through demonstration flights performed by an AW109SP helicopter.
OFA addressed	OFA02.01.01: Optimised 2D/3D Routes ENB01.01.04: Navigation
Applicable Operational Context	Introduction of RNP AR APCH with RNP navigation accuracy requirement of 0.1 NM along the initial, intermediate and final segments: • Class G airspace with local AFIS; • High terrain surrounding the landing location; • Nominal traffic scenario; • Day operation; • VFR/VMC conditions; • Phases of flight: initial, intermediate and final approach segments.
Demonstration Technique	Live trials, real-time simulations
Number of trials	14 flights (first campaign) and 11 flights (second campaign) using the helicopter and 2 flights using the FFS

Table 1: EXE-02.09-D-001 overview

Demonstration Exercise ID and Title	EXE-02.09-D-002: PinS non-standard[1] departure at Samedan airport
Leading organization	Rega
Demonstration exercise objectives	Assess the operational benefits coming from the implementation of PinS non-standard departure procedure with RNP 0.3 based on EGNOS at Samedan Airport, through demonstration flights performed by AW109SP helicopter.(The term non-standard has been inserted as in the design of the PinS procedure the secondary protection area was not considered in order to reduce the resulting procedure design gradient)..
OFA addressed	OFA02.01.01: Optimised 2D/3D Routes ENB01.01.04: Navigation
Applicable Operational Context	Introduction of PinS non-standard departure based on RNP 0.3 in: • Class G airspace with local AFIS • High terrain surrounding the departure location • Nominal traffic scenario • Day operation • VFR/VMC conditions • Phases of flight: departure
Demonstration Technique	Live trials, real-time simulations
Number of trials	13 flights using the Helicopter and 2 flights using the FFS

Table 2: EXE-02.09-D-002 overview

[1] See definition of “non-standard” term in “PinS non-standard departure” section in par. 4.1.2.1.1.1

Demonstration Exercise ID and Title	**EXE-02.09-D-003: Heliport-to-hospital connection in Switzerland**
Leading organization	Rega
Demonstration exercise objectives	Assess the operational benefits coming from the implementation of heliport-to-hospital rotorcraft IFR operations, connecting the PinS departure and approach segments with the relevant low level routes.
OFA addressed	OFA02.01.01: Optimised 2D/3D Routes ENB01.01.04: Navigation
Applicable Operational Context	Departure from Samedan airport for HEMS mission to the Trauma Centre in Chur and back to the Rega Base in VFR/VMC condition. Introduction of heliport-to-hospital connection in: • Class G airspace with local AFIS • LFN in airspace Echo • High terrain surrounding the departure location • Nominal traffic scenario • Day operation • VFR/VMC conditions • Phases of flight: departure, en-route, approach, landing
Demonstration Technique	Live trials, real-time simulations
Number of trials	12 flights using the Helicopter and 2 flights using the FFS

Table 3: EXE-02.09-D-003 overview

Demonstration Exercise ID and Title	EXE-02.09-D-004: PinS RNP APCH to LPV minima at Lørenskog heliport
Leading organization	NLA
Demonstration exercise objectives	Assess the benefits of the implementation of the PinS RNP APCH to LPV minima with GPA < 6.3° at Lørenskog heliport.
OFA addressed	OFA02.01.01: Optimised 2D/3D Routes ENB01.01.04: Navigation
Applicable Operational Context	Introduction of PinS RNP APCH to LVP minima along the final segment: • Class G airspace with AFIS; • Nominal traffic with dense GA-traffic from time to time; • Day operations; • IFR/IMC, VFR/VMC and PinS approach with LPV minima; • Continental artic type of climate; • Phase of flight: approach and STAR.
Demonstration Technique	Live trials
Number of trials	11

Table 4: EXE-02.09-D-004 overview

Demonstration Exercise ID and Title	EXE-02.09-D-005: PinS departure at Lørenskog heliport
Leading organization	NLA
Demonstration exercise objectives	Assess the operational benefits coming from the implementation of PinS standard departure procedure with RNP 0.3.
OFA addressed	OFA02.01.01: Optimised 2D/3D Routes ENB01.01.04: Navigation
Applicable Operational Context	Introduction of PinS departure with RNP 0.3 navigation specification: • Class G airspace; • Nominal traffic with dense GA-traffic from time to time; • Day operations; • IFR/IMC, VFR/VMC and PinS departure from Non IFR heliport • Continental artic type of climate; • Phase of flight: departure
Demonstration Technique	Live trials
Number of trials	6

Table 5: EXE-02.09-D-005 overview

Demonstration Exercise ID and Title	EXE-02.09-D-006: PinS RNP APCH to LPV minima at Ullevål heliport
Leading organization	NLA
Demonstration exercise objectives	Assess the benefits of the implementation of the PinS RNP APCH to LPV minima with GPA < 6.3° at Ullevål heliport.
OFA addressed	OFA02.01.01: Optimised 2D/3D Routes ENB01.01.04: Navigation
Applicable Operational Context	Introduction of PinS RNP APCH to LPV minima in: • Class G airspace with local frequency for traffic information; • High terrain surrounding the landing location; • Nominal traffic scenario; • Day operation; • VFR/VMC conditions; • Phases of flight: approach and STAR.
Demonstration Technique	Live trials
Number of trials	11

Table 6: EXE-02.09-D-006 overview

Demonstration Exercise ID and Title	EXE-02.09-D-007: PinS RNP APCH to LPV minima at Chur hospital
Leading organization	Rega
Demonstration exercise objectives	Assess the operational benefits of PinS RNP APCH approach procedures to LPV minimum with non-standard gradient (GPA>6.3°) for final segment and RNP0.3 navigation specification for initial, intermediate and missed approach segments, on VFR hospital landing sites, in critical environment.
OFA addressed	OFA02.01.01: Optimised 2D/3D Routes ENB01.01.04: Navigation
Applicable Operational Context	Introduction of PinS RNP APCH to LPV minima procedure and adoption of RNP 0.3 navigation specification in: • Class G airspace with local AFIS • High terrain surrounding the landing location • Nominal traffic scenario • Day operation • VFR/VMC conditions • Phases of flight: approach
Demonstration Technique	Live trials, real-time simulations
Number of trials	11 flights using the helicopter and 2 flights using the FFS

Table 7: EXE-02.09-D-007 overview

Demonstration Exercise ID and Title	EXE-02.09-D-008: PinS standard departure at CHUR hospital
Leading organization	Rega
Demonstration exercise objectives	Assess the operational benefits coming from the implementation of PinS departure procedure with RNP 0.3 in critical environment.
OFA addressed	OFA02.01.01: Optimised 2D/3D Routes ENB01.01.04: Navigation
Applicable Operational Context	Introduction of PinS departure based on RNP0.3 navigation specification in: • Class G airspace • High terrain surrounding the departure location • Nominal traffic scenario • Day operation • VFR/VMC conditions • Phases of flight: departure
Demonstration Technique	Live trials, real-time simulations
Number of trials	8 flights using the helicopter and 2 flights using the FFS

Table 8: EXE-02.09-D-008 overview

The PROuD Project falls in the scope of the research activities promoted by SESAR JU and the SESAR relevant Operational Focus Area linked to this project is OFA02.01.01 – Optimised 2D/3D Routes. The primary project identified as relevant for the project activities is P04.10 – GA and Rotorcraft Operations. The PROuD project is also linked to the Navigation enabler ENB01.01.04 – Navigation (see Chapter 2 of Demonstration Plan for details).

As "Airspace Organisation & Management" (AOM) SESAR OI Steps (see eATM Portal - https://www.atmmasterplan.eu/data/oi_steps), the following improvements have been addressed in PROuD project initially:

- AOM-0604 – Enhanced terminal operations with LPV using SBAS
- AOM-0605 – Enhanced terminal operations with automatic RNP transition to XLS/LPV

Furthermore, more specific AOM operational improvements have been defined for rotorcraft operations during PROuD lifecycle and therefore they have been addressed by PROuD project:

- AOM-0104 – Enhanced Rotorcraft Operations at VFR FATOs with specific Point-in-Space RNP procedures using satellite augmentation
- AOM-0810 – Integration into the TMA route structure of optimised Low Level IFR route network for rotorcraft using RNP-1/RNP-0.3

The outcomes of PROuD project can provide an input to the projects/solutions that will focus on rotorcraft advanced operations in the context of SESAR 2020.

3 Programme management

3.1 Organisation

3.1.1 PROuD Consortium

The members of the PROuD Consortium are IDS Ingegneria Dei Sistemi S.p.A (IDS), Swiss Air-Rescue Rega, Norsk Luftambulanse (NLA), Skyguide and Deep Blue (DBL).

Industry	Rotorcraft Operators	ANSP	Research and Consultancy Firm
IDS S.p.A.	Swiss Air-Rescue Rega Norsk Luftambulanse	Skyguide	Deep Blue

IDS Ingegneria Dei Sistemi S.p.A will act as Consortium coordinator. IDS will be responsible for the Project Management. From the technical point of view, IDS will take care of the helicopter RNP procedures, exploiting its experience in flight procedure design. Indeed, IDS service department received in 2012 the endorsement in Flight Procedure Design Organization by ICAO.

Swiss Air-Rescue Rega is a private foundation on the basis of a non-for-profit organisation and the main HEMS operator in Switzerland. The organisation has been founded in 1952 and is supported by more than 3.3m people representing more than 40% of the population. More than 11,000 missions are conducted per year on the 17 dedicated HEMS helicopters from 12 bases throughout the country. In 2014, the entire AgustaWestland AW109SP helicopter fleet has been upgraded with LPV capability. In this proposal, Rega is taking the role of the HEMS Operator. Rega will take care of the ground and flight procedure validation, the avionics DB preparation in close collaboration with Jeppesen, and when necessary request the permit to fly with assistance of its own Part 21 DOA, plan and execute the flight campaign and support the flight data collection with the access to the dedicated helicopter flight inspection kit.

Norsk Luftambulanse is a helicopter operator in Norway since 1978. Today they operate 9 helicopters on a state financed contract providing HEMS operation as a part of the Norwegian health care system. NLA was recently awarded the next EMS contract supporting the Norwegian population with helicopter emergency medical support for the period 2018 – 2024/28.

Skyguide, as the Swiss Air Navigation Services Provider, will provide ANS expertise in the domains of PANS-OPS procedures design and validation, CNS engineering, ATM expertise, safety assessment of ATM aspects and air traffic control.

Deep Blue is an Italian research and consultancy company bringing in the project the long term experience on safety, performance analysis and dissemination proven also through the involvement in the SESAR Programme on these transversal areas. Deep Blue (DBL) will be responsible for communication management and for the planning and execution of human performance and safety assessment. Moreover, DBL will lead the tasks assigned to data analysis and reporting.

The percentage of contribution for each partner, based on the effort/budget allocation is represented in the following pie-chart.

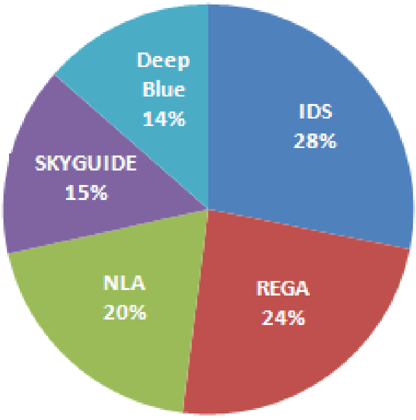


Figure 2: Consortium composition

3.1.2 PROuD Management Structure

The following section details the PROuD management monitoring and control approach and procedures and shows the adequacy of the PROuD team and resources towards effectively meeting the project's objectives. The Project Management structure is depicted in the figure below, which shows also the interfaces amongst the bodies involved.

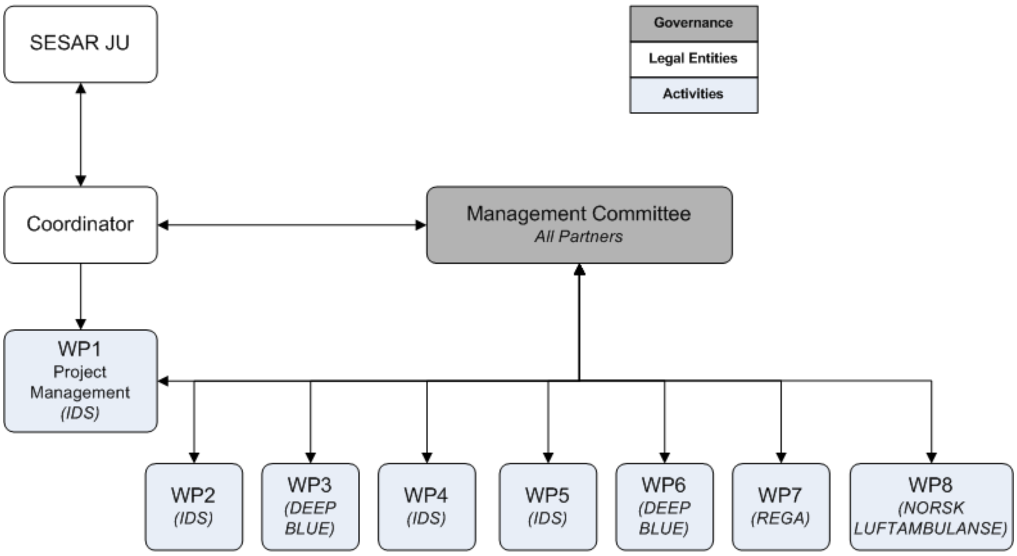


Figure 3: Project Management bodies and interfaces

This above logical view of the project management bodies and interfaces presents the main interactions for coordination within the project:

- The Consortium coordinator (PROuD Project Manager) acts as interface towards SESAR JU, for reporting, escalation, information;
- The Management Committee, as already presented above, is established at the beginning of the project and composed by one representative each partner and it represents the management board of the PROuD Consortium;
- Each work package has a clear leadership as well as each task in the work packages, to ensure coordination of the project activities also at lower level.

The Project is built on the following logical phases represented by specific WPs for the operational, technical and demonstration activities:

- WP2: Demonstration Planning and Reporting
- WP4: Facilities Adaptations
- WP5: Procedure Design and Validation
- WP6: Safety Assessment
- WP7: Demonstration Flight Campaign (Switzerland)
- WP8: Demonstration Flight Campaign (Norway)

WP1 (Project Management) and WP3 (Communication) are dedicated respectively to Project Management and Communication, therefore they will be ongoing for the full project lifetime and will be dependent by the technical results but will not affect their start/end, although if not performed adequately, might affect the project results and visibility.

The Project will be managed through a set of roles and corresponding responsibilities to be entrusted to key people selected on purpose by each Consortium member.

Considering that PROuD Consortium is made of five partners, a simplified, but effective, management structure will be set up.

The **Management Committee** (MC) comprises the Project Manager and one representative of each Consortium Member. They will be empowered to make decisions on behalf of their organisation regarding all the aspects of the project implementation. Due to the project size and the limited number of partners and with the objective of simplifying the management structure, the MC will accomplish the task of General Assembly and Executive Board, having the role of managing the high level decision and of providing operational support to the project management. MC formally meets every six months and it is a Coordinator duty to organise the meetings and prepare the agenda. Extraordinary meetings can be called by the Coordinator or by one of the partners. The MC will be chaired by the Project Manager.

The **Coordinator** is the legal entity responsible for the overall planning of the work and for managing the Co-Financing Agreement. It represents the consortium and is the single point of contact with the SESAR JU. The operational duties of Coordination are assigned to the Project Manager.

The **Project Manager** is appointed by the Coordinator. Assisted by the Management Committee, will implement and is responsible for the following tasks:

- Coordinating the project activities;
- Monitoring the progress of the work;
- Facilitating communications among the consortium members;
- Managing risks and identifying mitigation actions;
- Solving issues;
- Organising and leading meetings;
- Acting as contact point for the SESAR JU and relevant Consortium members, providing all the necessary information about technical and financial issues and being intermediary between the JU and the Consortium;
- Deliveries control and internal approval before submission to SESAR JU;
- Fulfilling of time, resources and budget constraints;
- Maintaining project configuration.

A **Project Configuration Manager (PCM)** will also be appointed for this project. The PCM will be responsible for the Configuration Management of the Project ensuring:

- establishment of the correct deliverables baseline;
- formal control of changes to the configuration items;
- maintenance of the configuration libraries;
- supporting internal and external audits;
- maintaining identification and traceability of the project Configuration Items.

In the frame of this project, the PCM, functionally dependents from the Project Manager and provides interface towards Project Quality Manager and Technical organization.

The Member Representative in the Management Committee is appointed by each partner and will take care of the implementation of the tasks under the relevant Partner responsibility. She/he will also be empowered to take decision inside the MC. Work Package implementation will be coordinated by one of the partners' representative, acting as Work Package Leader and providing the technical roadmap, being responsible for monitoring and stimulating the WP implementation.

The work package leader will provide all the necessary information to the Project Manager to let her/him has a clear overview of the progress of work. Beside formal information provided by progress reports, frequent informal communication will be maintained by e-mail, phone conversation or meetings.

The **Project Quality Manager (PQM)** is a representative of the IDS Quality and Safety Department will be overall responsible to assure the execution of all quality assurance tasks and to implement and verify compliance with all quality procedures related to the project. The PQM will also control the correct application of the standards, procedures, methods within the project, in compliance to the expected level of Quality.

The PQM supports the Configuration Management activities with the:

- Preparation, implementation and maintenance of specific Configuration Management Plan;
- Configuration audit execution.

A **Communication Manager,** appointed by the Consortium Leader, will be responsible for the definition of a detailed Communication Plan and to ensure that all communication activities are conducted effectively and ensure high visibility to the project. In coordination with the Project Manager and relevant key personnel of each Consortium member, she/he will implement the defined communication strategy, verify internally the production of all communication material and the support to all planned dissemination/communication events.

3.2 Work Breakdown Structure

The Work Breakdown structure of the project shows all required activities and it is also the base for identifying clearly the contribution of each Consortium Member reflecting specific competences on each activity.

The high level view of the WBS is presented below, where the work packages and tasks decomposition is identified.

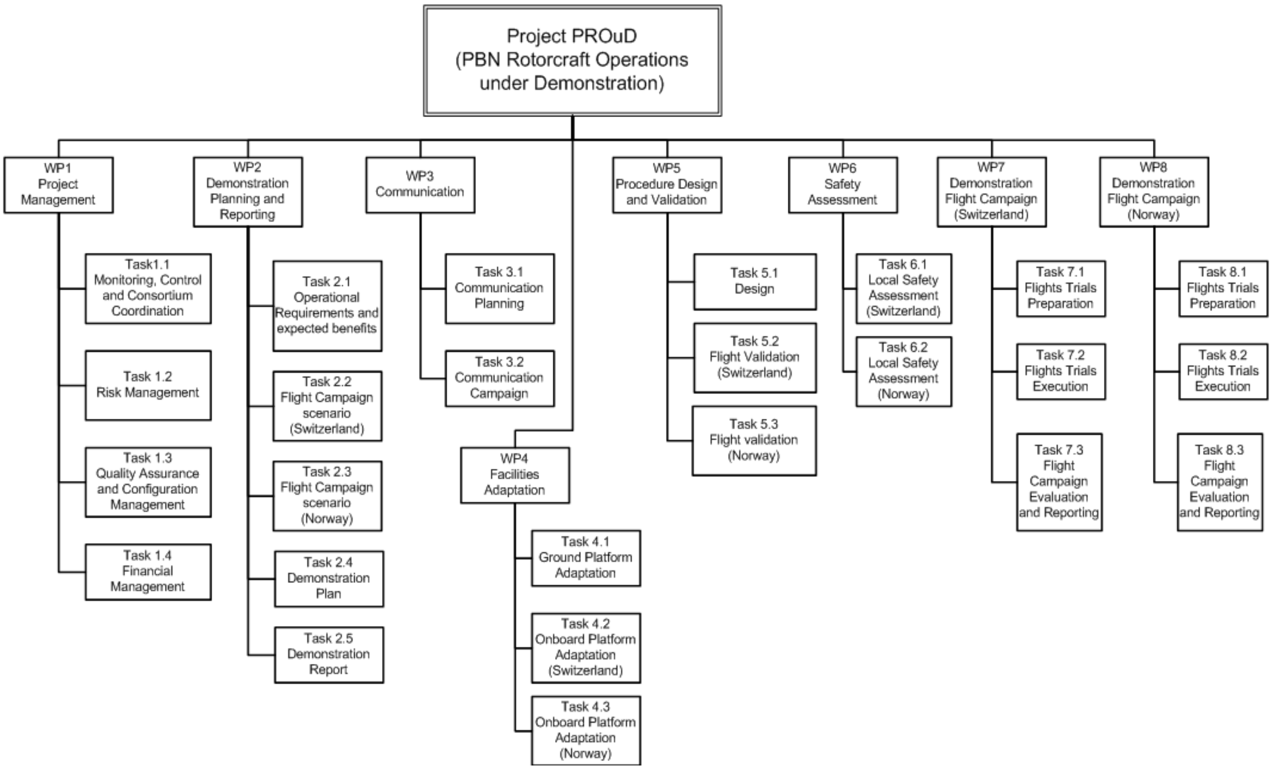


Figure 4: PROuD work breakdown structure

Each task is led by a single Partner, responsible for the timely conduction of all the tasks activities and for the production of the associated expected output. Depending on the competences all Members of the Consortium will be involved as contributors to relevant tasks, where they are not acting as Leader.

The following table provides, for each task in the WBS, the role undertaken by the Consortium members:

Task ID	IDS	REGA	NORSK LUFTAMBULANSE	SKYGUIDE	DEEP BLUE
WP1 Project Management					
1.1	L	C	C	C	C
1.2	L	C	C	C	C
1.3	L				
1.4	L				
WP2 Demonstration Planning and Reporting					
2.1	L	C	C	C	C
2.2	C	L		C	
2.3	C		L		
2.4	L	C	C	C	C
2.5	L	C	C	C	C
WP3 Communication					
3.1	C	C	C	C	L
3.2	C	C	C	C	L
WP4 Facilities Adaptations					
4.1	L	C		C	
4.2		L			
4.3	C		L		
WP5 Procedure Design and Validation					
5.1	L	C	C	C	
5.2	C	L		C	
5.3	C		L		
WP6 Safety Assessment					
6.1	C	C		L	C
6.2	C		L		C
WP7 Demonstration Flight Campaign (Switzerland)					
7.1		L		C	C
7.2	C	L		C	C
7.3	C	C		C	L
WP8 Demonstration Flight Campaign (Norway)					
8.1			L		C
8.2	C		L		C
8.3	C		C		L

Table 9: Company roles in PROuD WBS tasks

3.3 Deliverables

The main Milestones of the project, corresponding to the official release dates of the main project deliverables, are presented in the following table:

Deliverable name	Date
D01 (Ed.00.01.00) – Demonstration Plan 1st release	20 November 2014
D01 (Ed.00.02.00) – Demonstration Plan 2nd release	20 March 2015
D02 – Demonstration Report (B1)	06 September 2016

Table 10: Formal Deliverables

3.4 Risk Management

Risk management is managed and maintained always up to date on the extranet RIO page on LSD.02.09 PROuD.

4 Execution of Demonstration Exercises

4.1 Exercises Preparation

Several activities have been performed to prepare the flight trials, both for the Swiss and the Norwegian campaign. Some activities aimed at assuring measurement of the determined metrics and indicators and other were carried out for the configuration of the V&V platforms, systems and tools installed inside the environment.
The following main activities have been conducted before the execution of the trials, in order to contribute to the evaluation of the demonstration objectives. The main activities that have been conducted before, in order to contribute to the evaluation of the demonstration objectives, are:

- Local Safety Assessment (WP 6);
- Flight Procedures Design and Validation (WP 5);
- Data acquisition tools preparation (WP 4).

More detailed information is provided in the following paragraphs. Furthermore additional activities have been performed:

- Coordination between ATS units:

  A proper coordination between all the involved stakeholders was set up in order to guarantee the necessary coordination with the ATS units involved during flight trial execution (e.g. AFIS units).

- Procedure preparation:
  - Preparation and fulfilment of an in-house HEMS Helicopter Operator safety analysis;
  - Preparation of timely briefing for all participants for the flight validation trial (e.g. airport staff, procedure designer, regulators, flight crew) and flight validation execution plan;
  - Reservation and preparation of the installation of the dedicated flight inspection kit in the helicopter.
- Pilot training:
  - Training of pilots with full flight simulator (Swiss cases).

4.1.1 Local Safety Assessment

The goal of the safety assessments was to demonstrate that the safety level of the flight trials themselves would be acceptable, i.e. there would not be an increase of risk with respect to current operations, which are considered to be safe. Such a demonstration was a mandatory pre-requisite for the conduction of the flight trials.

Given that goal, the Norwegian and Swiss safety assessments have been focused only on risks and mitigations related to the conduction of simulated IFR flights trials in the specific identified sites.

All risks related to VFR/VMC flights have been already addressed, as current operations are safely conducted. Therefore the focus of the safety assessments was mainly on the phases of the flights affected by a change in roles, flight procedures, routes and equipment used with respect to current operations.

The safety assessment included the following activities:

1. Review of existing relevant international standards and documentation for what concerns common hazards and safety requirements;
2. Local Safety Assessments workshops
   a. Identification of hazards for safety with the involvement of subject matter experts (i.e. operational, technical, safety and human factors experts) to identify and classify hazards specific to the PROuD operational scenarios (Switzerland and Norway);

b. Definition of mitigation means, in terms of equipment, procedures, human performance and training solutions for:

   i. hazard prevention and

   ii. hazard effect mitigation and recovery;

3. Collation of the locally identified mitigation means and safety requirements with those gathered during the literature review;

4. Verification of SRs (just first part of SSA).

A brief description of these activities is provided in the following paragraphs.

Activity 2 (Hazards and mitigation means) is based on the EUROCONTROL Safety Assessment Methodology. This methodology encompasses three different phases, as illustrated in Figure 5.

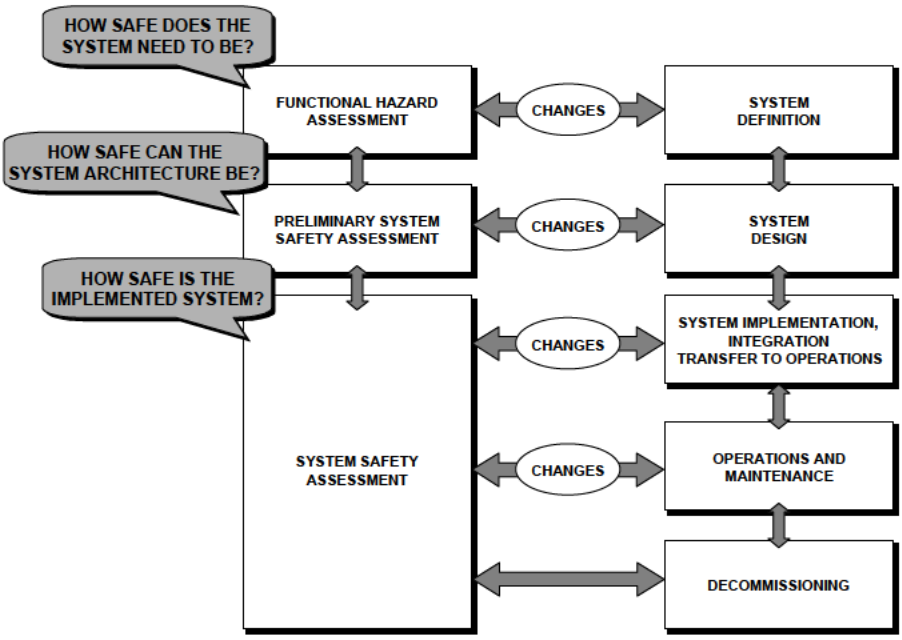


Figure 5: Relationships between the Safety Assessment Process and the Overall System Life Cycle (from “EUROCONTROL Air Navigation System Safety Assessment Methodology” [15])

Three phases are identified by SAM:

Functional Hazard Assessment (FHA): aimed at determining how safe the system needs to be. The process identifies potential failures modes and hazards. It assesses the consequences of their occurrences on the safety of operations, including aircraft operations, within a specified operational environment. For each hazard likelihood and severity are assigned. The most important output of this phase is the identification of the safety objectives of the hazards, i.e. the maximum tolerable likelihood for those hazards to occur.

Preliminary System Safety Assessment (PSSA): it is a step performed during the design of the system and it aims at deriving safety requirements, which are characteristics (related to design, performance etc.) that equipment, procedures or people’s performance will have to feature in order to ensure that the *safety objectives* will be met. Safety requirements can be qualitative or quantitative; prescribing specific training modules the personnel involved in the new system will have to take or defining in numbers the expected reliability of a piece of equipment.

System Safety Assessment (SSA): the objective of performing a SSA is to demonstrate that:

- the new system as practically implemented achieves an acceptable risk;
- it satisfies the safety objectives specified in the FHA and;

- the system elements meet their Safety Requirements specified in the PSSA.

As PinS IFR procedures, currently defined in ICAO PANS-OPS and considered in PROuD, have reached the V3 maturity level of the concept lifecycle (as defined in the E-OCVM), the SAM phases applicable in the project are FHA and PSSA, as transfer in operations and maintenance are not addressed by PROuD. SSA will be only partially addressed as verification that safety requirements will be addressed before flight trials begin.

Moreover, taking into consideration the level of maturity of the technologies (already existing and used), the information already available, pilots experience in the use of similar procedures in different contexts and practical and logistic reasons, we proposed the use of a methodology already used in several safety assessments activities in similar projects, that merges and simplifies the FHA and PSSA phases, performing one unique session (a workshop) in which subject matter experts are supported and guided by Safety experts into the identification of hazards, their severity assessments and the definition of mitigations means.

For the identification of the hazards and to assure that the relevant hazards are correctly identified and addressed, two techniques have been used. As suggested in the SAM guidance material, the identification of hazards requires a combination of at least two complementary approaches:

- A functional approach: consider the various way in which each individual function of the system under analysis can fail;
- A brainstorming approach: brainstorming session to look for “functionally unimaginable” hazards by assessing normal, abnormal and particular combination of unrelated event scenarios.

These approaches have been both used during the workshop at NLA facilities in Oslo on April 2015 for the Norwegian Local Safety Assessment and at the Rega facilities in Zurich in May 2015 for the Swiss Local Safety Assessment.

The aim of the workshop was to encourage a group of domain experts with different backgrounds – both operational and technical – in brainstorming about possible hazardous situations related to the system under assessment in specific operational scenarios.

This kind of analysis allowed particularly the operational experts to reason in terms of their concrete experiences with situations potentially challenging, rather than in the abstract and logical terms of a functional analysis.

The elements taken into consideration are not only the technical components of the system and their possible failures, but also the other contextual factors affecting the system performance, such as the specific geographical characteristics of the area, the airspace configuration, the runway design, the typical traffic flows, the working methods and procedures adopted, etc. The hazards caused by possible critical interactions between these elements are better envisaged if the operational expertise is adequately conveyed into the discussion by means of representation of realistic operational scenarios.

During the brainstorming sessions of the FHA workshop the attendants have been asked to identify possible hazards which potentially could occur in the PROuD scenarios, as well as in others. The possibility to focus the attention each time on the representation of a specific situation helped the participants in having a shared representation of the hazards discussed, taking into account the combination of local and contextual factors.

At the end of the workshop, all the data have been collected, further analysed and added to a Local Safety Assessment document which explains in depth the process that has been used and the results that have been gathered.

The Swiss and Norwegian Local Safety Assessments can be found in Appendix E and Appendix F respectively.

4.1.2 Flight Procedures Design and Validation

Within the PROuD project, the following list of the preparatory activities related to design and validation activities have been performed:

- Input data and operational requirements collection:
  - No ad-hoc survey has been used. Aeronautical Data and Metadata acquisition and import into the design environment: DTM/DSM, Airport/Heliport data, Obstacle data, ATS environment, other data/information;
  - Definition of the operational requirements for the design of the procedure.

- Landing site assessment and new procedures design:
  - Obstacle and terrain surfaces modelling and assessment for landing site suitability verification to support IFR procedures;
  - Design of procedures.

- Flight Procedure Ground Validation and avionic database preparation:
  - Verification of accuracy of the data used for flight procedure design;
  - Verification of the correct application of ICAO PANS-OPS criteria for flight procedure design;
  - Full flight simulations (Swiss cases) for flight procedure flyability assessment;
  - Navigation DB Preparation and upload on the FMS.

The procedures reported in the table below have been designed Within the PROuD project. Reference of each procedure to the scenario and exercise is traced.

PROuD Procedure	Scenario	Exercise
RNP AR APCH at Samedan airport	Samedan airport (SCN-0209-001)	EXE-02.09-D-001
PinS “non-standard” departure at Samedan airport	Samedan airport (SCN-0209-001)	EXE-02.09-D-002
Low level IFR route between Chur and Samedan	Samedan/Chur airport to hospital (SCN-0209-002)	EXE-02.09-D-003
PinS RNP APCH to LPV minimum at Chur hospital	Chur hospital (SCN-0209-005)	EXE-02.09-D-007
PinS departure at Chur hospital	Chur hospital (SCN-0209-005)	EXE-02.09-D-008
PinS RNP APCH to LPV minima at Lørenskog heliport	Lørenskog heliport (SCN-0209-003)	EXE-02.09-D-004
PinS departure at Lørenskog heliport	Lørenskog heliport (SCN-0209-003)	EXE-02.09-D-005
PinS RNP APCH to LPV minima at Ullevål heliport	Ullevål heliport (SCN-0209-004)	EXE-02.09-D-006

Table 11: PROuD procedures and related scenario and exercise

4.1.2.1 Flight Procedures Design & Validation

The flight procedure design has been performed in compliance with ICAO PANS-OPS criteria, with some exceptions as highlighted in the following paragraphs. The main output of the procedure design activities are:

- Flight procedure chart;
- Submission form;
- Procedure coding and packing for upload on FMS;
- FAS data block, only for PinS approach with LPV minima (supported by EGNOS).

The following sections report the final charts approved by the partners. All the procedures have been flown during the flight trials.

4.1.2.1.1 Swiss procedures

4.1.2.1.1.1 Samedan airport

RNP AR APCH – produced for the first campaign

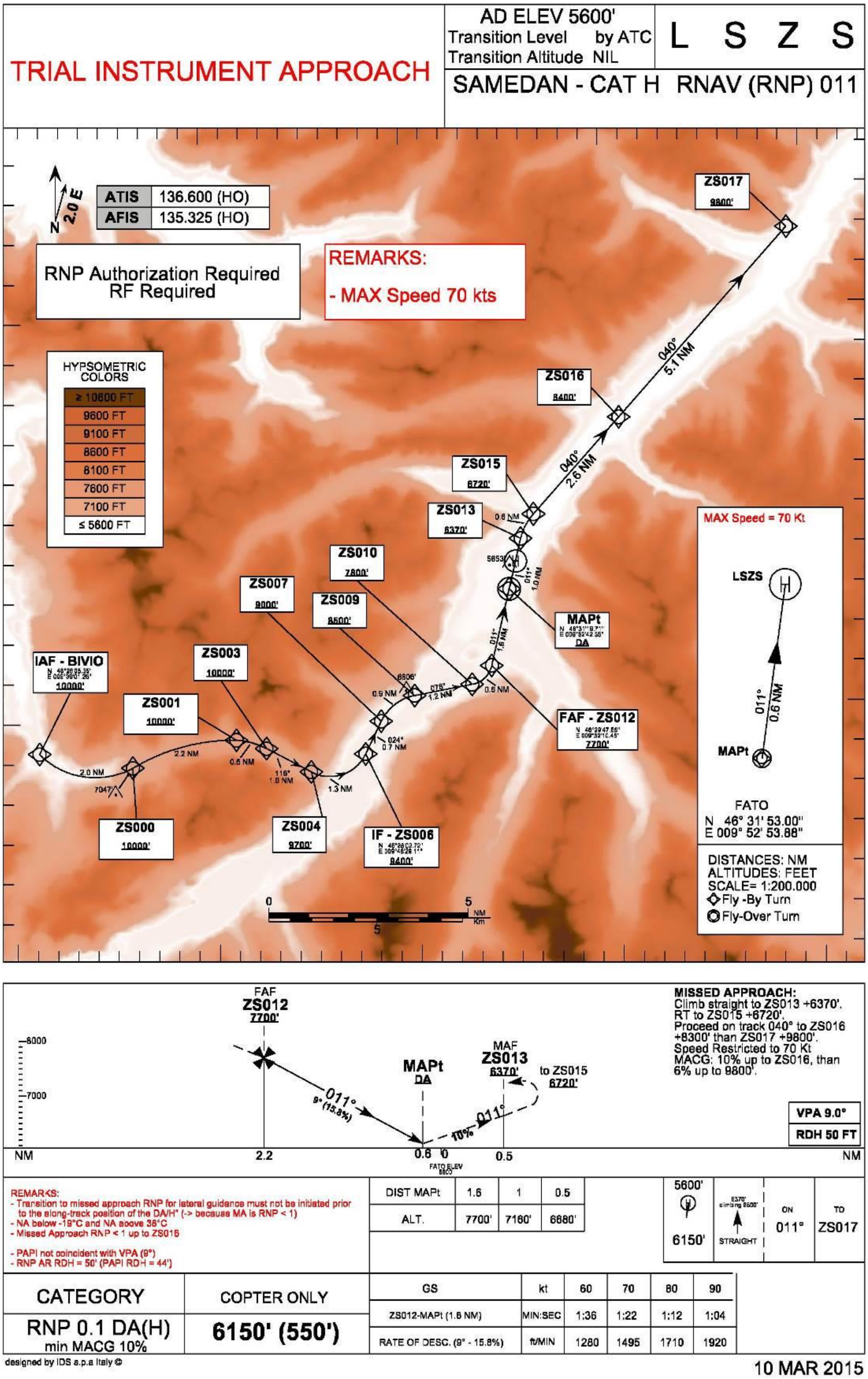


Figure 6: RNAV (RNP) 011 - Samedan

The RNAV (RNP) 011 procedure has been designed following the RNP AR criteria (ICAO Doc. 9905) for the initial, intermediate, final and the missed approach segments. The missed approach segment starts with RNP 0.1 (final RNP value) and it presents a transition to RNP 1.0 passing through RNP 0.3 in order to be compliant with §4.6.7 [12]. Since a turn is required in order to avoid obstacles, a different construction technique has been considered and adopted reducing the MAS lateral accuracy (RNP) values below 1.0. The compliance of missed approach segment to design criteria defined above, especially for RNP 1.0 transition, had an impact on the procedure minima and the missed approach climb gradient.

RNAV (RNP) RWY 21 - produced for the second campaign

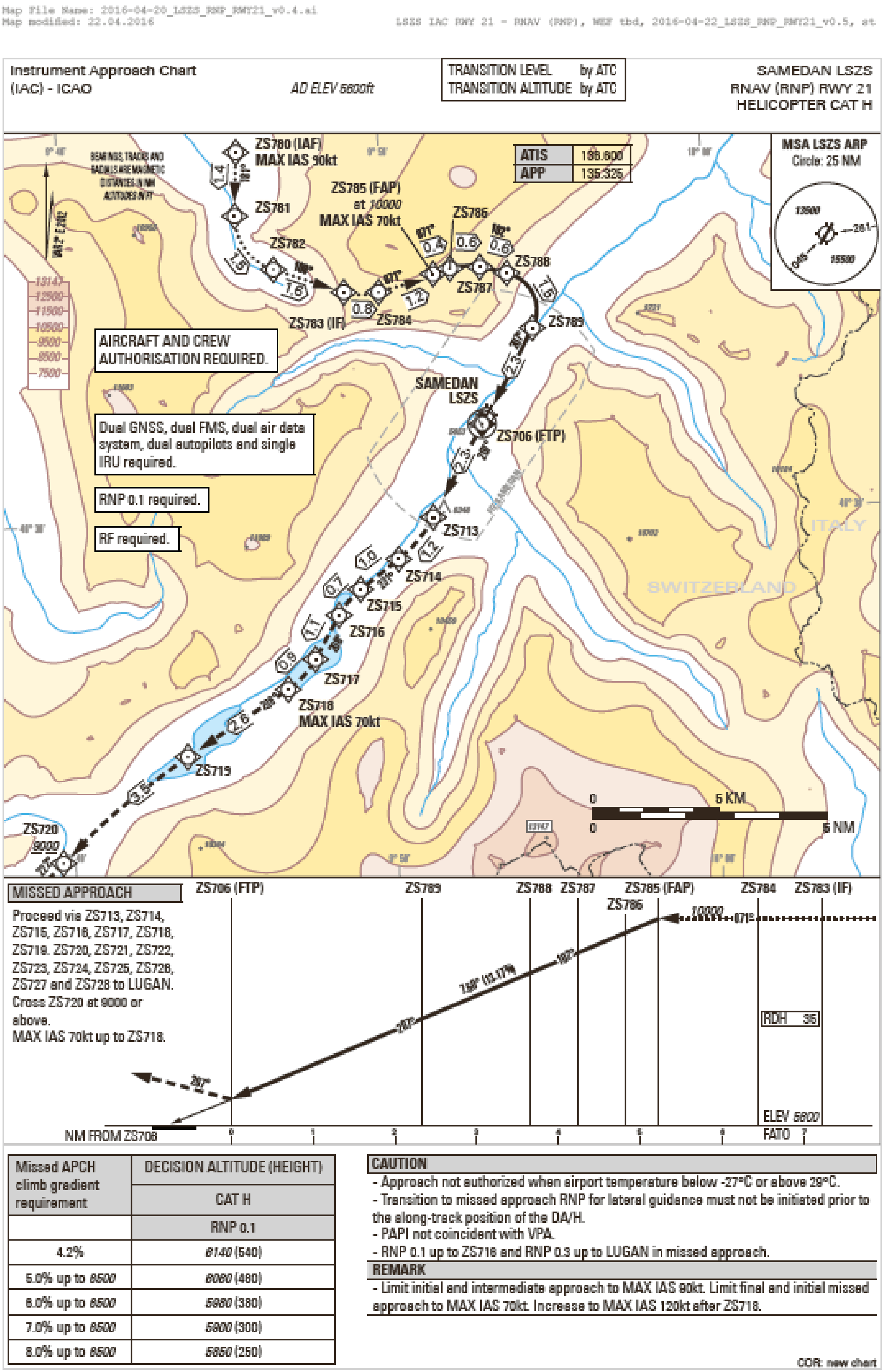


Figure 7: RNAV (RNP) RWY 21 - Samedan

RNAV (RNP) RWY 03 - produced for the second campaign

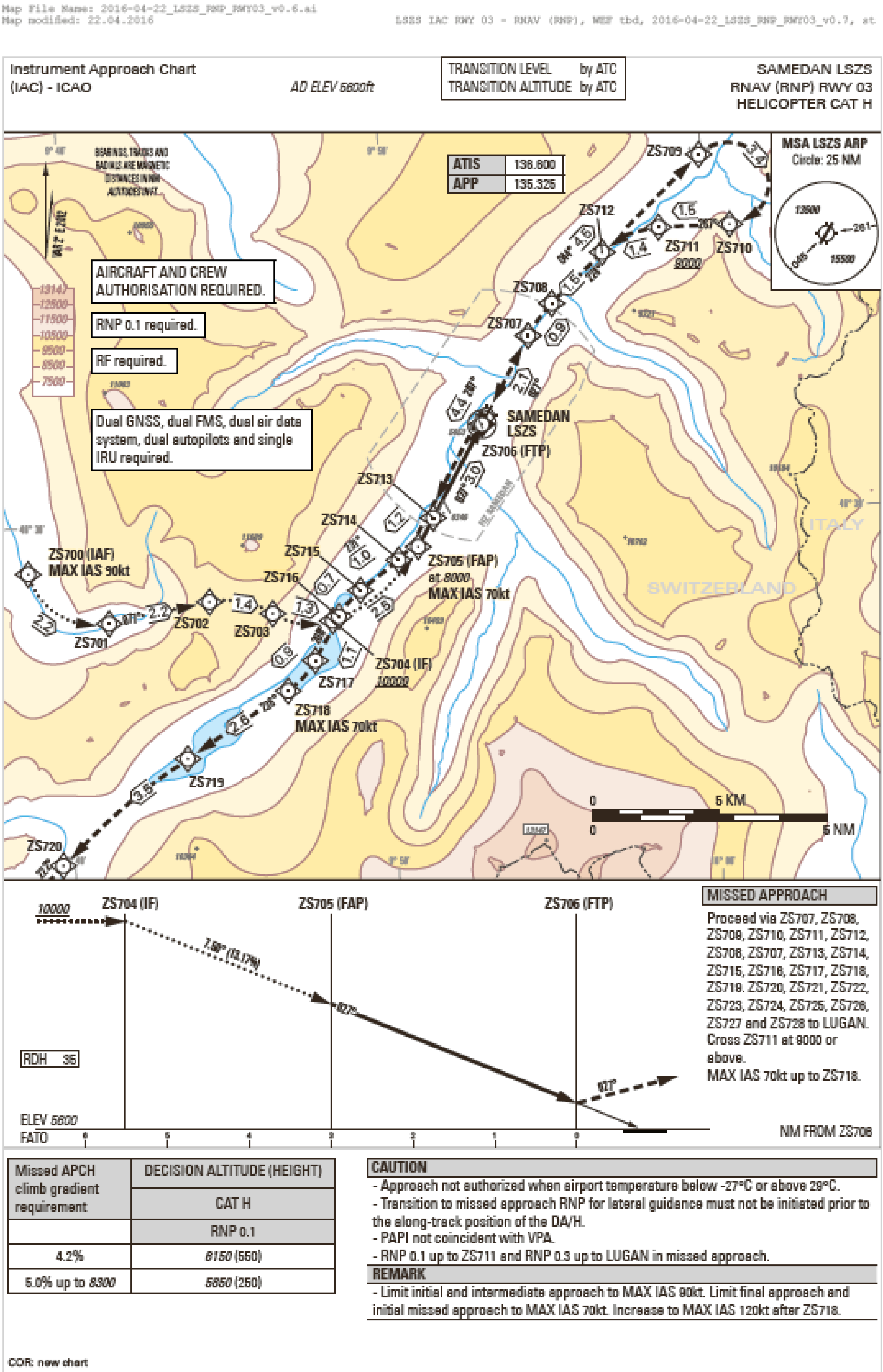


Figure 8: RNAV (RNP) RWY 03 - Samedan

PinS non-standard departure

The term “non-standard” is used to highlight that the design criteria used are partially not compliant with ICAO PANS-OPS criteria. The orographic environment did not allow to design a fully compliant PinS departure with an operational usable procedure design gradient. The “non-standard” solution adopted ignores the secondary protection areas in the obstacle assessment in order to exclude more penalizing obstacles.

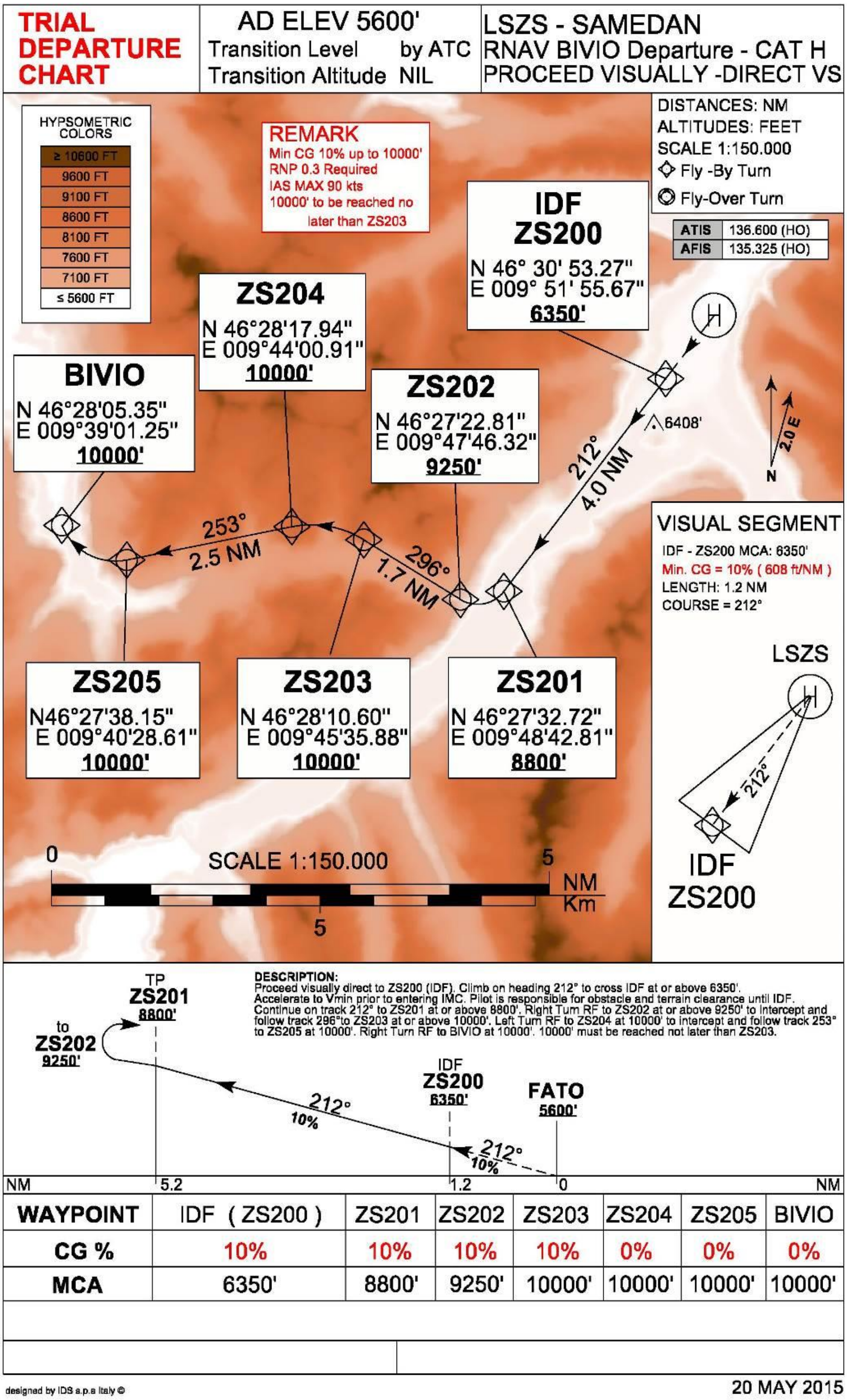


Figure 9: RNAV BIVIO Departure - Samedan

4.1.2.1.1.2 Low level IFR route between Chur and Samedan

The following helicopter Low Level IFR Routes have been designed for connection between Samedan and Chur using RNP 0.3 navigation specification.

Figure 10: Low level IFR route – Chur to Samedan

Figure 11: Low level IFR route – Samedan to Chur

4.1.2.1.1.3 Chur hospital

PinS RNP APCH to LPV minima

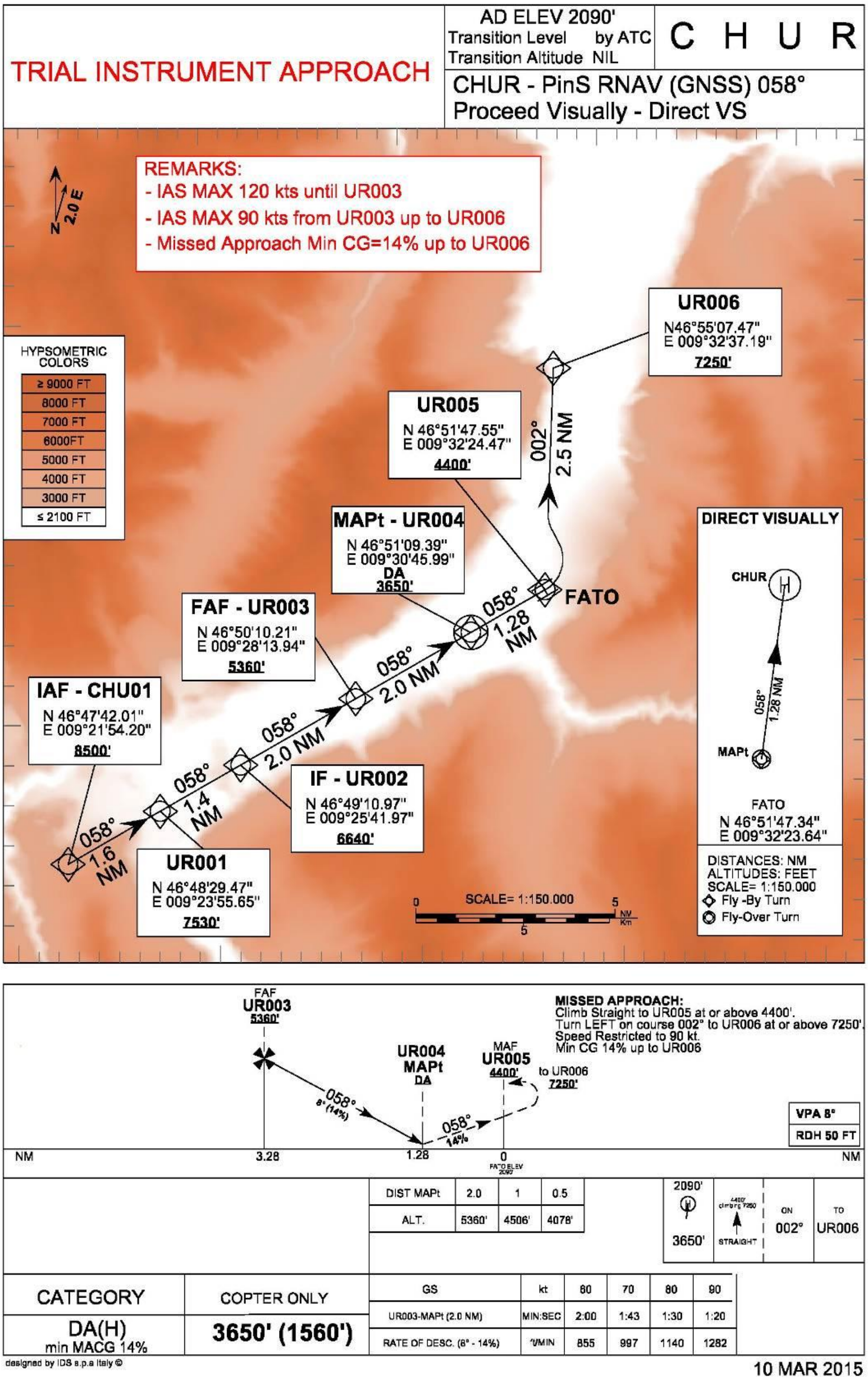
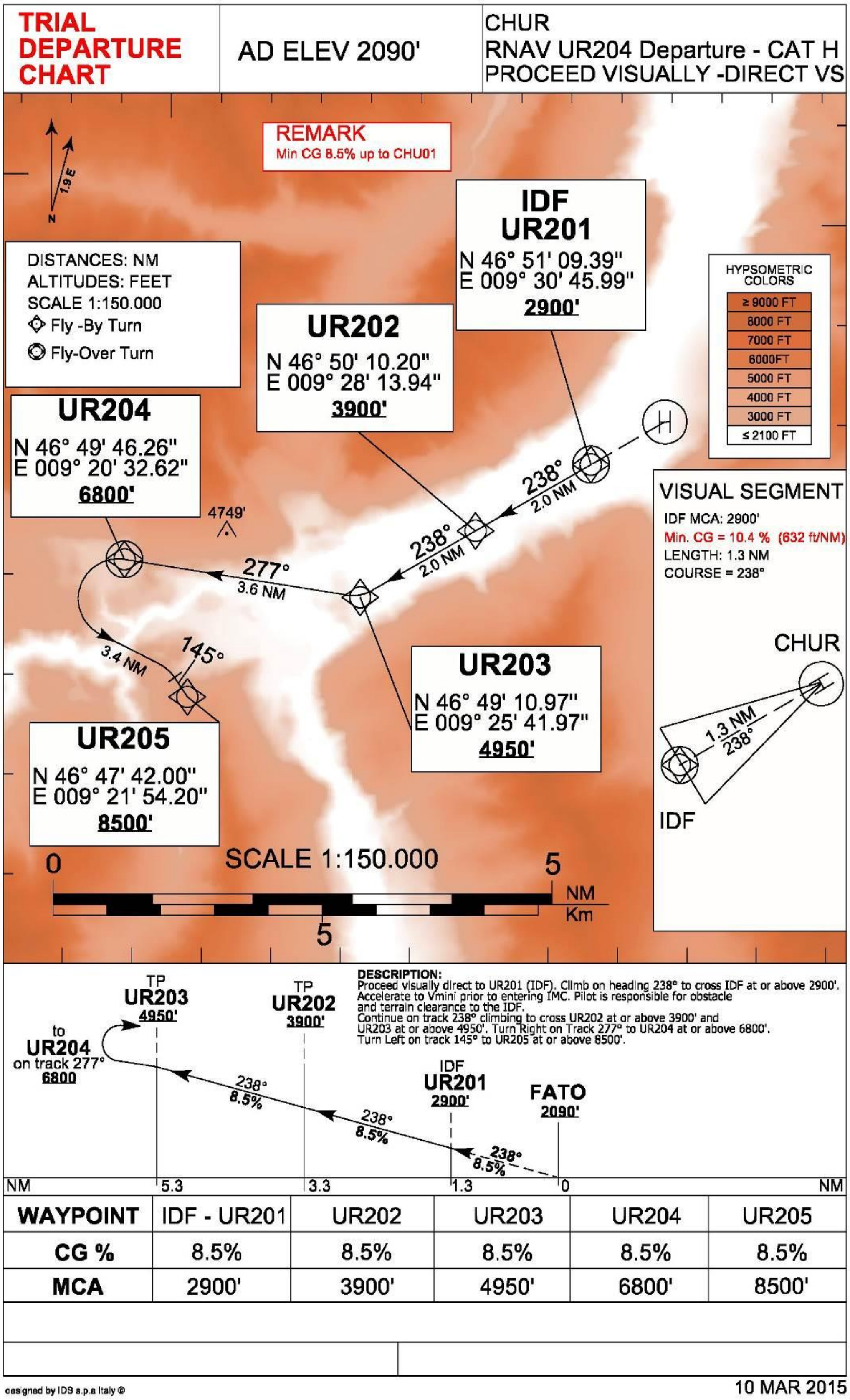


Figure 12: PinS RNP APCH to LPV minima - Chur

PinS departure



WAYPOINT	IDF - UR201	UR202	UR203	UR204	UR205
CG %	8.5%	8.5%	8.5%	8.5%	8.5%
MCA	2900'	3900'	4950'	6800'	8500'

Figure 13: PinS departure – Chur

4.1.2.1.1.4 Validation activities

The purpose of the flight procedure validation is to obtain a qualitative assessment of the procedure design, including obstacles, terrain and navigation data, as well as to provide an assessment of possibility to fly the procedure.

The validation is one of the final steps in quality assurance in the procedure design process for instrument flight procedures (IFP) and is essential before the procedure design documentation is issued as part of the integrated aeronautical information package.

The full validation process includes ground validation and flight validation.

- **Ground validation** must always be undertaken. It encompasses a systematic review of the steps and calculations involved in the procedure design as well as the impact on flight operations by the procedure. The ground validation consists of an independent IFP design review and a pre-flight validation.
- **Flight validation** consists of a flight simulator evaluation using the Rega AW109SP Full Flight Simulator and an evaluation flown in the Rega AW109Sp helicopter.

Simultaneously to the flight validation, the helicopter was equipped with the highly specialised flight inspection kit “AD-AFIS 220” from Flight Calibration Services GmbH (FCS). The equipment is capable to acquire all relevant dates in accordance to the ICAO DOC 8071. All procedures have a comprehensive flight inspection report for communication, navigation and surveillance, as well as the for the helicopter total system error (TSE) during entire flight profile.

The ground and the flight validation were performed by trained and FOCA authorized Rega Pilots. In addition, the helicopter flight inspection equipment was managed by the trained and authorized FCS Technician.

In accordance with ICAO DOC 9906 Volume 5, the procedures have been validated during the flight validation inspection and found to be partially acceptable (please see comments below) by the responsible pilots. A copy of Samedan flight inspection reports produced by FCS – Flight Calibration Services – is referenced in Appendix K and reported in “PROuD Demonstration Report – Appendix K” document).

For each designed procedure, validation activities were performed and the following findings have been identified:

<u>**Samedan airport**</u>

- **RNP AR APCH** for Samedan airport (SCN-0209-001)

  An adjustment to the vertical flight profile is needed in order to reduce the pilot’s workload and to comply with the continuous descent final approach technique.

  This recommendation from the flight validation pilot has been implemented for the second campaign related to the Samedan approach.

- **PinS non-standard departure** for Samedan airport (SCN-0209-001)

  An adjustment of the procedures is required due to the high climb gradient. In addition, for emergency cases constituency procedures need to be established and might be included in the chart.

<u>**Low flight network**</u>

- **Low level IFR route (Chur to Samedan)** (SCN-0209-002)

  No findings.

- **Low level IFR route (Samedan to Chur)** (SCN-0209-002)

  No findings.

<u>**Chur hospital**</u>

- **PinS RNP APCH to LPV minima** for Chur hospital (SCN-0209-005)

PinS LPV procedure with a high DA requires re-adjustment for operational benefits.

Establishing RNP-AR or LP procedures will permit lower minima.

- **PinS departure** for Chur heliport (SCN-0209-005)

  No findings.

4.1.2.1.2 Norwegian procedures

The following sections report the final charts designed by IDS and approved by the partners. All the procedures have been flown during the flight trials.

4.1.2.1.2.1 Lørenskog heliport

PinS RNP APCH to LPV minima

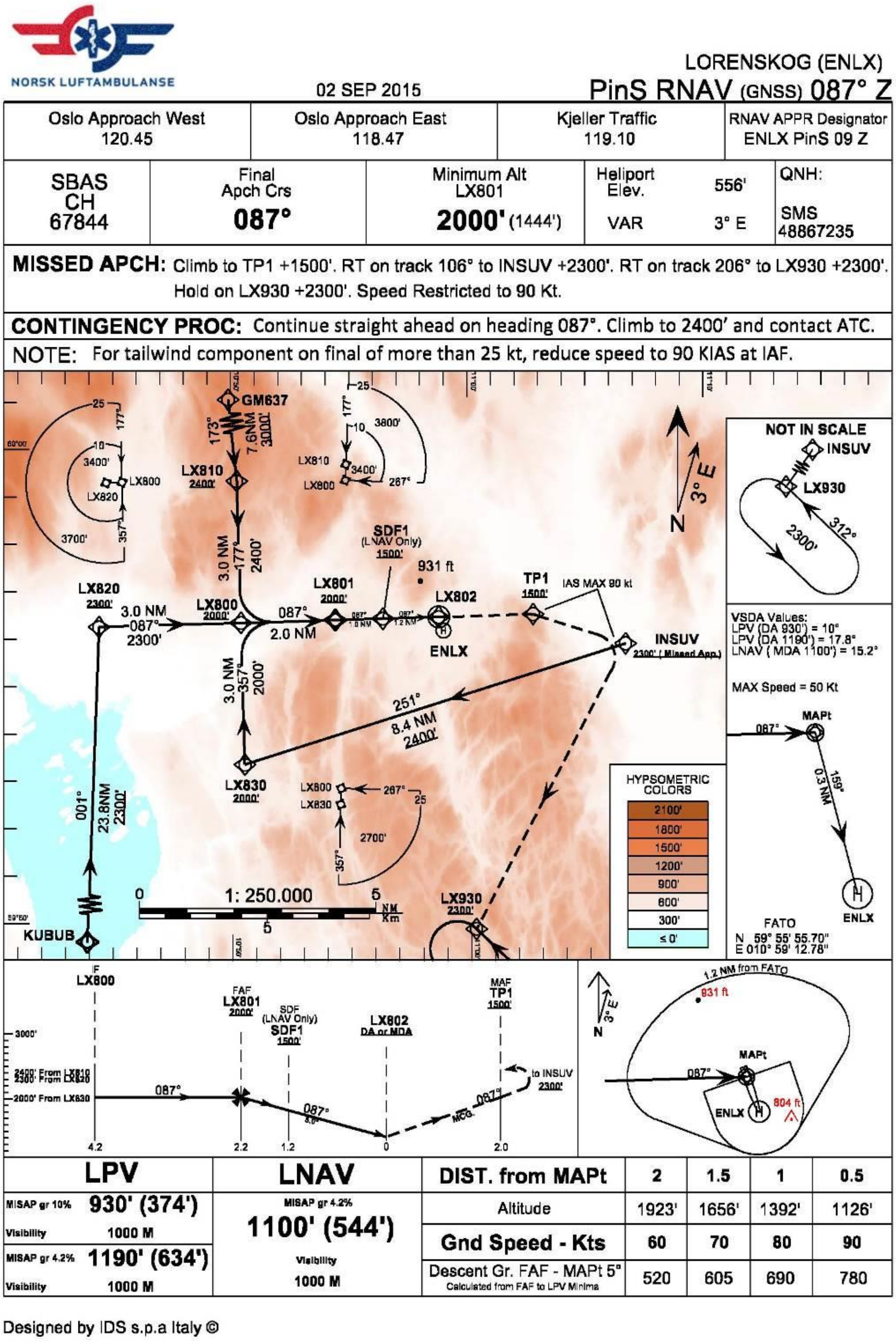


Figure 14: PinS RNP APCH to LPV minima - Lørenskog

PinS departure

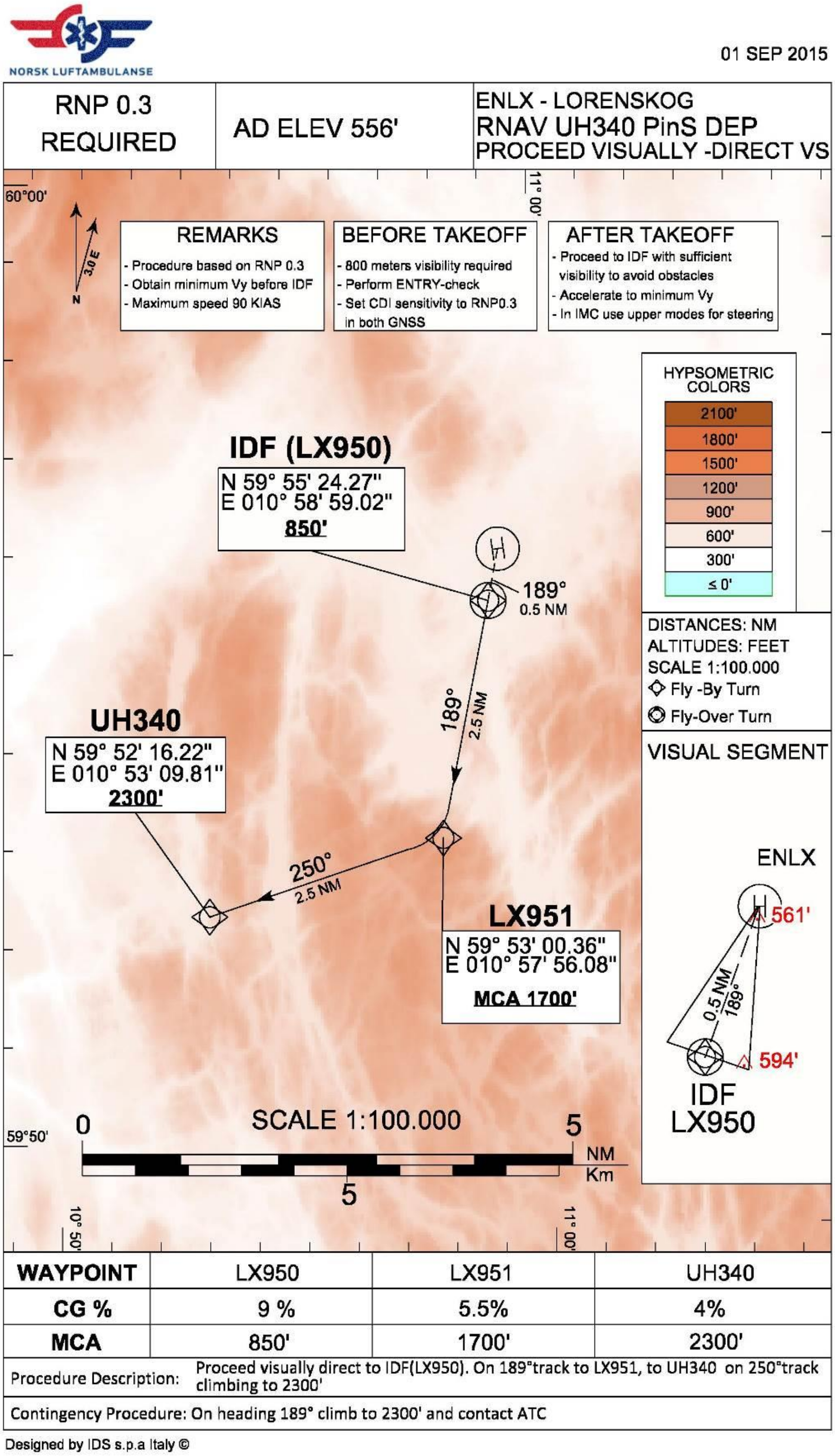


Figure 15: PinS departure - Lørenskog

4.1.2.1.2.2 Ullevål

PinS RNP APCH to LPV minima

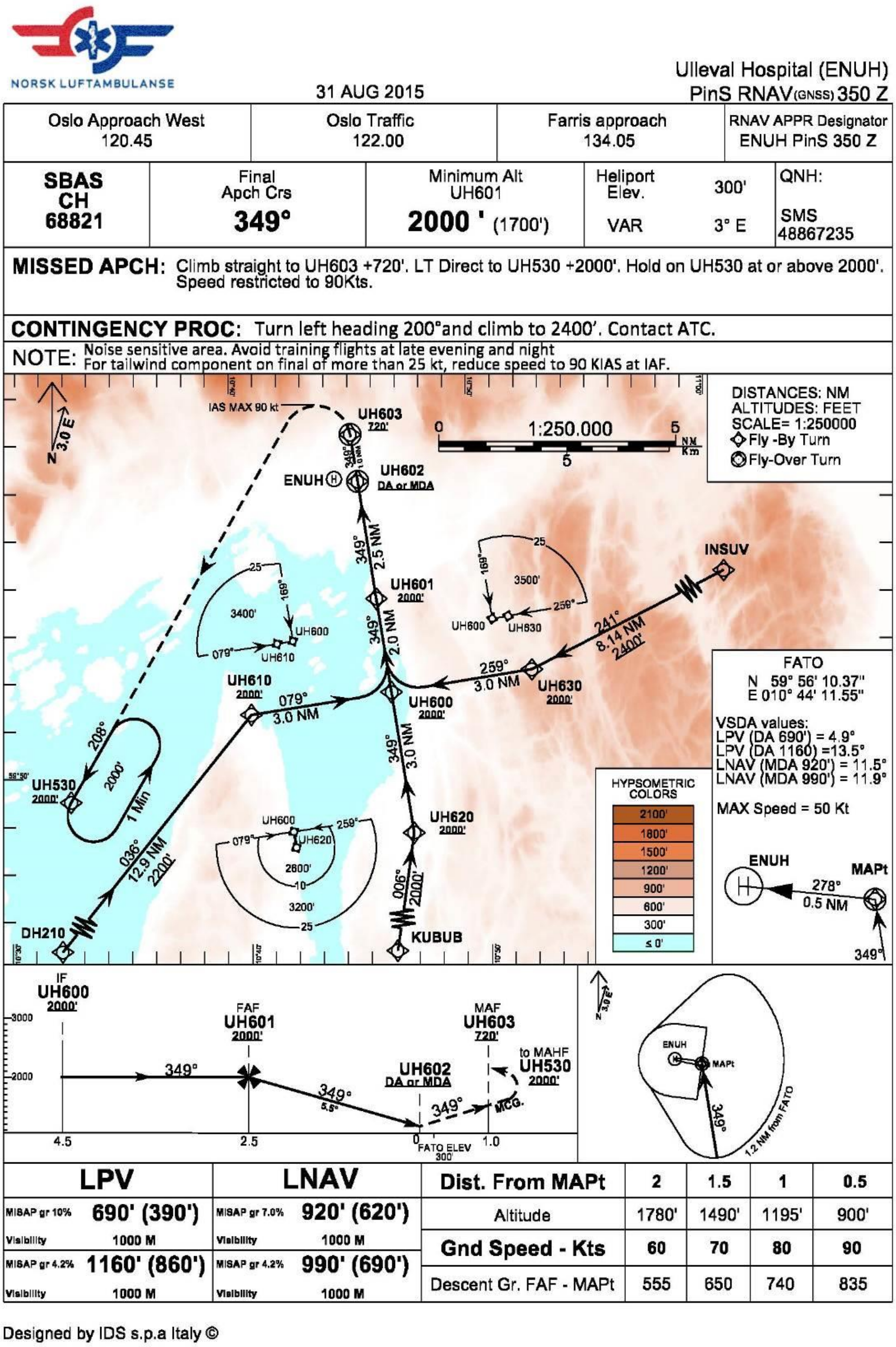


Figure 16: PinS RNP APCH to LPV minima - Ullevål

4.1.2.1.2.3 Validation activities

The validation of the procedures was from the beginning meant to result in operationally implemented into the daily operations. The aim was then to do the flight validation according to accepted procedure from the Norwegian CAA. The approval letter has been produced by Norwegian CAA [13].

The validations were performed in the helicopter only. Since NLA did not have a certified LPV/SBAS helicopter, so Airbus Helicopters came up with a solution to use one of their H135T3 prototype helicopters for the flight validation and demonstration flights.

The flight validation was performed with an authorized Flight Validation Pilot on-board from the NCAA.

Coding and publishing of the procedure was done via NLAs custom agreement with Jeppesen in Frankfurt on a tailored database for the Garmin GTN750. Procedure verification was done prior to the helicopter departing Donauwørth in Germany to make sure the procedures were programmed correctly.

Lørenskog

See FV-report for details [10], [11].

Procedures were successfully validated and only minor changes to charts were necessary and implemented.

Approach procedure is implemented in the daily operation of NLA, and is now published in the operations manual part B.

Ullevål

See FV-report for details [12].

Procedure was successfully validated and only minor changes to chart were necessary and implemented.

The procedure is implemented in the daily operation of NLA, and is now published in the operations manual part B.

4.1.3 Data acquisition tools description

In order to gather the needed data, several systems and tools have been used during the trials. See following paragraphs for detail.

4.1.3.1 On board adaptations

4.1.3.1.1 REGA Helicopter – Flight Inspection equipment

Today's demand for flight inspection of helicopter procedures is still limited, however the flight inspection requires adapted system installations, and is therefore costly. An efficient solution must be found. The combination of flight inspection and flight validation is a major requirement for economical and ecological reasons. A highly professional flight inspection system is required to fulfil international and national standards.

In general, helicopter procedures cannot be flown by fixed wing aircraft, mainly due to the limited turn radius and due to relatively excessive approach angles for fixed wing aircraft. Flight inspection was only possible with workarounds, e.g. flying each leg separately one after the other with a new line up in between, creating additional flight time and costs.

In order to collect and record the flight data on board the Rega helicopter during the flight trail, the flight inspection, the flight calibration kit "Aerodata AFIS -220", provided by Flight Calibration Service GmbH. was used.

The AFIS-220 was designed for an installation in King Air 350s and is equipped with a large number of sensors not required for a helicopter flight inspection system. The system was reconfigured and adapted to a standard basic helicopter configuration with the following components:

a) real time computer for the data acquisition and a display computer with one monitor;
b) hybrid position solution with an inertial navigation system, a GNSS carrier phase solution and an Omnistar wide area augmentation system;
c) Novatel OEM3 GNSS receiver, a TSO approved Collins GPS-4000S GNSS receiver and a Rohde&Schwarz EB200 monitoring receiver;
d) telemetry link for a local DGPS station.

Additionally the following provisions are integrated:

e) interface for a Collins GNLU-930 GBAS receiver;
f) interface for an AD-RNZ-850 NAV/ILS/ DME/MKR flight inspection receiver;
g) interface for a Rohde&Schwarz EVS300 measuring receiver;
h) interface for FCS SISMOS (Signal in space monitoring system);
i) interface for LASER tracker positioning update.

The system allows an online evaluation of all results and also permits post flight evaluations with a lab system or a King Air system.
The software remains exactly the same as for the FCS King Air 350s. Aircraft typical configuration files (e.g. for lever arms, antenna positions, antenna data and cable losses) are included in the standard software distribution kits and are automatically detected and applied by a hardware coding.

As the helicopter flight inspection system remains identical with the King Air flight inspection system for the operation, the effort for documentation, training and certification remain minimal.

In addition to the HeliFIS a geodetic JAVAD SIGMA GNSS receiver with an independent antenna was installed, providing another source of GNSS data independent from the cockpit equipment. The detailed post-processing for the second flight campaign in Samedan was performed by Skyguide and integrated in section 6.1.3.1.2.1.

4.1.3.1.1.1 ADS-B transponder

The AW109SP helicopter was temporary equipped with an ADS-B capable ATC Mode-S transponder unit TDR-94 Rockwell Collins P/N 622-9352-409 to support the APM – Approach Path Monitoring tool installed on ground in Samedan airport. The Rega Part 21 DO issued the modification engineering report and the flight order ENT-7723-FO-E_03 / 01.03.2015.

All the required preparation finally ended with the issue of the EASA Flight Condition Approval (EASA Project No: 60044994).

4.1.3.1.2 NLA Helicopter – Flight validation equipment

Flight data were collected on board the NLA helicopters from a set of additional flight validation equipment.
The flight recording system used in Norway is also more advanced than is required to validate and record SBAS APV procedures in most countries.

Reference system:	Trimble SPS 850
FMS:	Garmin GTN 750
Computer:	Asus UX32V (can be changed without notification)
Navscope:	Version 7 MAP A/S

The flight validation system is using the Trimble SPS 850 system to determine and record the aircraft's position in space relative to WGS-84 reference system. The uncertainty of measurement is by far better than the parameter being inspected.

The flight validation system is recording parameters from the reference system and the FMS. The data acquisition device is a laptop PC with MS Windows operating system.

The flight validation system is using a Trimble Zephyr II for high accuracy and low multipath. It is a multi-frequency antenna receiving the GPS and GLONASS L1 and L2 frequencies and the ESAT_ used for OmniSTAR. It is mounted under the windscreen on the helicopter.

The measurement uncertainty is small compared to the requirements for the procedure. Estimated accuracy of SATREF CPOS is better than 5 centimetres horizontally and 8 centimetres vertically (1 σ). OmniSTAR G2 service provides accuracy 10 cm, 95%CEP as standard and 20 cm in difficult multipath condition.

4.1.3.2 On-ground equipment – Samedan Airport

4.1.3.2.1 GNSS Operative Monitoring Equipment (GNOME) System

The GNOME (GNSS Operative Monitoring Equipment) system is a distributed network of remote sentinels designed to monitor the integrity, reliability and spoofing/interference immunity of GNSS signals.

The key features of the system derive from the ICAO requirements and recommendations, which highly advise continuous monitoring and legal recording of the GNSS performance and integrity, both in the signal and in the navigation domain.

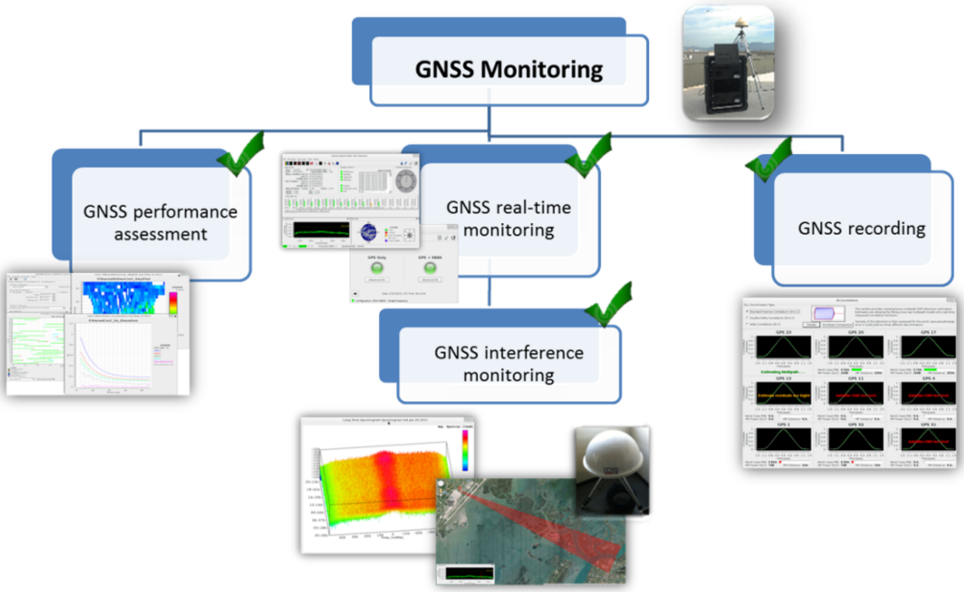


Figure 17: GNOME System capabilities

Each GNOME sentinel is based on a Software-Defined Radio (SDR) kernel, which can be considered the core of the sentinel itself. This technology offers large advantages in terms of configurability/upgradability and reduces the use of hardware components that typically raise costs and make the system less flexible. GNOME monitors the full GPS/EGNOS "processing" stack from the navigation domain down to the physical layer. Any possible GNSS infrastructure anomaly becomes visible, even in cases where it seems apparently hidden.

Within PROuD project one GNOME sentinel has been installed in Samedan for the real time monitoring of GPS and EGNOS performance during flight validation trials (first Samedan campaign) as well as off-line performance assessment and GNSS environment characterization (e.g. EM horizon due to terrain masking, interference).

4.1.3.2.2 APM tool – Approach Path Monitoring tool

APM (Approach Path Monitoring) an innovative ground safety net to support airport operators in small airports, to monitor approaching aircraft and provide an RNP tunnel-incident detection alarm in the case of tunnel infringement along the flight path, using ADS-B data.

APM tool was used during the flight trial execution in Samedan airport to monitor the capabilities of the Rega helicopter to remain within the RNP 0.1 tunnel along approach procedure. ADS-B position report haven been used also to quantify the cross-track distance between the nominal path and the position data contained within the ADS-B messages.

Preliminary simulations have been performed before the installation of the ADS-B receiving antenna in order to have an estimation of the radio link and of the orography masking.

The APM tool was used only during the first flight campaign in Samedan airport (July 2105).

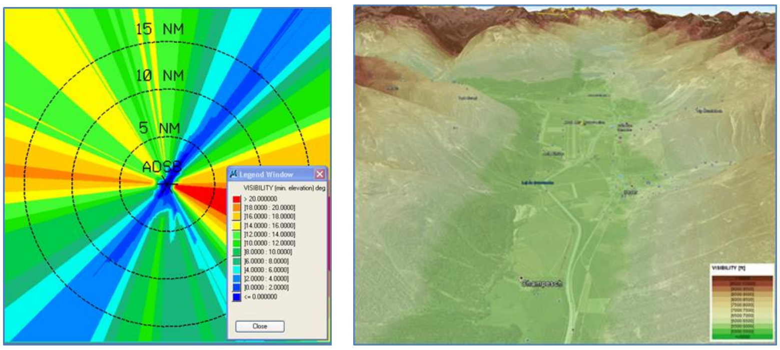


Figure 18: Pre installation activities – ADS-B visibility analysis

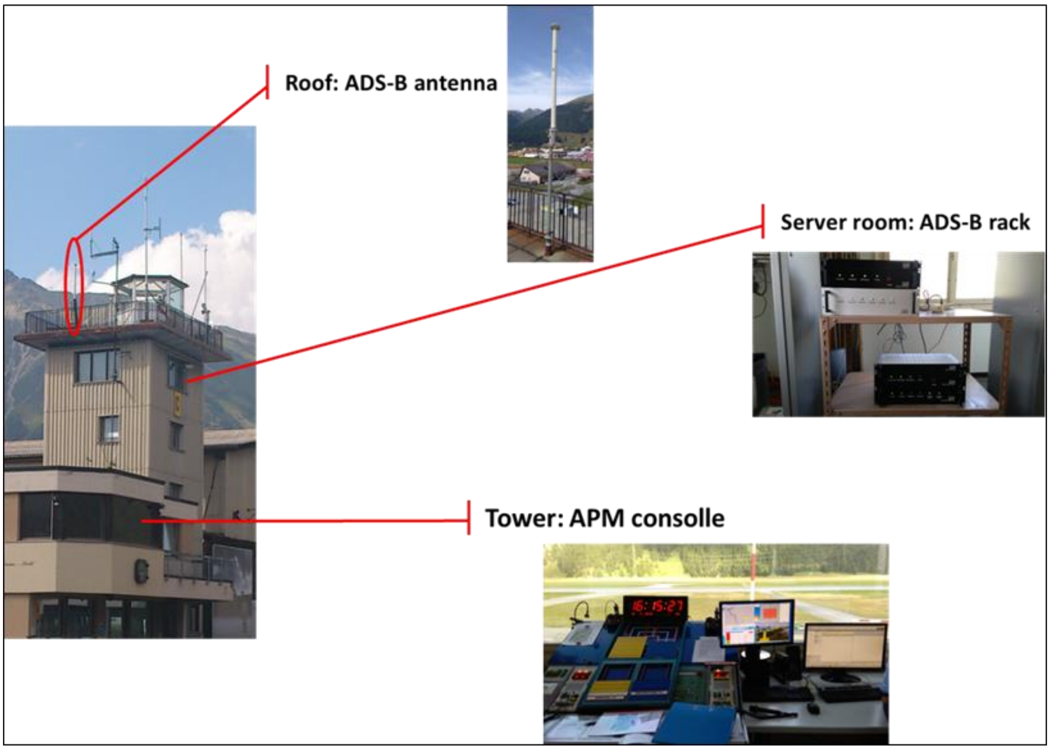


Figure 19: APM tool and ADS-B equipment installation

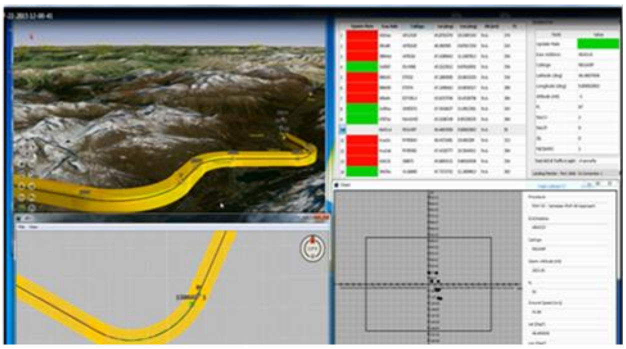


Figure 20: APM operational display

4.1.3.3 Observations

Observation is used to gather data regarding activity conducted in complex and dynamic systems. It involves observing an individual or group of individuals performing work related activity.
Over-the-shoulder, non-intrusive observation has the purpose to provide detailed, complete and reliable information on the way the activity is carried out, especially if further commented and discussed with the observed users. Direct observation enables gathering a high quantity of data, especially qualitative data that cannot be collected through other methods. One of the objectives of the direct observation was the possibility to capture the difference between the current way of working and the proposed one with the new procedures.

In PROuD project, direct observations have been performed during the flight campaign aiming at collecting information on specific aspects of pilots and system behaviours. During the flight campaign human factor experts used multiple techniques like the think aloud, interviews and questionnaire to elicit data from pilots and the whole work was also supported by notes and photos.

High level goals for PROuD observation have been:

- To explore how the procedures are used in operative context;
- To get the interaction of pilots with the system;
- To get pilots comments and verbalized thoughts during the use.

These methods applied during the data collection have been selected and structured, according to the way the observation was carried out, and to steer its focus towards the clear and pre-defined objectives. The main benefits coming from the adoption of these techniques have been:

- To make all members of the human factors team adopting the same focus of observation;
- To ensure that relevant data are effectively collected;
- To ensure coherence and comparability of data collected;
- To avoid biases due to extemporaneous (not structured) observations;
- To make team members interchangeable during the observation.

4.1.3.4 Questionnaire and analysis tool

One of the methodologies mainly used to gather pilots' feedback was the elaboration of ad-hoc questionnaires for the Swiss and Norwegian campaigns.

The ad-hoc questionnaires have been developed by Deep Blue and were used to collect pilots' feedback after the flight performance of the new procedures.

This post-exercise questionnaire was prepared with Google Form.

The questionnaire aims at collecting pilots' feedback on their experience during the performance of the new procedures and at obtaining their expert opinion, regarding the possible impact of new procedures on Search and Rescue operations.

The questions referred specifically to what the pilots experienced during the flights, while others had the scope to collect pilots' expert opinion or prevision on the impact that the new procedures could have if they would be put in daily operations.

In the majority of the questions it was asked pilots to justify their answers with examples related to the flights they have performed or to their professional experience.

The benefits provided by this technique consist in:

- Speeding up the analysis process;
- Providing an input for the conduction of debriefing sessions: knowing in real-time the results of the questionnaire allow to focus on selected aspects/issues;
- Reducing data-entry errors because no transcription is needed and the subjects can input the data through a very intuitive touch-based interface.

The following indicators have been collected by means of questionnaires and debriefings (see next paragraph for more information):

- Subjective feedback on Safety: the expected impact on safety of the new procedures respect to the current ones
- Subjective feedback on Accessibility: the expected impact on the possibility to land of the new procedures respect to the current ones
- Subjective feedback on Availability: the expected impact on the possibility to departure of the new procedures respect to the current ones
- Subjective feedback on Efficiency: the expected impact on flight time of the new procedures respect to the current ones
- Subjective feedback on Predictability: the expected impact on flight predictability of the new procedures respect to the current ones on site to site connections
- Subjective feedback on Human Performance:
    - The expected impact of the new procedures on pilots' operating methods (Operating methods)
    - The expected impact of the new procedures on pilots' performance (Pilots' task performance)
    - The expected impact of technical systems failure on pilots' performance (Performance of the technical system)
- Subjective feedback on Workload: the expected impact on pilots' workload of the new procedures respect to the current ones
- Subjective feedback on Situation Awareness: the expected impact on pilots' situation awareness of the new procedures respect to the current ones

A questionnaire sample is available in section G.1, while the full list of questionnaires and the relative answers are provided in Appendix G.

Four questionnaires have been developed and administrated:

- Swiss Campaign (Samedan, Chur and Low Level Network between Samedan and Chur)
- 2nd Swiss Campaign (only Samedan approaches)
- Norwegian Campaign (Lørenskog, Ullevål)
- Denmark Campaign

The results of the questionnaires have been processed (eliminating outliers) and the numeric answers are presented in the documents as Graphics presenting the average answer for the different indicators, together with the standard deviation.

All the numeric answers provided are comparison between the current procedures and the PROuD's ones. Some of them are provided in a Likert scale from 1 (much lower) to 5 (much higher), in which 3 means no difference respect to the current procedures. When speaking of workload, for example, whereas the value 1 as answer means that the workload experienced by pilots is considered much lower than the workload they perceive during current operations; while 5 means a much higher workload perception.

Other answers are provided as percentages, with 0 meaning no difference respect to the current procedures.

The same results are also reported in paragraph 5.4 with a small text explaining their meaning; to simplify the interpretation of the numbers we considered, in average, to consider relevant only differences of more than 0.5 (so for example 3.1 is considered as "no impact", 3.5 "slight positive impact" and so on).

4.1.3.5 Debriefings

At the end of each exercise a final debriefing has been carried out with the participation of pilots, HF experts and procedures designers. Semi-structured debriefing has been conducted, starting from a

general outline, enriched by the preliminary results coming from observation and questionnaire answers.
The main goal of debriefings was to facilitate constructive discussions about group-specific topics that emerged during the evaluation session and get an agreement on results. Flight crews were provided with different kinds of information and they were required to:

- Discuss system performance (accuracy, representation, reliability etc.);
- Comment their activities with the information provided by the new system/procedure;
- Make a comparison between activities carried out with or without the concepts, which constituted the objectives of the demonstration;
- Envision the applicability of PBN IFR procedures and their effectiveness in daily operations.

4.1.3.6 Weather data analysis

To estimate the impact of the new procedures in terms of accessibility and availability, a tool has been developed able to compare the visibility and ceiling minima of the current and new type of procedures with the actual meteorological conditions in two project sites (Samedan and Lørenskog), using as input the historical METAR data for Samedan heliport and Oslo Airport (close enough to Lørenskog to have the same meteorological conditions even though there might be some variations).

The tool is able, for each METAR record, to compute if the meteorological conditions permit or not to fly, according to different minima. Hence, it was possible to count the number of METAR records compatible with the current minima and the number of METAR records compatible with the new minima associated with the procedures developed within the project.

Comparing these numbers enables to estimate the percentage variation of the possibility to land (accessibility) and to take off (availability) generated by the introduction of the new procedures. Basically this is a “what if” exercise: how much difference in the possibility to operate in the two selected sites would be experienced if the new procedures were used instead of the current ones in the last years?

The data available cover 4 years (from 2012 to 2015; source:
https://mesonet.agron.iastate.edu/request/download.phtml?network=CH__ASOS).

The tool logic and the minima input data (visibility and ceiling) used for the analysis are described in Appendix H.

The tool is able to discriminate if the single METAR record refers to night or day, using this algorithm (https://launchpad.net/astral). Day is described as half hour before the sunrise and half hour after the sunset.

Unfortunately, the METAR dataset for Samedan was not complete (half of the data was missing) and the data was not randomly missing, making the resulting analysis results visibly spoilt. It was so possible to report only the analysis executed for the Lørenskog site.

We used the same tool and data also to calculate how much the presence of on board de-icing equipment impacts the flyability of the procedures. We have used also the METAR data regarding temperature, and considered +4° as a threshold temperature under which it is not possible to fly IFR procedures unless helicopters are equipped with de-ice system.

An interactive version of the results of the analysis is available here:

https://public.tableau.com/profile/publish/PROuDProject-LrenskogAvailabilityandaccessibility/Normal#!/publish-confirm

4.2 Exercises Execution

The execution of the exercise has been structured in pre-flight activities, the demonstration flights performance and post-flight activities.

Below the exercise’s steps are listed as they have been executed.

Pre-flight activities:

Preparation of timely briefing for all participants of the flight trial (local authority, local ATS, regulator, flight crew), invitation and flight trial execution plan.

Flight trials execution:

Execution of flights:

- PinS departure procedure;
- RNP AR APCH approach;
- IFR heliport to heliport procedure;
- PinS Approach procedure with LPV minima;

During the execution of the exercises, data have been collected on board helicopters and on ground (only for Samedan campaign).

Moreover on ground equipment have been used during flights execution for:

- real time monitoring of GPS and EGNOS performance in the signal and navigation domain;
- real time monitoring of adherence of approach against the flight procedure nominal path using ADS-B data.

Qualitative techniques of data collection have been also used during the trials and they included over-the-shoulder non-intrusive observations of pilots and system behaviour during the trials, together with the think aloud methodologies.

Post Flight activities:

Immediately after the flights, a debriefing has been held between involved stakeholders (local authority, local ATC, regulator, flight crew).

At the end of the exercises the following activities have been executed:

- Extraction of flight data records from helicopter on board equipment;
- Processing of navigation data acquired on board and elaboration of data acquired on ground;
- Performance assessment and anomaly investigation execution.

The information gathered during the exercises served as a description of the system performance when using the PBN IFR procedures. Quantitative and qualitative measures contributed to the final assessment of the flight trials.
Regarding the navigation performance assessment it is worth mentioning that Rega Flight inspection console, used during the flight trials allows the recording of all the necessary navigation parameters for the post processing activities.

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-02.09-D-001	RNP AR APCH at Samedan airport *(first campaign)*	20/07/2015	22/07/2015	08/03/2016	31/05/2016
	RNP AR APCH at Samedan airport *(second campaign)*	21/04/2016	21/04/2016	24/04/2016	30/07/2016
EXE-02.09-D-002	PinS non-standard departure at Samedan airport	20/07/2015	22/07/2015	08/03/2016	31/05/2016
EXE-02.09-D-003	IFR connection between Samedan airport and Chur hospital	20/07/2015	22/07/2015	08/03/2016	31/05/2016
EXE-02.09-D-004	PinS RNP APCH to LPV minima at Lørenskog heliport	08/06/2015	09/06/2015	04/02/2016	31/05/2016

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-02.09-D-005	PinS departure at Lørenskog heliport	08/06/2015	09/06/2015	04/02/2016	31/05/2016
EXE-02.09-D-006	PinS RNP APCH to LPV minima at Ullevål heliport	08/06/2015	09/06/2015	04/02/2016	31/05/2016
EXE-02.09-D-007	PinS RNP APCH to LPV minima at Chur hospital	20/07/2015	22/07/2015	08/03/2016	31/05/2016
EXE-02.09-D-008	PinS departure at Chur hospital	20/07/2015	22/07/2015	08/03/2016	31/05/2016

Table 12: Exercises execution/analysis dates

4.2.1 Swiss Exercises execution details

Before the demonstration flights could be executed, the procedures documentations had to be reviewed by Rega FOCA authorized flight validation Pilots, followed by the coding by Jeppesen. The dedicated Rega test database was then uploaded in the FMS of the helicopter as well as the full flight simulator for validation purposes.
All procedures have been evaluated in the Rega AW109SP full flight simulator (FFS) on 16.June 2015. A total of 10 flights have been executed in the AW109 FFS for the validation and found to be acceptable for the flight demonstration trial.

Exercise ID	No	Exercise Title	Actual Exercise execution start date	Actual Exercise execution start time
EXE-02.09-D-001	2	RNP AR APCH at Samedan airport	16/07/2015	16:00- 18:00
EXE-02.09-D-002	2	PinS non-standard departure at Samedan airport	16/07/2015	16:00- 18:00
EXE-02.09-D-003	2	IFR connection between Samedan airport and Chur Hospital	16/07/2015	16:00- 18:00
EXE-02.09-D-007	2	PinS RNP APCH to LPV minima at Chur	16/07/2015	16:00- 18:00
EXE-02.09-D-008	2	PinS departure at Chur heliport	16/07/2015	16:00- 18:00

Table 13: Flight procedure evaluation in the Rega FFS

After the flights in the FFS, flight inspection and demonstration with the helicopter AW109SP HB-ZRP was carried out.
The details of each demonstration flight, including major parameters of GPS and EGNOS signals, were recorded by the flight inspection system and evaluated by the flight inspector. All relevant primary flight data (primary GPS, FMS etc.) was recorded by a prior installed quick access recorder (Avionica miniQAR MKIII)
For details please see the FCS reports of the first and second Samedan flight trials in Appendix K.

Exercise ID	No	Exercise Title	Actual Exercise execution start date	Actual Exercise execution start time	Data considered for post-processing analysis
EXE-02.09-D-001	1	RNP AR APCH at Samedan airport (1st campaign)	20/07/2015	15:09:23	YES
EXE-02.09-D-001	2	RNP AR APCH at Samedan airport (1st campaign)	21/07/2015	07:42:55	YES
EXE-02.09-D-001	3	RNP AR APCH at Samedan airport (1st campaign)	21/07/2015	08:06:37	YES
EXE-02.09-D-001	4	RNP AR APCH at Samedan airport (1st campaign)	21/07/2015	11:07:33	YES
EXE-02.09-D-001	5	RNP AR APCH at Samedan airport (1st campaign)	21/07/2015	11:30:41	YES
EXE-02.09-D-001	6	RNP AR APCH at Samedan airport (1st campaign)	21/07/2015	13:14:56	YES
EXE-02.09-D-001	7	RNP AR APCH at Samedan airport (1st campaign)	21/07/2015	15:14:15	YES
EXE-02.09-D-001	8	RNP AR APCH at Samedan airport (1st campaign)	21/07/2015	15:33:39	NO
EXE-02.09-D-001	9	RNP AR APCH at Samedan airport (1st campaign)	22/07/2015	07:26:34	YES
EXE-02.09-D-001	10	RNP AR APCH at Samedan airport (1st campaign)	22/07/2015	07:56:00	YES
EXE-02.09-D-001	11	RNP AR APCH at Samedan airport (1st campaign)	22/07/2015	09:04:49	NO
EXE-02.09-D-001	12	RNP AR APCH at Samedan airport (1st campaign)	22/07/2015	10:04:40	YES
EXE-02.09-D-001	13	RNP AR APCH at Samedan airport (1st campaign)	22/07/2015	10:28:15	YES
EXE-02.09-D-001	14	RNP AR APCH at Samedan airport (1st campaign)	22/07/2015	13:27:41	YES
EXE-02.09-D-001	1	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	06:42:55	NO
EXE-02.09-D-001	2	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	07:17:55	YES
EXE-02.09-D-001	3	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	07:33:15	YES
EXE-02.09-D-001	4	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	08:16:10	YES
EXE-02.09-D-001	5	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	09:12:10	YES
EXE-02.09-D-001	6	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	09:40:53	YES
EXE-02.09-D-001	7	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	10:08:17	YES
EXE-02.09-D-001	8	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	12:20:55	YES
EXE-02.09-D-001	9	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	12:40:21	YES
EXE-02.09-D-001	10	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	13:22:55	NO
EXE-02.09-D-001	11	RNP AR APCH at Samedan airport (2nd campaign)	21/04/2016	14:41:25	NO

Exercise ID	No	Exercise Title	Actual Exercise execution start date	Actual Exercise execution start time	Data considered for post-processing analysis
EXE-02.09-D-002	1	PinS non-standard departure at Samedan airport	21/07/2015	07:30:50	YES
EXE-02.09-D-002	2	PinS non-standard departure at Samedan airport	21/07/2015	07:55:44	YES
EXE-02.09-D-002	3	PinS non-standard departure at Samedan airport	21/07/2015	08:19:37	YES
EXE-02.09-D-002	4	PinS non-standard departure at Samedan airport	21/07/2015	09:06:48	YES
EXE-02.09-D-002	5	PinS non-standard departure at Samedan airport	21/07/2015	11:19:50	YES
EXE-02.09-D-002	6	PinS non-standard departure at Samedan airport	21/07/2015	13:03:23	YES
EXE-02.09-D-002	7	PinS non-standard departure at Samedan airport	21/07/2015	13:27:16	YES
EXE-02.09-D-002	8	PinS non-standard departure at Samedan airport	22/07/2015	06:19:56	YES
EXE-02.09-D-002	9	PinS non-standard departure at Samedan airport	22/07/2015	07:41:58	YES
EXE-02.09-D-002	10	PinS non-standard departure at Samedan airport	22/07/2015	09:01:04	NO
EXE-02.09-D-002	11	PinS non-standard departure at Samedan airport	22/07/2015	10:17:33	YES
EXE-02.09-D-002	12	PinS non-standard departure at Samedan airport	22/07/2015	13:09:50	YES
EXE-02.09-D-002	13	PinS non-standard departure at Samedan airport	22/07/2015	13:35:56	YES
					YES
EXE-02.09-D-003	1	IFR connection between Samedan airport and Chur hospital	20/07/2015	14:58:10	YES
EXE-02.09-D-003	2	IFR connection between Samedan airport and Chur hospital	21/07/2015	09:17:03	YES
EXE-02.09-D-003	3	IFR connection between Samedan airport and Chur hospital	21/07/2015	11:03:23	NO
EXE-02.09-D-003	4	IFR connection between Samedan airport and Chur hospital	21/07/2015	13:35:48	YES
EXE-02.09-D-003	5	IFR connection between Samedan airport and Chur hospital	21/07/2015	15:02:46	YES
EXE-02.09-D-003	6a	IFR connection between Samedan airport and Chur hospital	22/07/2015	06:28:12	YES
EXE-02.09-D-003	6b	IFR connection between Samedan airport and Chur hospital	22/07/2015	06:39:14	YES
EXE-02.09-D-003	7	IFR connection between Samedan airport and Chur	22/07/2015	07:14:12	YES

Exercise ID	No	Exercise Title	Actual Exercise execution start date	Actual Exercise execution start time	Data considered for post-processing analysis
		hospital			
EXE-02.09-D-003	8	IFR connection between Samedan airport and Chur hospital	22/07/2015	09:24:13	YES
EXE-02.09-D-003	9	IFR connection between Samedan airport and Chur hospital	22/07/2015	09:52:20	YES
EXE-02.09-D-003	10	IFR connection between Samedan airport and Chur hospital	22/07/2015	13:46:39	YES
EXE-02.09-D-003	11	IFR connection between Samedan airport and Chur hospital	22/07/2015	14:32:29	NO
EXE-02.09-D-007	1	PinS RNP APCH to LPV minima at Chur hospital	20/07/2015	12:35:54	YES
EXE-02.09-D-007	2	PinS RNP APCH to LPV minima at Chur hospital	20/07/2015	13:56:32	YES
EXE-02.09-D-007	3	PinS RNP APCH to LPV minima at Chur hospital	20/07/2015	14:17:54	YES
EXE-02.09-D-007	4	PinS RNP APCH to LPV minima at Chur hospital	21/07/2015	09:28:49	NO
EXE-02.09-D-007	5	PinS RNP APCH to LPV minima at Chur hospital	21/07/2015	09:37:49	YES
EXE-02.09-D-007	6	PinS RNP APCH to LPV minima at Chur hospital	21/07/2015	10:39:09	YES
EXE-02.09-D-007	7	PinS RNP APCH to LPV minima at Chur hospital	21/07/2015	13:48:06	YES
EXE-02.09-D-007	8	PinS RNP APCH to LPV minima at Chur hospital	22/07/2015	06:46:37	YES
EXE-02.09-D-007	9	PinS RNP APCH to LPV minima at Chur hospital	22/07/2015	09:30:09	YES
EXE-02.09-D-007	10	PinS RNP APCH to LPV minima at Chur hospital	22/07/2015	13:58:15	YES
EXE-02.09-D-007	11	PinS RNP APCH to LPV minima at Chur hospital	22/07/2015	14:32:29	NO
EXE-02.09-D-008	1	PinS departure at Chur hospital	20/07/2015	13:46:47	YES
EXE-02.09-D-008	2	PinS departure at Chur hospital	20/07/2015	14:08:05	YES
EXE-02.09-D-008	3	PinS departure at Chur hospital	20/07/2015	14:50:17	YES
EXE-02.09-D-008	4	PinS departure at Chur hospital	21/07/2015	10:28:44	YES
EXE-02.09-D-008	5	PinS departure at Chur hospital	21/07/2015	10:49:21	YES
EXE-02.09-D-008	6	PinS departure at Chur hospital	21/07/2015	14:55:18	YES
EXE-02.09-D-008	7	PinS departure at Chur hospital	22/07/2015	07:05:19	YES

Exercise ID	No	Exercise Title	Actual Exercise execution start date	Actual Exercise execution start time	Data considered for post-processing analysis
EXE-02.09-D-008	8	PinS departure at Chur hospital	22/07/2015	09:44:32	YES

Table 14: Exercises and flight inspection and evaluation using the Rega helicopter HB-ZRP[2]

4.2.1.1 Weather Conditions

All the trials have been conducted under VMC conditions, as no other procedures were published during the flight trials execution. Moreover, according to the then-existing Swiss Regulation, IFR operations were not allowed within Class G airspace.

4.2.2 Norwegian Exercises execution details

The following table reports the list of PROuD flight trials performed in Norway:

Exercise ID	No	Exercise Title	Actual Exercise execution start date	Actual Exercise execution start time	Data considered for post-processing analysis
EXE-02.09-D-004	1	PinS RNP APCH to LPV minima at Lørenskog heliport	08/06/2015	09:55:52	YES
EXE-02.09-D-004	2	PinS RNP APCH to LPV minima at Lørenskog heliport	08/06/2015	10:02:20	YES
EXE-02.09-D-004	3	PinS RNP APCH to LPV minima at Lørenskog heliport	08/06/2015	10:09:44	YES
EXE-02.09-D-004	4	PinS RNP APCH to LPV minima at Lørenskog heliport	08/06/2015	10:26:41	YES
EXE-02.09-D-004	5	PinS RNP APCH to LPV minima at Lørenskog heliport	08/06/2015	13:52:18	YES
EXE-02.09-D-004	6	PinS RNP APCH to LPV minima at Lørenskog heliport	08/06/2015	14:23:55	YES
EXE-02.09-D-004	7	PinS RNP APCH to LPV minima at Lørenskog heliport	08/06/2015	14:41:49	YES
EXE-02.09-D-004	8	PinS RNP APCH to LPV minima at Lørenskog heliport	09/06/2015	08:43:00	YES
EXE-02.09-D-004	9	PinS RNP APCH to LPV minima at Lørenskog heliport	09/06/2015	09:13:00	YES
EXE-02.09-D-004	10	PinS RNP APCH to LPV minima at Lørenskog heliport	09/06/2015	11:20:11	YES
EXE-02.09-D-004	11	PinS RNP APCH to LPV minima at Lørenskog heliport	09/06/2015	11:30:37	YES
EXE-02.09-D-005	1	PinS departure at Lørenskog heliport	08/06/2015	09:09:29	YES
EXE-02.09-D-005	2	PinS departure at Lørenskog heliport	08/06/2015	13:30:56	YES
EXE-02.09-D-005	3	PinS departure at Lørenskog heliport	08/06/2015	14:00:38	YES

[2] Some of the 2nd campaign flights were conducted with the HB-ZRR helicopter (hence without HeliFIS installed, only JAVAD data available).

Exercise ID	No	Exercise Title	Actual Exercise execution start date	Actual Exercise execution start time	Data considered for post-processing analysis
EXE-02.09-D-005	4	PinS departure at Lørenskog heliport	09/06/2015	08:37:09	YES
EXE-02.09-D-005	5	PinS departure at Lørenskog heliport	09/06/2015	08:51:53	YES
EXE-02.09-D-005	6	PinS departure at Lørenskog heliport	09/06/2015	11:06:19	YES
EXE-02.09-D-006	1	PinS RNP APCH to LPV minima at Ullevål heliport	08/06/2015	09:10:37	YES
EXE-02.09-D-006	2	PinS RNP APCH to LPV minima at Ullevål heliport	08/06/2015	09:21:30	YES
EXE-02.09-D-006	3	PinS RNP APCH to LPV minima at Ullevål heliport	08/06/2015	09:28:34	YES
EXE-02.09-D-006	4	PinS RNP APCH to LPV minima at Ullevål heliport	08/06/2015	09:45:19	YES
EXE-02.09-D-006	5	PinS RNP APCH to LPV minima at Ullevål heliport	08/06/2015	13:35:56	YES
EXE-02.09-D-006	6	PinS RNP APCH to LPV minima at Ullevål heliport	08/06/2015	13:43:48	YES
EXE-02.09-D-006	7	PinS RNP APCH to LPV minima at Ullevål heliport	08/06/2015	14:05:08	YES
EXE-02.09-D-006	8	PinS RNP APCH to LPV minima at Ullevål heliport	08/06/2015	14:15:29	YES
EXE-02.09-D-006	9	PinS RNP APCH to LPV minima at Ullevål heliport	09/06/2015	08:55:14	YES
EXE-02.09-D-006	10	PinS RNP APCH to LPV minima at Ullevål heliport	09/06/2015	09:06:03	YES
EXE-02.09-D-006	11	PinS RNP APCH to LPV minima at Ullevål heliport	09/06/2015	11:10:14	YES

Table 15: Exercises and flight trials performed in Norway using the NLA helicopter

4.3 Deviations from the planned activities

With respect to the content of the Demonstration Plan the following changes have been made:

- In order to allow the evaluation of a full helicopter IFR connection, including departure, en-route and approach phases of flight, further approach and departure procedures have been designed, within the project, for Chur hospital. The following scenarios have been added:
  - **Scenario 05 (SCN-0209-005)**: Chur hospital (LSHC) area (15-20 NM surrounding the hospital). See B.1.3.
- The following exercises have been added:
  - **EXE-02.09-D-007**: PinS RNP APCH to LPV minimum at Chur (see Table 7)
  - **EXE-02.09-D-008**: PinS departure at Chur hospital (see Table 8)
- Due to environment constraints at Samedan airport, several attempts have been performed to design a PinS RNP APCH to LPV minima at Samedan airport. The very challenging environment around the airport did not permit reaching DA/H minima within the operational limits (DH<2000ft). Therefore, it was agreed with Rega and Skyguide to design a helicopter RNP AR APCH. The adoption of RNP AR criteria with an RNP navigation accuracy requirement of 0.1 NM allows to reach a significantly lower minimum compared to a PinS RNP APCH procedure.

- Specific objectives have been added (OBJ-0209-102, OBJ-0209-106, OBJ-0209-108) to evaluate also this kind of RNP AR APCH procedure (see Appendix C and Appendix I).
- The objective OBJ-0209-010 to assess VFR airport accessibility of RNP AR APCH approach procedure in critical environment was modified (the previous description has been implicitly included in the reformulation of this objective).
- The existing objectives related to PinS RNP APCH to LPV minima (OBJ-0209-002, OBJ-0209-004, OBJ-0209-006, OBJ-0209-008, OBJ-0209-017, OBJ-0209-018, OBJ-0209-019), mapped to the Samedan approach in the demonstration plan [2], have been covered by the procedure designed for the new Chur hospital scenario (SCN-0209-005). See Appendix I.
- Within PROuD project, in addition to the planned approach and departure procedures planned in the demonstration plan, a low level IFR route between Samedan and Chur has been designed and the specific objective (OBJ-0209-116) to address Safety KPA for heliport to hospital exercise (EXE-02.09-D-003) has been added (see Appendix C and Appendix I).
- Removed the objective OBJ-0209-009 related to the flight efficiency of the adoption of RNP0.3 navigation specification in the arrival phase of flight (STAR) since RNP 0.3 was not used for transition segments. RNP1 has been used since this allowed to reach expected benefits. RNP 0.3 would not have further improved operational benefits.
- In regard to KPAs and KPIs, no deviations occurred for the KPAs reported in the Demonstration Plan, while the following deviations have been identified for the KPIs:
  - “Adherence to the computed flight path” was modified with “Flight track adherence”;
  - “Number of performed departures in time of the day / conditions that would have previously not allowed them” was changed with “Meteo data”;
  - “Timeliness of actions” has been included in the “Flight crew subjective feedback”.
- Meteorological data analysis was executed only for the Lørenskog site. Data for Gardermoen (ENGM) were used. METAR data for the other heliports were not available and for Samedan airport they were not complete.
- RNAV procedures have been flown in Denmark and pilots’ feedback have been collected to evaluate the pilots’ experience during the performance of the PinS RNP APCH procedures and the possible impact of these procedures in HEMS (see Appendix J).

5 Exercises Results

5.1 Summary of Exercises Results

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
EXE-02.09-D-001	Safety of RNP AR APCH	OBJ-0209-102	Increased safely level of helicopter approach operations is expected in comparison with current VFR/VMC operations in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action.	A medium increase of safety is noted, compared to the VFR/VMC condition in day operations. Significant safety improvements are expected in marginal weather situations and during night operations. Several RNP APCH AR approach procedures have been designed and flown with different operational feedback by the pilots. Some adjustments to the procedures are needed in order to get operational approval by reducing the MA climb gradient, particularly in OEI situations and icing conditions. In IMC condition the procedure contributes to the increase of inter hospital transfer possibilities which otherwise would not be existent, neither for helicopter nor fixed wing airplanes.	OK
	Site accessibility using RNP AR APCH	OBJ-0209-010	An increase in airport accessibility is expected in terms of increased landing possibility and reduction of number of diversions and	The average value of the pilots' feedback demonstrates that the new procedures will permit to fly through a cloud or fog layer, when there are bad weather conditions thus improving site accessibility, reducing diversions	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
			missed approaches in comparison with VFR approaches.	and missed approaches.	
	Environmental sustainability using RNP AR APCH	OBJ-0209-106	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	The flight track for the RNP AR procedure is longer and the approach speed is slower compare to VFR approach; the environmental impact is not reduced but the accessibility to the airport will increase in bad weather and HEMS service availability is improved.	NOK
	Flight efficiency of RNP AR APCH	OBJ-0209-108	An optimization of efficiency of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR operations.	Compared to VFR flights RNP AR APCH procedures are less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless these new procedures are often the only solution to permit life-saving flights in IMC as they ensure the access to hospitals and airports in emergencies /catastrophic situations. In the light of higher costs as a result of a significantly worse medical result due to a significant delay in the patient´s definitive treatment, the additional efforts of RNP AR APCH procedures in costs and environmental burden pay off from both a humanitarian as well as from an economic point of view.	NOK (aviation view in good VMC conditions) OK (humanitarian and economic views)
	HP - Operating methods - using new procedures	OBJ-0209-017	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods	The changes in the current operating methods (basically the shift from visual to instrumental flight) are considered acceptable. Regular training is considered needed to develop the necessary skills and practice.	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
			in relation to the overall environment, are expected to be within acceptable margins.		
	HP (Pilots' task performance) using new procedures	OBJ-0209-018	Errors and untimely actions related to the new concept as well as the level of workload and situational awareness are expected to be within acceptable margins.	The procedure design in the intermediate segment from BIVIO to FAF with several stepdown fixes increased the HP task performance, in terms of pilot workload, because the altitude changes for the fixes had to be flown manually by the pilot (no coding). The final segment did not involve any changes or deficit in pilot human performance in comparison to the normal RNAV approach	OK
	HP - Performance of the technical system - using new procedures	OBJ-0209-019	Pilot's performance is expected to be within acceptable margins, even in case of degraded accuracy and timeliness of system information.	Possible hazards and related mitigations have been identified such as in case of autopilot failure and GNSS system performance degradations. No anomalous behaviour occurred during the flight trials.	OK
EXE-02.09-D-002	Safety of PinS departures	OBJ-0209-011	No negative impact on the safety level of helicopter departure operations is expected in comparison with VFR operations in terms of pilots' error propensity, workload, situational awareness and timeliness of actions.	The flight trials demonstrate that for the PinS non-standard departure the safety level is expected to slightly increase with respect to current operations. However taking into account that non-standard design criteria have been adopted, safety implications and additional potential hazards need to be properly deepened.	OK
	Site availability using PinS departure	OBJ-0209-012	Increased site availability is expected in comparison with VFR operations in terms of	The average value of the pilots' feedback demonstrates that the new procedure will extend the site availability for departure	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
			IFR departures allowance during poor visibility with a reduced departure minimum cloud ceiling and minimum visibility.	operations also in bad weather conditions.	
	Environmental sustainability using PinS departure	OBJ-0209-013	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	The flight track for the PinS departure is longer than VFR one; the environmental impact is not reduced, but the availability of the airport will increase in bad weather and HEMS service availability is improved.	NOK
	Flight efficiency of PinS departure	OBJ-0209-014	An optimization of efficiency of HEMS operations is expected in terms of fuel consumption, mileage in comparison with VFR operations	Compared to VFR flights PinS departure procedure is less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless these new procedures are often the only solution to permit life-saving flights in IMC as they ensure the departure operation in emergencies /catastrophic situations.	NOK (aviation view in good VMC conditions) OK (humanitarian and economic views)
	HP - Operating methods - using new procedures	OBJ-0209-017	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods in relation to the overall environment, are expected to be within acceptable margins.	The changes in the current operating methods (basically the shift from visual to instrumental flight) are considered acceptable. Regular training is considered needed to develop the necessary skills and practice.	OK
	HP - Pilots' task performance -	OBJ-0209-018	Errors and untimely actions related to the new concept as	Some hazards have been identified to be mitigated by procedures design, training and	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
	using new procedures		well as the level of workload and situational awareness are expected to be within acceptable margins.	equipment maintenance. No significant impact on workload is expected. No impact on situation awareness is foreseen.	
	HP - Performance of the technical system – using new procedures	OBJ-0209-019	Pilot's performance is expected to be within acceptable margins, even in case of degraded accuracy and timeliness of system information.	Possible technical hazards have been identified (autopilot failure and the degradation of the system due to inadequate satellite position or coverage) and mitigations proposed (e.g. systems redundancy, failures related training). No anomalous behaviour occurred during the flight trials.	OK
EXE-02.09-D-003	Efficiency and HEMS service availability of heliport-to-hospital connection	OBJ-0209-015	Increase of HEMS service availability and an optimization of flight efficiency of HEMS operations is expected in terms of reduction of flight preparation time, mileage, flight duration and fuel consumption in comparison with VFR operations.	The new IFR connection provides the possibility to operate also in bad weather conditions, thus significantly increase the HEMS service availability, in particular in bad weather conditions, increasing the number of saved lives. Compared to VFR flights IFR heliport to heliport flights are less efficient in terms of flight time, limited to VMC conditions.	OK (humanitarian and economic views) Partially OK (aviation view in marginal VMC conditions)
	Predictability of heliport-to-hospital connection	OBJ-0209-016	Increased predictability in terms of adherence of the flown path to planned flight.	According to pilots an increment of the predictability with respect to the current operations is expected with the introduction of the new procedures. The results demonstrated that IFR GNSS navigation allows to increase the adherence to the nominal path and the possibility to precisely calculate the time needed to perform heliport to heliport HEMS	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
				operations.	
	HP (Operating methods) using new procedures	OBJ-0209-017	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods in relation to the overall environment, are expected to be within acceptable margins.	The changes introduced by the adoption of the new procedures are expected to be feasible, consistent and acceptable as with respect to current operating methods and to the overall operational environment	OK
	HP (Pilots' task performance) using new procedures	OBJ-0209-018	Errors and untimely actions related to the new concept as well as the level of workload and situational awareness are expected to be within acceptable margins.	Possible hazards have been identified to be mitigated by procedures design, training and equipment maintenance. No significant impact on workload is experienced. No impact on situation awareness is identified.	OK
	Safety of heliport-to-hospital connection	OBJ-0209-116	Increased safely level of helicopter RNP heliport to heliport connections enabled by GNSS is expected in comparison with VFR/VMC operations in terms of workload, situational awareness and timeliness of action.	The results of the data analysis demonstrate that the implementation of the Low Level IFR Route is expected to increase the safety level with respect to the current VFR operations	OK
EXE-02.09-D-004	Safety of PinS RNP APCH to LPV minima with GPA<6.3°	OBJ-0209-001	Increased safely level of helicopter approach operations is expected in comparison with VFR operations and approach	An improvement of the new procedure in terms of safety has been experimented.	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
			operations without vertical guidance in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action.		
	Site accessibility using PinS RNP APCH to LPV minima with GPA<6.3°	OBJ-0209-003	An increased heliport accessibility is expected in terms of increased landing possibility and reduction of number of diversions and missed approaches in comparison with VFR operations and approach operations without vertical guidance.	The accessibility is increased respect to the existing procedures. One of the benefits is the possibility to arrive closer to the landing point, thus improving landing site accessibility. The analysis of historical meteorological data (METAR) and the relation with the new approach minima, against existing ones, confirm the increase in accessibility in quantitative terms.	OK
	Environmental sustainability using PinS RNP APCH to LPV minima with GPA<6.3°	OBJ-0209-005	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	Since an IFR procedure generally includes more track miles the procedure itself does not allow a more environmental friendly operation, but the fact that the pilot can choose a direct routing in clouds instead of flying around the terrain when weather is below VFR minimum, can bring a benefit from an environmental point of view.	Partially OK (in marginal VFR)
	Flight efficiency of PinS RNP APCH to LPV minima with GPA<6.3°	OBJ-0209-007	An optimization of efficiency of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR	Compared to VFR flights (considering that there were not any LNAV approach procedures from the considered approach direction), PinS approach procedure is less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless this	NOK (aviation view in good VMC conditions) OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
			operations.	new procedure is an additional solution to permit life-saving flights in IMC as it ensures the approach operation in emergencies /catastrophic situations from an additional direction and with also lower minima. In the light of higher costs as a result of a significantly worse medical result due to a significant delay in the patient´s definitive treatment, the additional efforts of PinS RNP APCH to LPV minima in costs and environmental burden pay off from both a humanitarian as well as from an economic point of view.	(humanitarian and economic views)
	HP - Operating methods - using new procedures	OBJ-0209-017	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods in relation to the overall environment, are expected to be within acceptable margins.	Feedback from pilots not homogeneous, ranging from slight negative to positive impact but in any case within acceptable margins.	OK
	HP - Pilots' task performance - using new procedures	OBJ-0209-018	Errors and untimely actions related to the new concept as well as the level of workload and situational awareness are expected to be within acceptable margins.	Some hazards have been identified (e.g. colour coding) to be mitigated by procedures design, training and equipment maintenance. Improvements in the procedure design have been implemented. No significant impact on workload is experienced. No impact on situation awareness is identified.	OK
	HP - Performance of the technical	OBJ-0209-019	Pilot's performance is expected to be within	Possible technical hazards have been identified (autopilot failure and the degradation of the	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
	system - using new procedures		acceptable margins, even in case of degraded accuracy and timeliness of system information.	system due to inadequate satellite position or coverage) and mitigations proposed (e.g. systems redundancy, failures related training). No anomalous behaviour occurred during the flight trials.	
EXE-02.09-D-005	Safety of PinS departure	OBJ-0209-011	No negative impact on the safety level of helicopter departure operations is expected in comparison with VFR operations in terms of pilots' error propensity, workload, situational awareness and timeliness of actions.	The data collected during the flight trials show that a slight increase in safety level has been experienced with respect to the safety of current VFR operations. The possibility of having predefined routes is considered one of the benefits of the implementation of the new procedures.	OK
	Site availability of PinS departure	OBJ-0209-012	Increased site availability is expected in comparison with VFR operations in terms of IFR departures allowance during poor visibility with a reduced departure minimum cloud ceiling and minimum visibility.	The visibility requirement for VFR compared to PinS departure with *proceed VFR to the IDF* instruction is identical, but in the PinS departure it only needs to be considered in the visual segment of the departure and hence it is more likely to depart on an IFR than VFR flight in marginal VFR conditions. The analysis of historical meteorological data (METAR) and the relation with the new departure against existing ones, confirm the increase in site availability in quantitative terms.	Ok
	Environmental sustainability of PinS departure	OBJ-0209-013	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	Less noise to sensitive areas since the procedure is designed outside these areas.	Partially OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
	Flight efficiency of PinS departure	OBJ-0209-014	An optimization of efficiency of HEMS operations is expected in terms of fuel consumption, mileage in comparison with VFR operations.	This is valid for missions in the direction of the departure. More PinS departures from same location will increase efficiency.	OK
	HP (Operating methods) using new procedures	OBJ-0209-017	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods in relation to the overall environment, are expected to be within acceptable margins.	No negative impact or degradation with respect to the current operations is foreseen.	OK
	HP - Pilots' task performance - using new procedures	OBJ-0209-018	Errors and untimely actions related to the new concept as well as the level of workload and situational awareness are expected to be within acceptable margins.	Possible hazards have been identified to be mitigated by procedures design, training and equipment maintenance. Adjustments in the procedure design have been implemented. No significant impact on workload is experienced. No impact on situation awareness is identified.	OK
	HP (Performance of the technical system - using new procedures	OBJ-0209-019	Pilot's performance is expected to be within acceptable margins, even in case of degraded accuracy and timeliness of system information.	Possible technical hazards have been identified (autopilot failure and the degradation of the system due to inadequate satellite position or coverage) and mitigations proposed (e.g. systems redundancy, failures related training). No anomalous behaviour occurred during the flight trials.	OK
EXE-02.09-D-	Safety of PinS	OBJ-0209-001	Increased safely level of	An improvement of the new procedure in terms	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
006	RNP APCH to LPV minima with GPA<6.3°		helicopter approach operations is expected in comparison with VRF operations and approach operations without vertical guidance in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action.	of safety has been experimented.	
	Site accessibility using PinS RNP APCH to LPV minima with GPA<6.3°	OBJ-0209-003	Increased heliport accessibility is expected in terms of increased landing possibility and reduction of number of diversions and missed approaches in comparison with VFR operations and approach operations without vertical guidance.	The accessibility is increased respect to the existing procedures. One of the benefits is the possibility to arrive closer to the landing point, thus improving landing site accessibility.	OK
	Environmental sustainability for PinS RNP APCH to LPV minima with GPA<6.3°	OBJ-0209-005	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	The procedure itself does not introduce a more environmental friendly operation, but the fact that the pilot can choose a direct routing in clouds instead of flying around the terrain when weather is below VFR minimum, can bring a benefit from an environmental point of view. Furthermore, a steeper approach is more silent than a normal VFR approach.	Partially OK (in marginal VFR)
	Efficiency of PinS RNP APCH to LPV	OBJ-0209-007	An optimization of efficiency	Compared to VFR flights (considering that there were not any LNAV approach procedures from	NOK (aviation view in good

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
	minima with GPA<6.3°		of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR operations.	the considered approach direction), PinS approach procedure is less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless this new procedure is an additional solution to permit life-saving flights in IMC as it ensures the approach operation in emergencies /catastrophic situations from an additional direction and with also lower minima. In the light of higher costs as a result of a significantly worse medical result due to a significant delay in the patient´s definitive treatment, the additional efforts of PinS RNP APCH to LPV minima in costs and environmental burden pay off from both a humanitarian as well as from an economic point of view.	VMC conditions) OK (humanitarian and economic views)
	HP - Operating methods - using new procedures	OBJ-0209-017	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods in relation to the overall environment, are expected to be within acceptable margins.	The changes introduced by the adoption of the new procedures are expected to be feasible, consistent and acceptable as with respect to current operating methods and to the overall operational environment	OK
	HP - Pilots' task performance - using new procedures	OBJ-0209-018	Errors and untimely actions related to the new concept as well as the level of workload	Workload is expected to increase in the phase of preparation to the landing with respect to the current operations, while less workload is	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
			and situational awareness are expected to be within acceptable margins.	expected in the landing phase. Some aspects which can trigger errors have been identified (e.g. colour coding). Pilots' performance is expected to remain within acceptable margins.	
	HP - Performance of the technical system - using new procedures	OBJ-0209-019	Pilot's performance is expected to be within acceptable margins, even in case of degraded accuracy and timeliness of system information.	Possible technical hazards have been identified (autopilot failure and the degradation of the system due to inadequate satellite position or coverage) and mitigations proposed (e.g. the use of contingency procedures, the activation of warnings in case of loss of signals and the regular training of pilots). No anomalous behaviour occurred during the flight trials.	
EXE-02.09-D-007	Safety of PinS RNP APCH to LPV minima with GPA>6.3°	OBJ-0209-002	Increased safely level of helicopter approach operations is expected in comparison with VFR/VMC operations in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action.	The results confirmed a slight positive impact in terms of several indicators used for the assessment. The safety improvement is mainly in bad weather conditions and during night operations. In IMC condition the procedure contributes to the increase of inter hospital transfer possibilities which otherwise would not be for helicopter.	OK
	Site accessibility using PinS RNP APCH to LPV minima with GPA>6.3°	OBJ-0209-004	An increase in airport accessibility is expected in terms of increased landing possibility and reduction of number of diversions and missed approaches in comparison with VFR operations.	The average value of the pilots' feedback demonstrates that the new procedure permits to fly through a cloud or fog layer, when there are bad weather conditions thus improving site accessibility. However the improvement is very limited due to the high value of the LPV minima reached because of the challenging environment.	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
	Environmental sustainability of PinS RNP APCH to LPV minima with GPA>6.3°	OBJ-0209-006	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	The flight track for the PinS RNP APCH to LPV minimum procedure is longer compared to VFR approach; the environmental impact is not reduced but the accessibility to the airport will increase in bad weather and HEMS service sustainability is positively affected.	NOK
	Flight efficiency of PinS RNP APCH to LPV minima with GPA>6.3°	OBJ-0209-008	An optimization of efficiency of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR operations.	Compared to VFR flights PinS RNP APCH to LPV minimum procedures are less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless these new procedures are often the only solution to permit life-saving flights in IMC as they ensure the access to hospitals and airports in emergencies /catastrophic situations. In the light of higher costs as a result of a significantly worse medical result due to a significant delay in the patient´s definitive treatment, the additional efforts of PinS RNP APCH to LPV minimum procedures in costs and environmental burden pay off from both a humanitarian as well as from an economic point of view.	NOK (aviation view in good VMC conditions) OK (humanitarian and economic views)
	HP - Operating methods - using new procedures	OBJ-0209-017	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods in relation to the overall environment, are expected to	The changes in the current operating methods (basically the shift from visual to instrumental flight) are considered acceptable. Regular training is considered needed to develop the necessary skills and practice.	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
			be within acceptable margins.		
	HP - Pilots' task performance - using new procedures	OBJ-0209-018	Errors and untimely actions related to the new concept as well as the level of workload and situational awareness are expected to be within acceptable margins.	Possible hazards have been identified to be mitigated by procedures design, training and equipment maintenance. A positive impact on workload is experienced. No impact on situation awareness is identified.	OK
	HP - Performance of the technical system - using new procedures	OBJ-0209-019	Pilot's performance is expected to be within acceptable margins, even in case of degraded accuracy and timeliness of system information.	Possible technical hazards have been identified (autopilot failure and the degradation of the system due to inadequate satellite position or coverage) and mitigations proposed (e.g. the use of contingency procedures, the activation of warnings in case of loss of signals and the regular training of pilots). No anomalous behaviour occurred during the flight trials.	OK
EXE-02.09-D-008	Safety of PinS departure	OBJ-0209-011	No negative impact on the safety level of helicopter departure operations is expected in comparison with VFR operations in terms of pilots' error propensity, workload, situational awareness and timeliness of actions.	A slight improvement of the new procedure in terms of safety has been experimented.	OK
	Site availability of PinS departure	OBJ-0209-012	Increased site availability is expected in comparison with VFR operations in terms of IFR departures allowance	The average value of the pilots' feedback demonstrates that the new procedure will extend the site availability for departure operations also in bad weather conditions.	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
			during poor visibility with a reduced departure minimum cloud ceiling and minimum visibility.		
	Environmental sustainability of PinS departure	OBJ-0209-013	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	The flight track for the PinS departure is longer than VFR one; the environmental impact is not reduced, but the availability of the airport will increase in bad weather and HEMS service sustainability is positively affected.	NOK
	Flight efficiency of PinS departure	OBJ-0209-014	An optimization of efficiency of HEMS operations is expected in terms of fuel consumption, mileage in comparison with VFR operations.	Compared to VFR flights PinS departure procedure is less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless these new procedures are often the only solution to permit life-saving flights in IMC as they ensure the departure operation in emergencies /catastrophic situations.	NOK (aviation view in good VMC conditions) OK (humanitarian and economic views)
	HP (Operating methods) using new procedures	OBJ-0209-017	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods in relation to the overall environment, are expected to be within acceptable margins.	The changes in the current operating methods (basically the shift from visual to instrumental flight) are considered acceptable. Regular training is considered needed to develop the necessary skills and practice.	OK
	HP - Pilots' task	OBJ-0209-018	Errors and untimely actions	Possible hazards have been identified to be	OK

Exercise ID	Demonstration Objective Title	Demonstration Objective ID	Success Criterion	Exercise Results	Demonstration Objective Status
	performance - using new procedures		related to the new concept as well as the level of workload and situational awareness are expected to be within acceptable margins.	mitigated by procedures design, training and equipment maintenance. No relevant impact on workload is experienced. No impact on situation awareness is identified.	
	HP - Performance of the technical system - using new procedures	OBJ-0209-019	Pilot's performance is expected to be within acceptable margins, even in case of degraded accuracy and timeliness of system information.	Possible technical hazards have been identified (autopilot failure and the degradation of the system due to inadequate satellite position or coverage) and mitigations proposed (e.g. the use of contingency procedures, the activation of warnings in case of loss of signals and the regular training of pilots). No anomalous behaviour occurred during the flight trials.	OK

Table 16: Summary of Demonstration Exercises Results

5.2 Choice of metrics and indicators

Objective ID	KPA	Success Criterion / Expected Benefit	Result of the demonstration
OBJ-0209-001	Safety	Increased safely level of helicopter approach operations is expected in comparison with VFR operations and approach operations without vertical guidance in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action.	The result is an increase of Safety level, of the new approach operations. Significant safety improvements have been reached through the adoption of the 3D final segment up to a lower landing minima (LPV minima), using the service augmentation provided by EGNOS system and the related ILS-like vertical guidance for a more precise final approach.
OBJ-0209-002	Safety	Increased safely level of helicopter approach operations is expected in comparison with VFR/VMC operations in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action.	The results confirmed a slight positive impact in terms of several indicators used for the assessment. The safety improvement is mainly in bad weather conditions and during night operations. In IMC condition the procedure contributes to the increase of inter hospital transfer possibilities which otherwise would not be for helicopter.
OBJ-0209-003	Accessibility	Increased heliport accessibility is expected in terms of increased landing possibility and reduction of number of diversions and missed approaches in comparison with VFR operations and approach operations without vertical guidance.	The average value of the pilots' feedback demonstrates that the new procedure permits to fly through a cloud or fog layer, when there are bad weather conditions thus improving site accessibility. However the improvement is very limited due to the high value of the LPV minima reached because of the challenging environment.
OBJ-0209-004	Accessibility	An increase in airport accessibility is expected in terms of increased landing possibility and reduction of number of	The results confirmed the accessibility is

		diversions and missed approaches in comparison with VFR operations.	increased respect to the existing procedures. One of the benefits is the possibility to arrive closer to the landing point, thus improving landing site accessibility and reducing the number of diversions and missed approaches. However the improvement is very limited due to the high value of the LPV minima reached because of the challenging environment.
OBJ-0209-005	Environmental Sustainability	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	The new procedures did not allow more environmental friendly operations. IFR procedure generally includes more track miles. However the fact that the pilot can chose a direct routing in clouds instead of flying around the terrain when weather is below VFR minimum, can bring a benefit from an environmental point of view.
OBJ-0209-006	Environmental Sustainability	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	The flight track for the PinS RNP APCH to LPV minimum procedure is longer compared to VFR approach; the environmental impact is not reduced but the accessibility to the airport will increase in bad weather and HEMS service availability.
OBJ-0209-007	Efficiency	An optimization of efficiency of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR operations.	The results showed that, limited to VMC conditions. PinS approach procedures are less efficient in terms of flight time, compared to VFR flights. Nevertheless this new procedure is an additional solution to permit life-saving flights in IMC as it ensures the approach operation in emergencies /catastrophic situations from an additional direction and with also lower minima. In the light of higher costs as a result of a significantly worse medical result due to a significant delay in

			the patient´s definitive treatment, the additional efforts of PinS RNP APCH to LPV minima in costs and environmental burden pay off from both a humanitarian as well as from an economic point of view.
OBJ-0209-008	Efficiency	An optimization of efficiency of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR operations.	The results showed that, limited to VMC conditions .PinS approach procedures are less efficient in terms of flight time, compared to VFR flights. Nevertheless this new procedure is an additional solution to permit life-saving flights in IMC as it ensures the approach operation in emergencies /catastrophic situations from an additional direction and with also lower minima. In the light of higher costs as a result of a significantly worse medical result due to a significant delay in the patient´s definitive treatment, the additional efforts of PinS RNP APCH to LPV minima in costs and environmental burden pay off from both a humanitarian as well as from an economic point of view.
OBJ-0209-010	Accessibility	An increase in airport accessibility is expected in terms of increased landing possibility and reduction of number of diversions and missed approaches in comparison with VFR approaches.	The average value of the pilots' feedback demonstrates that the new procedures will permit to fly through a cloud or fog layer, when there are bad weather conditions thus improving site accessibility, reducing diversions and missed approaches.
OBJ-0209-011	Safety	No negative impact on the safety level of helicopter departure operations is expected in comparison with VFR operations in terms of pilots' error propensity, workload, situational awareness and timeliness of actions.	The average results confirmed a slight positive impact in terms of several indicators used for the assessment. A low increase of safety is noted, compared to the VFR/VMC condition in day operations During night time, the improvement in terms of safety is higher.

OBJ-0209-012	Availability	Increased site availability is expected in comparison with VFR operations in terms of IFR departures allowance during poor visibility with a reduced departure minimum cloud ceiling and minimum visibility.	The increase of the availability for all the sites under assessment has been demonstrated.
OBJ-0209-013	Environmental Sustainability	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations	The flight track for the PinS departure is longer than VFR one; the environmental impact is not reduced, but the availability of the airport will increase in bad weather and HEMS service availability is improved.
OBJ-0209-014	Efficiency	An optimization of efficiency of HEMS operations is expected in terms of fuel consumption, mileage in comparison with VFR operations.	Compared to VFR flights PinS departure procedure is less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless these new procedures are often the only solution to permit life-saving flights in IMC as they ensure the departure operation in emergencies/catastrophic situations.
OBJ-0209-015	Efficiency and service availability	An optimization of flight efficiency of HEMS operations is expected in terms of reduction of flight preparation time, mileage, flight duration and fuel consumption in comparison with VFR operations.	IFR connection provides the possibility to operate also in bad weather conditions, thus significantly increase the HEMS service availability, in particular in bad weather conditions, increasing the number of saved lives.
OBJ-0209-016	Predictability	Increased predictability in terms of adherence of the flown path to planned flight.	The results demonstrated that IFR GNSS navigation allows to increase the adherence to the nominal path and the possibility to precisely calculate the time needed to perform heliport to heliport HEMS operations.
OBJ-0209-017	HP (Operating methods)	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods in relation to the overall environment, are expected to be within acceptable margins.	The changes in operating methods introduced by the new procedures do not have a negative impact on the flight operations. It was demonstrated that the feasibility, consistency and acceptability remain in admissible margins.
OBJ-0209-018	HP	Errors and untimely actions related to the new concept as	The new procedures demonstrate that errors

	(Pilots' task performance)	well as the level of workload and situational awareness are expected to be within acceptable margins.	and untimely actions related to the new concept, the level of workload and situational awareness do not overcome the acceptable margins.
OBJ-0209-019	HP (Performance of the technical system)	Pilot's performance is expected to be within acceptable margins, even in case of degraded accuracy and timeliness of system information.	Technical hazards have been identified and mitigations proposed that will allow pilots' performance to remain within acceptable margins in case of technical failures.
OBJ-0209-102	Safety	Increased safely level of helicopter approach operations is expected in comparison with current VFR/VMC operations in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action.	The average result shows a slight increase of safety level in comparison with current VFR operations. Several RNP APCH AR approach procedures have been designed and flown with different operational feedback by the pilots. New procedures are considered safer than the current ones are especially marginal weather situations and night operations
BJ-0209-106	Environmental Sustainability	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.	The flight track for the RNP AR procedure is longer and the approach speed is slower compared to VFR approach. The environmental impact is not reduced but the accessibility to and from the airport will increase in bad weather.
OBJ-0209-108	Efficiency	An optimization of efficiency of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR operations.	the new procedure has a negative impact on efficiency, as the IFR approach requires more miles to be flown and takes more time with respect to current VFR operations. Nevertheless, pilots consider this value acceptable because the current procedure cannot be flown in bad visibility conditions, so its efficiency, during bad weather, is zero; with the new procedure, even if the flight time increases, pilots will be able to operate in adverse weather conditions, thus increasing the number of missions performed.

OBJ-0209-116	Safety	Increased safely level of helicopter RNP heliport to heliport connections enabled by GNSS is expected in comparison with VFR/VMC operations in terms of workload, situational awareness and timeliness of action.	The results of the data analysis demonstrate that, the implementation of the Low Level IFR Route is expected to increase the safety level with respect to the current VFR operations mainly in bad visibility conditions.

Table 17: Summary of metrics and indicators

5.3 Summary of Assumptions

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASP-0209-001	VFR/VMC conditions - Swiss Scenarios	Simulated IFR	The live trials of the new RNP PinS departure and approach procedures for PROuD will be flown for the demonstration flights in good visibility conditions (VFR/VMC) although they will be executed as simulated IFR.	VFR/VMC conditions are required for the live trials in simulated IFR, purely for safety reasons.	Approach/ Departure/ En-Route	Safety	Project Team	N/A	Skyguide	L

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
ASP-0209-002	Input data for flight procedure Design – Swiss Scenario	Input data availability	Input data for flight procedure design will respect ICAO accuracy and resolution requirements	The quality of the new flight procedure heavy depends on the data used for flight procedure design	Approach/ Departure/	Safety	Project Team	N/A	Skyguide	M
ASP-0209-003	Input data for flight procedure Design – Norwegian Scenarios	Input data availability	Input data for flight procedure design will respect ICAO accuracy and resolution requirements	The quality of the new flight procedure heavily depends on the data used for flight procedure design	Approach/ Departure/	Safety	Project Team	N/A	NLA	M

Table 18: Demonstration Assumptions

5.3.1 Results per KPA

Since each PROuD objective maps to one specific KPA, please refer to results provided in Table 16 (the KPA is contained in "Demonstration Objective Title") and in Table 17.

5.3.2 Impact on Safety, Capacity and Human Factors

Please refer to results provided in Table 17.

5.3.3 Description of assessment methodology

For each Validation Objective, relevant KPIs have been collected.

Some of them are qualitative (e.g. "noise footprint"), while some others are quantitative (e.g. meteorological data). Some of them are objective measurements taken during the flight trials (e.g. flight track adherence) while some others are subjective estimations given by pilots by means of questionnaires and debriefings (e.g. Flight crew subjective feedback on Safety or Workload).

The different KPIs collected (see Table 18) have been combined to express a feedback on each KPAs. When all indicators were coherent in demonstrating that the Success Criterion has been reached, the OK status has been assigned to the Validation Objective.

When indicators demonstrated that the Success Criterion was not reached, we assigned the NOK status.

For some Validation Objectives, some indicators reached the Success Criterion threshold while some others no. In these cases we assigned both the OK and NOK status, specifying the respective indicators (see Table 16).

For each Validation Objective, also a summary of the related results has been provided, presenting the results of the demonstration for that specific objective, briefly explaining the main and more relevant findings (see Table 17).

5.3.4 Results impacting regulation and standardisation initiatives

The experience gained during the procedure design process indicates that in a demanding terrain environment like the Swiss Alps, operationally acceptable approach minima may not be achieved with PinS LPV procedures for helicopters. Dedicated helicopter RNP AR procedures criteria must be established to achieve that. The capabilities of modern light weight avionic systems must be taken in consideration for redundant requirements.

Experience gathered with the RNP AR procedure in Samedan is fed into the ICAO IFPP for improvement of the current RNP AR design criteria and their extension to support helicopter PinS type of procedures.

The procedure design trials have also revealed that, based on today's set of navigation specifications and procedure design criteria, no fully compliant and operationally acceptable departure procedure can be accommodated in certain demanding terrain environments such as the Engadin valley. It is an example of a terrain environment where procedure design criteria based on a more demanding navigation specification could prove its benefit. The capabilities of modern light weight avionic systems and MTBF capability should be taken in consideration for redundant requirements.

In ICAO PANS OPS 8168 vol 2 part 4 chapter 2.10 "Proceed VFR" for the visual maneuvering both for departure and approach should be more precisely defined. The VFR definition seems quite binding to strict; in order to ease the access to this kind of operation, there should be stated that only the visibility (horizontal and/or ceiling) requirement is regulatory. When the procedure is "Proceed VFR" – it should be possible to publish a night time minima. It is suggested to submit the request to competent panel (e.g. IFPP) to discuss this possibility and to define the value to be added to MDA (e.g. 100ft), taking into account the operational scenario.

In order to foster the implementation of the new PinS Procedures in location without Weather reporting facilities, REGA (as a member of the EASA Helicopter AWO RMT WG) recommends to include in the EASA CAT.OP.MPA.300 and/or CAT.OP.MPA.305 the content reported in the following section, based on the current FAA Part135.611 and 135.213.

IFR operations at locations without weather reporting

(a) If a certificate holder is authorized to conduct helicopter IFR operations, the Agency may authorize the certificate holder to conduct IFR helicopter air ambulance operations at airports with an instrument approach procedure and at which a weather report is not available from the national weather service, a source approved by the national weather service, or a source approved by the NAA, subject to the following limitations:

(1) The certificate holder must obtain a weather report from a weather reporting facility operated by the national weather service, a source approved by the national weather service, or a source approved by the NAA, that is located within 15 nautical miles of the airport. If a weather report is not available, the certificate holder may obtain the area forecast from the national weather service, a source approved by the national weather service, or a source approved by the NAA, for information regarding the weather observed in the vicinity of the airport;

(2) Flight planning for IFR flights conducted under this paragraph must include selection of an alternate airport and unless otherwise authorized by the Agency, no person may include an alternate airport in an IFR flight plan unless this airport is a complies with CAT.OP.MPA.107 and there is enough fuel to reach the alternate airport

(3) In Class G airspace, IFR departures with visual transitions are authorized only after the pilot in command determines that the weather conditions at the departure point are at or above takeoff minimums depicted in the published Obstacle Departure Procedure or VFR minimum ceilings and visibilities in accordance with SPA.HEMS.120.

(4) All approaches must be conducted at Category A approach speeds as required for the type of approach being used.

(b) Pilots conducting operations pursuant to this section may use the weather information obtained in paragraph (a) to satisfy the weather report and forecast requirements.

(c) After completing a landing at the airport at which a weather report is not available, the pilot in command is authorized to determine if the weather meets the takeoff requirements of the certificate holder's operations specification, as applicable.

[135.611 Doc. No. FAA–2010–0982, 79 FR 9975, Feb. 21, 2014, as amended by Amdt. 135–131, 79 FR 43622, July 28, 2014]

5.4 Analysis of Exercises Results

The following table presents the indicators measured. Some of them are qualitative (e.g. “noise footprint”), while some others are quantitative (e.g. meteorological data). Some of them are objective measurements taken during the flight trials (e.g. flight track adherence) while some others are subjective estimations given by pilots by means of questionnaires and debriefings (e.g. Flight crew subjective feedback on Safety or Workload). The methods used for data collection and analysis have been presented in paragraph 4.1.3.

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
EXE-02.09-D-001	OBJ-0209-102	SCN-0209-001	Samedan airport	Safety	• Flight crew subjective feedback	3,33/5 First campaign 3,25/5 Second campaign
					• Flight crew situation awareness	3,17/5 First campaign 3/5 Second campaign
					• Flight crew workload	4,33/5 First campaign 2,75/5 Second campaign
					• Flight track adherence	See 6.1.3.1.1.1 First campaign See 6.1.3.1.2.1 Second campaign
EXE-02.09-D-001	OBJ-0209-010	SCN-0209-001	Samedan airport	Accessibility	• Flight crew subjective feedback	+23% First campaign +33% Second campaign
EXE-02.09-D-001	OBJ-0209-106	SCN-0209-001	Samedan airport	Environmental sustainability	• Emissions per flight • Noise footprint	See 6.1.3.1.1.3 First campaign See 6.1.3.1.2.3 Second campaign
EXE-02.09-D-001	OBJ-0209-108	SCN-0209-001	Samedan airport	Efficiency	• Flight crew subjective feedback	See 6.1.3.1.1.4 First campaign 6.1.3.1.2.4 Second campaign
EXE-02.09-	OBJ-0209-	SCN-0209-	Samedan	Human performance (Operating	• Flight crew subjective	2,83/5 First campaign

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
D-001	017	001	airport	methods)	feedback	2,5/5 Second campaign
EXE-02.09-D-001	OBJ-0209-018	SCN-0209-001	Samedan airport	Human performance (Pilots' task performance)	• Flight crew subjective feedback	Some issues identified (similar to any other IFR procedure)
					• Flight crew workload	4,33/5 First campaign 2,75/5 Second campaign
					• Flight crew situation awareness	3,17/5 First campaign 3/5 Second campaign
EXE-02.09-D-001	OBJ-0209-019	SCN-0209-001	Samedan airport	Human performance (Performance of the technical system)	• Total System Error (TSE) cross track	See 6.1.3.1.1.1 First campaign See 6.1.3.1.2.1 Second campaign
					• Navigation System Error (NSE)	See 6.1.3.1.1.7 First campaign 6.1.3.1.2.7 Second campaign
					• Flight crew subjective feedback	6.1.3.1.1.7 First campaign See 6.1.3.1.2.7 Second campaign
EXE-02.09-D-002	OBJ-0209-111	SCN-0209-001	Samedan airport	Safety	• Flight crew subjective feedback	3,5/5
					• Flight crew situation awareness	3,17/5
					• Flight crew workload	3,33/5
					• Flight track adherence	See 6.2.3.1.1.1

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
EXE-02.09-D-002	OBJ-0209-012	SCN-0209-001	Samedan airport	Availability	• Flight crew subjective feedback	+23%
EXE-02.09-D-002	OBJ-0209-013	SCN-0209-001	Samedan airport	Environmental Sustainability	• Emissions per flight • Noise footprint	See 6.2.3.1.1.3
EXE-02.09-D-002	OBJ-0209-014	SCN-0209-001	Samedan airport	Efficiency	• Flight crew subjective feedback	See 6.2.3.1.1.4
EXE-02.09-D-002	OBJ-0209-017	SCN-0209-001	Samedan airport	Human Performance (Operating Methods)	• Flight crew subjective feedback	2,83/5
EXE-02.09-D-002	OBJ-0209-018	SCN-0209-001	Samedan airport	Human Performance (Pilots' task performance)	• Flight crew subjective feedback	Some issues identified (similar to any other IFR procedure)
					• Flight crew workload	3.33/5
					• Flight crew situation awareness	3,17/5
EXE-02.09-D-002	OBJ-0209-019	SCN-0209-001	Approach Samedan	Human Performance (Performance of the technical system)	Total System Error (TSE) cross track	See 6.2.3.1.1.1
					• Navigation System Error (NSE)	See 6.2.3.1.1.7
					• Flight crew subjective feedback	See 6.2.3.1.1.7
EXE-02.09-D-003	OBJ-0209-116	SCN-0209-005	Heliport-to-hospital	Safety	• Flight crew subjective feedback	3,67/5
					• Flight crew workload	2,83/5

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
					• Flight crew situation awareness	3,17/5
					• Flight track adherence	See 6.3.3.1.1.1
EXE-02.09-D-003	OBJ-0209-015	SCN-0209-005	Heliport-to-hospital	Efficiency and service availability	• Flight crew subjective feedback	See 6.3.3.1.1.2
EXE-02.09-D-003	OBJ-0209-016	SCN-0209-005	Heliport-to-hospital	Predictability	• Flight crew subjective feedback	+18,33%
					• Flight track adherence	See 6.3.3.1.1.1
EXE-02.09-D-003	OBJ-0209-017	SCN-0209-001	Samedan airport	Human Performance (Operating Methods)	• Flight crew subjective feedback	2,83/5
EXE-02.09-D-003	OBJ-0209-018	SCN-0209-001	Samedan airport	Human Performance (Pilots' task performance)	• Flight crew subjective feedback	No issues identified
					• Flight crew workload	2,83/5
					• Flight crew situation awareness	3,17/5
EXE-02.09-D-004	OBJ-0209-001	SCN-0209-003	Lørenskog heliport	Safety	• Flight crew subjective feedback	3,09/5
					• Flight crew workload	2,63/5
					• Flight crew situational awareness	3,08/5
					• Flight track adherence	See 6.3.3.1.1.1

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
EXE-02.09-D-004	OBJ-0209-003	SCN-0209-003	Lørenskog heliport	Accessibility	• Flight crew subjective feedback	+18%
					• Meteo data analysis	See 6.4.3.1.1.2
EXE-02.09-D-004	OBJ-0209-005	SCN-0209-003	Lørenskog heliport	Environmental Sustainability	• Emissions per flight • Noise footprint • Flight track adherence	See 6.4.3.1.1.3
EXE-02.09-D-004	OBJ-0209-007	SCN-0209-003	Lørenskog heliport	Efficiency	• Mileage • Time to land • Fuel consumption • Flight crew subjective feedback	See 6.4.3.1.1.4
EXE-02.09-D-004	OBJ-0209-017	SCN-0209-004	Lørenskog heliport	Human Performance (Operating Methods)	• Flight crew subjective feedback	2,82/5
EXE-02.09-D-004	OBJ-0209-018	SCN-0209-004	Lørenskog heliport	Human Performance (Pilots' task performance)	• Flight crew subjective feedback	See 6.4.3.1.1.6
					• Flight crew workload	2,63/5
					• Flight crew situation awareness	3,08/5
EXE-02.09-D-004	OBJ-0209-019	SCN-0209-004	Lørenskog heliport	Human Performance (Performance of the technical	• Flight Technical Error (FTE) cross track	6.3.3.1.1.1

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
				system)	• Flight crew subjective feedback	Pilots' feedback was positive, with a high success rate of the operations, in situations of a system failure.
EXE-02.09-D-005	OBJ-0209-011	SCN-0209-003	Lørenskog heliport	Safety	• Flight crew subjective feedback	3,42/5
					• Flight crew workload	2,60/5
					• Flight crew situational awareness	3,08/5
					• Flight track adherence	See 6.5.3.1.1.1
EXE-02.09-D-005	OBJ-0209-012	SCN-0209-003	Lørenskog heliport	Availability	• Meteo data analysis	N.A.
					• Flight crew subjective feedback	+22%
EXE-02.09-D-005	OBJ-0209-013	SCN-0209-003	Lørenskog heliport	Environmental sustainability	• Emissions per flight • Noise footprint: • Flight track adherence	See 6.5.3.1.1.3
EXE-02.09-D-005	OBJ-0209-014	SCN-0209-003	Lørenskog heliport	Efficiency	• Mileage • Fuel consumption • Time to land • Flight crew subjective feedback	See 6.5.3.1.1.4

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
EXE-02.09-D-005	OBJ-0209-017	SCN-0209-001	Lørenskog heliport	Human Performance (Operating Methods)	• Flight crew subjective feedback	2,82/5
EXE-02.09-D-005	OBJ-0209-018	SCN-0209-001	Lørenskog heliport	Human Performance (Pilots' task performance)	• Flight crew subjective feedback	Some issues identified (similar to any other IFR procedure)
					• Flight crew workload	2,60/5
					• Flight crew situation awareness	3,08/5
EXE-02.09-D-006	OBJ-0209-001	SCN-0209-004	Ullevål heliport	Safety	• Flight crew subjective feedback	3,27
					• Flight crew workload	3/5
					• Flight crew situational awareness	3,08/5
					• Flight track adherence	See 6.6.3.1.1.1
					• Operational errors' propensity	See 6.6.3.1.1.7
EXE-02.09-D-006	OBJ-0209-003	SCN-0209-004	Ullevål heliport	Accessibility	• Flight crew subjective feedback	+18%
EXE-02.09-D-006	OBJ-0209-005	SCN-0209-004	Ullevål heliport	Environmental sustainability	• Emissions per flight • Noise footprint	See 6.6.3.1.1.3
EXE-02.09-D-006	OBJ-0209-007	SCN-0209-004	Ullevål heliport	Efficiency	• Flight crew subjective feedback	See 6.6.3.1.1.4
EXE-02.09-	OBJ-0209-	SCN-0209-	Ullevål	Human Performance (Operating	• Flight crew subjective	2,82/5

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
D-006	017	001	heliport	Methods)	feedback	
EXE-02.09-D-006	OBJ-0209-018	SCN-0209-001	Ullevål heliport	Human Performance (Pilots' task performance)	• Flight crew subjective feedback	Some issues identified (similar to any other IFR procedure)
					• Flight crew workload	3/5
					• Flight crew situation awareness	3,08/5
EXE-02.09-D-006	OBJ-0209-019	SCN-0209-001	Ullevål heliport	Human Performance (Performance of the technical system)	• Flight Technical Error (FTE) cross track.	See 6.6.3.1.1.1
					• Flight crew subjective feedback	Pilots' feedback was positive, with a high success rate of the operations, in situations of a system failure.
EXE-02.09-D-007	OBJ-0209-002	SCN-0209-006	Chur hospital	Safety	• Flight crew subjective feedback	3,17/5
					• Flight crew workload	3,83/5
					• Flight crew situational awareness	3,17/5
					• Flight tack adherence	See 6.7.3.1.1.1
EXE-02.09-D-007	OBJ-0209-004	SCN-0209-006	RNP APCH approach Chur	Accessibility	• Flight crew subjective feedback	+23%

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
EXE-02.09-D-007	OBJ-0209-006	SCN-0209-006	Chur hospital	Environmental sustainability	• Emissions per flight	See 6.7.3.1.1.3
					• Noise footprint	
EXE-02.09-D-007	OBJ-0209-008	SCN-0209-006	Chur hospital	Efficiency	• Flight crew subjective feedback	See 6.7.3.1.1.4
EXE-02.09-D-007	OBJ-0209-017	SCN-0209-001	Chur hospital	Human Performance (Operating Methods)	• Flight crew subjective feedback	2,83/5
EXE-02.09-D-007	OBJ-0209-018	SCN-0209-001	Chur hospital	Human Performance (Pilots' task performance)	• Flight crew subjective feedback	The probability that the hazards identified can occur is reduced by the design of the new procedures
					• Flight crew workload	3,83/5
					• Flight crew situation awareness	3,17/5
EXE-02.09-D-007	OBJ-0209-019	SCN-0209-001	Chur hospital	Human Performance (Performance of the technical system)	• Total System Error (TSE) cross track	See 6.7.3.1.1.1
					• Navigation System Error (NSE)	See 6.7.3.1.1.7
					• Flight crew subjective feedback	Pilots' feedback was positive, with a high success rate of the operations, in situations of a system failure.
EXE-02.09-	OBJ-0209-	SCN-0209-	Chur hospital	Safety	• Flight crew subjective	3,33

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
D-008	011	006			feedback	
					• Flight crew workload	3,17/5
					• Flight crew situational awareness	3,17/5
					• Flight track adherence	See 6.8.3.1.1.1
EXE-02.09-D-008	OBJ-0209-012	SCN-0209-006	Chur hospital	Availability	• Flight crew subjective feedback	+23%
EXE-02.09-D-008	OBJ-0209-013	SCN-0209-006	PinS departure Chur	Environmental Sustainability	• Emissions per flight • Noise footprint	See 6.8.3.1.1.3
EXE-02.09-D-008	OBJ-0209-014	SCN-0209-006	Chur hospital	Efficiency	• Flight crew subjective feedback	See 6.8.3.1.1.4
EXE-02.09-D-008	OBJ-0209-017	SCN-0209-001	Chur hospital	Human Performance (Operating Methods)	• Flight crew subjective feedback	2,83/5
EXE-02.09-D-008	OBJ-0209-018	SCN-0209-001	Chur hospital	Human Performance (Pilots' task performance)	• Flight crew subjective feedback	The probability that the hazards identified can occur is reduced by the design of the new procedures.
					• Flight crew workload	3,83/5
					• Flight crew situation awareness	3,17/5
EXE-02.09-D-008	OBJ-0209-019	SCN-0209-001	Chur hospital	Human Performance (Performance of the technical	• Total System Error (TSE) cross track	See 6.8.3.1.1.1

Exercise ID	Objective ID	Scenario ID	Scenario Title	KPA	KPI ID	Measure Value
				system)		
					• Navigation System Error (NSE)	See 6.8.3.1.1.7
					• Flight crew subjective feedback	Pilots' feedback was positive, with a high success rate of the operations, in situations of a system failure.

Table 19: Performance Indicators

5.4.1 Unexpected Behaviours/Results

For the Samedan scenario, a new type of procedure has been designed and flown: helicopter RNP AR APCH procedure. The adoption of this more demanding procedure during the first Samedan campaign highlighted the need to perform some software adaptations to the flight inspection platform in order to allow the required processing activities for the evaluation of the on-board navigation performance. Indeed, a second flight campaign has been performed to fly additional RNP AR APCH procedures in Samedan scenario using the updated Flight Inspection console in April 2016. Details are reported in 6.1.3.1.4.

5.5 Confidence in Results of Demonstration Exercises

5.5.1 Quality of Demonstration Exercises Results

The Swiss flight campaigns were performed using Rega's AW109SP helicopter. This helicopter is equipped with ETSO-C146 certified GPS/SBAS receivers and is already approved by FOCA for operational procedure under RNP 0.3 and RNP APCH operations (as per the following documents: FAA AC 20 138D and ICAO DOC 9613 PBN, Chapter 7). Swiss flight data was collected on board the Rega helicopter from a geodetic JAVAD receiver and a set of additional flight inspection equipment provided by Flight Calibration Service GmbH. Details are reported in 6.1.3.1.5

The Norwegian flight campaign was performed using the AIRBUS H135T3 helicopter. A qualified flight validation pilot was riding along together with test flight pilot and test flight engineer from Airbus helicopters. Regarding the on board equipment for data acquisition and analysis, the Trimble and NAVSCOPE 7.0 were mounted on-board the helicopters for the design validation. The operational data acquisition was retrieved from the GARMIN GNSS GTN 750.

Therefore, all data collected during the flight trials can be considered highly reliable and provide accuracy of results and the confidence in the results.

5.5.2 Significance of Demonstration Exercises Results

The results collected during the flight trials have a good significance from an operational point of view since they were executed during different times and by different pilots. The number of performed flights allowed elaboration of meaningful statistics.
The new Swiss procedures were flown with advanced avionic equipment and flight data gathered and processed with state of the art flight inspection console. It is worth noting that some trials present some distortions of FTE/TSE statistics, due to unknown manual pilot input and/or an improper interception of the first leg in case of approach procedure.

5.5.3 Conclusions and recommendations

Several types of procedures and phases of flight have been assessed within the PROuD project, aiming at demonstrating the real operational and safety benefits for HEMS operators. The KPAs reported in the following table have been addressed, and for each KPA, a set of KPI has been used to qualitatively and quantitatively estimate the benefits.

For both Swiss and Norwegian scenarios most of the KPAs have been positively impacted by the introduction of the new PBN operations. No improvements in comparison with current operations have been identified mainly in terms of environmental sustainability, while efficiency benefits result partially reached.

KPA	Objective[3]	Phase of flight	Country
Safety	OBJ-0209-001	Approach	Norway
	OBJ-0209-002	Approach	Switzerland
	OBJ-0209-116	Heliport-to-hospital	Switzerland
	OBJ-0209-011	Departure	Switzerland Norway
	OBJ-0209-102	Approach	Switzerland
Accessibility	OBJ-0209-003	Approach	Norway
	OBJ-0209-004	Approach	Switzerland
	OBJ-0209-010	Approach	Switzerland
	OBJ-0209-012	Departure	Switzerland Norway
Environmental Sustainability	OBJ-0209-005	Approach	Norway
	OBJ-0209-006	Approach	Switzerland
	OBJ-0209-013	Departure	Switzerland Norway
	OBJ-0209-106	Approach	Switzerland
Efficiency	OBJ-0209-007	Approach	Norway
	OBJ-0209-008	Approach	Switzerland
	OBJ-0209-014	Departure	Switzerland Norway
	OBJ-0209-108	Approach	Switzerland
Efficiency and service availability	OBJ-0209-015	Heliport-to-hospital	Switzerland
Predictability	OBJ-0209-016	Heliport-to-hospital	Switzerland
HP (Operating methods)	OBJ-0209-017	Approach/ Departure	Switzerland Norway
HP (Pilots' task performance)	OBJ-0209-018	All	Switzerland Norway
HP (Performance of the technical system)	OBJ-0209-019	Arrival-Approach	Switzerland Norway

Table 20: Overview of KPAs and demonstration objectives status

For details see tables in paragraphs 5.1, 5.2 and 5.4.

The initial feedback has been positive, and the pilots are confident that these new procedures can definitely improve the performance of Search & Rescue missions under adverse meteorological conditions. Other aviation benefits are a reduction in the pilots' workload and the improvement of safety during flights, especially in bad weather conditions.

[3] The legend related to the filling of "Objective" cell is the following:

- green → demonstration objective status is "OK"
- yellow → demonstration objective status is "Partially OK"
- red→ demonstration objective status is "NOK"

The PROuD project provides important output to support future evaluations by the Swiss Federal Office of Civil Aviation (FOCA) for the use of IFR procedures in class G uncontrolled airspace, currently prohibited by the Swiss regulation.

Rega successfully tested a new helicopter RNP 0.3 low level IFR route between Samedan airport and Chur hospital and new PBN approach and departure procedures, with an AgustaWestland AW109SP Da Vinci helicopter earmarked by Rega for the flight inspection task, equipped with an Aerodata AD-AFIS-220 flight inspection system and a Rockwell Collins TDR 94 ADS-B 1090 ES transponder. The flight procedures designed in the PROuD project were validated with the contribution of an FCS (Flight Calibration Services GmbH) Flight Inspector.

In the Norwegian campaign, the Norwegian Air Ambulance (Norsk Luftambulanse) and Airbus Helicopters performed test flights of the new instrument based departure and approach procedures with a latest generation Airbus Helicopters H135 helicopter, equipped with a Garmin GTN 750 navigation console for validation flights, at the Lørenskog base and Ullevål heliport in the Oslo area.
The flights were successfully executed and the procedures worked as expected to the great satisfaction of the entire team. The flight procedures designed in the PROuD project were validated with the contribution of ACAMS Airport Tower Solution Flight Inspector. The Norwegian CAA attended the flight trials and has recently approved the approach procedures with LNAV and LPV minima for operational use by Norsk Luftambulanse. The PinS departure procedure was also validated and approved. The results of the PROuD trials have been used to convince the local CAA that the operational implementation of RNP 0.3 navigation specification in all phases of flight needs a specific EASA AMC so that European operators can utilized this navigation specification. NLA has received a temporary approval based on the PinS departure criteria together with some other company approval based on the ICAO DOC 8168 Vol. 2.
The flight test campaign demonstrated improved accessibility for sites affected by low visibility and improved safety through EGNOS vertical guidance and reduced landing minima.

6 Demonstration Exercises reports

6.1 Demonstration Exercise EXE-02.09-D-001 Report

6.1.1 Exercise Scope

The first demonstration exercise covers the concept of RNP AR APCH with RNP navigation accuracy requirement of 0.1 NM along the initial, intermediate and final segments, and 0.3 NM / 1 NM for the missed approach.

The objective of the exercise is to assess the operational impact of the RNP AR APCH concept applied at Samedan airport.

In regard to the level of the exercise, it corresponds to the E-OCVM level V4, as the exercise consisted of live trials in an operational environment.

6.1.2 Conduct of Demonstration Exercise EXE-02.09-D-001

6.1.2.1 Exercise Preparation

In relation to the preparation of the exercise EXE-02.09-D-001, several activities have been performed according to the ICAO regulations and criteria. With reference to exercise preparation activities described in 4.1 the following list of activities, mentioned in the D01 PROuD Demonstration Plan, have been performed in order to allow the execution of this exercise:

- Input data and operational requirements collection:
  - Aeronautical Data and Metadata acquisition and import into the design environment: DTM/DSM, Airport/Heliport data, Obstacle data, ATS environment, Other data/information;
  - Definition of the operational requirements for the design of the new approach procedure.
- Landing site assessment and PinS approach procedure design:
  - Obstacle and terrain surfaces modelling and assessment for landing site suitability verification to support IFR PinS approach procedures
  - Design attempts of PinS RNP APCH to LPV minimum and design of RNP AR APCH Approach procedures (details are reported in §6.1.2.3).
- Flight Procedure Ground Validation and avionic database preparation:
  - Verification of accuracy of the data used for flight procedure design;
  - Verification of the correct application of ICAO PANS OPS criteria for flight procedure design;
  - Full flight simulations using the Rega AW109 full flight simulator for flight procedure flyability assessment;
  - Navigation DB Preparation and upload on the FMS.
- On board platform adaptation:
  - Fight inspection equipment installation provided by Flight Calibration Service GmbH. Additional data acquisition and recording platform miniQaR and JAVAD were already installed in the AW109 Helicopter.
  - Installation of ADS-B 1090ES certified transponder.
- On ground platform installation:
  - Site survey execution in Samedan airport for the identification of suitable installation sites for GNSS monitoring equipment and Approach Path Monitoring tool (see 4.1.3.2);
  - Ground equipment adaptations and installation.
- Coordination between ATS units:

- In parallel to the activities listed above, a proper coordination between all the involved stakeholders was set up in order to guarantee the necessary coordination with the AFIS Samedan.

- Procedure preparation:
  - Preparation and fulfilment of an in-house Rega SAFE (safety analyses in front of engagement);
  - Preparation of timely briefing for all participants for the flight validation trial (airport authority Samedan, local AFIS, flight crew) and flight validation execution plan;
  - Reservation and preparation of the installation of the dedicated flight inspection kit in the helicopter.

- Pilot training:
  - Training of pilots with Rega full flight simulator.

6.1.2.2 Exercise execution

The execution of the exercise has been structured in pre-flight activities, the demonstration flights performance and post-flight activities.

Below the exercise steps are listed as they have been executed:

1. Pre-flight activities:

   Preparation of timely briefing for all participants for the flight trial (airport authority Samedan, local AFIS, local residents, regulator, flight crew) invitation and flight trial execution plan.

2. Flight trials execution:

   A number of 14 flight trials (including additional 2 flights in the FFS) were executed during the first campaign in 2015. A second campaign in April 2016 included 13 new flight trials.

   During the execution of the exercise, data has been collected on board Rega the helicopters.

   Moreover, on-ground equipment has been used during flight execution for:

   - real time monitoring of GPS and EGNOS performance in the signal and navigation domain
   - real time monitoring of adherence of approach against the flight procedure nominal path using ADS-B data

Qualitative techniques of data collection have been also used during the trials and they included over-the-shoulder non-intrusive observations of pilots and system behaviour during the trials, together with the think aloud methodologies

3. Post-flight activities:

Immediately after the flights, debriefings were held between involved stakeholders (local AFIS, flight crew, procedure designer, safety experts).

At the end of the exercise the following activities have been executed:

- Extraction of flight data records from the helicopter on-board equipment;
- Processing of navigation data acquired on board and elaboration of the data acquired on ground;
- Performance assessment and anomaly investigation execution.

The information gathered during the exercise served as a description of the system performance when using the PBN procedures. Quantitative and qualitative measures contributed to the final assessment of the flight trials.
Regarding the navigation performance assessment it is worth mentioning that Rega Flight inspection console, used during the flight trials allows the recording of all the necessary navigation parameters for the post processing activities.

REFERENCE SCENARIO

At Samedan (ICAO code LSZS) airport only VFR operations are currently allowed for both fixed wing and rotary wing aircraft.
No IFR approach procedure is available, hence the airport is only accessible in VMC conditions.

The airport overview, airspace classification, weather minima and current operations are detailed in B.1.1.

SOLUTION SCENARIO

The implementation of a RNP AR APCH with RNP navigation accuracy requirement of 0.1 NM along the initial, intermediate and final segments has been identified by Rega as both a necessary and an effective solution to overcome current existing limitations in terms of safety and airport capacity/accessibility (the deviation of the solution scenario from the one reported in the demonstration plan is explained in 6.1.2.3). The missed approach is performed with an RNP navigation accuracy requirement of 0.3 NM in the initial part and then 1 NM, according to regulation criteria.

PROuD flight trials at Samedan airport have been conducted in VFR/VMC conditions during the flight trials.
The flights performed at Samedan airport for this exercise (EXE-02.09-D-001) are reported in Table 14. It has to be noted that there is currently no helicopter certified for RNP0.3 for all phases of flight, however Rega has been granted a trial authorisation by FOCA for these procedures and trials.

6.1.2.3 Deviation from the planned activities

Due to environment constraints in Samedan airport, several attempts have been performed to design a PinS RNP APCH to LPV minimum in Samedan airport. The very challenging environment around the airport did not allow to reach operationally usable DA/H minima (DH<2000ft). Therefore, it was agreed also with Rega and Skyguide to design an RNP AR APCH for rotorcraft operations. The adoption of RNP AR criteria with an RNP navigation accuracy requirement of down to 0.1 NM in conjunction with the use of RF legs allows to reach a significantly lower minimum compared to a PinS RNP APCH to LPV minimum.

A total of 14 flights were performed during the first campaign and another 11 flights during the second campaign, in line with the demonstration plan. Furthermore, 11 additional approach flights have been performed in the Chur scenario (SCN-0209-005 - see B.1.3).

The following objectives OBJ-0209-102, OBJ-0209-106, OBJ-0209-108 for RNP AR APCH procedures were added and the OBJ-0209-010 to assess VFR airport accessibility of RNP AR APCH approach procedures in critical environment was modified (the previous description has been implicitly included in the reformulation of this objective).

The objectives in the Demonstration Plan related to PinS RNP APCH to LPV minimum at Samedan airport (OBJ-0209-002, OBJ-0209-004, OBJ-0209-006, OBJ-0209-008), have been achieved through approach performed in the additional Chur scenario (SCN-0209-005 - see B.1.3).

6.1.3 Exercise Results

6.1.3.1 Summary of Exercise Results

6.1.3.1.1 Results per KPA – First Campaign

6.1.3.1.1.1 Safety

The impact of the new procedures on safety has been evaluated using the following Key Performance Indicators (KPIs):

- Flight crew subjective feedback on safety;
- Flight crew situation awareness;

- Flight crew workload;
- Flight track adherence.

The first three indicators have been evaluated using feedback collected through pilot's questionnaires (see Appendix G to have a look to the Swiss first flight campaign questionnaire results), the last one using the data collected by the on board flight inspection system.

Flight crew subjective feedback on safety

Pilots provided their view about the impact of the new procedure on safety, comparing it with the procedures they are currently used (VFR procedures). The data collected for this indicator during the first campaign show that a slight increase in safety level has been experienced (the average value is 3,33/5) with respect to the safety of current VFR operations. Detailed information is provided in Appendix G.

The circumstances that made the new procedures safer than the current ones are especially marginal weather situations and night operations. Pilots highlighted the risk, in case the procedure is used in good weather conditions, to shift the pilot's attention from outside of the cockpit to inside, with the possibility to produce air to air collisions.

The causes of possible hazardous situations have been identified in case of system errors or failure on board, as well as hazards related to GNSS unavailability. The risk has to be mitigated by redundancy of systems and a proper training, including failure scenarios.

Also contingency procedures could be developed in order to mitigate the risks related to helicopter failures.

The flight trials pilots' expected impact of the new procedures on subjective feedback on safety, situation awareness and workload compared with the current ones (answers' average), is shown in the figure below.

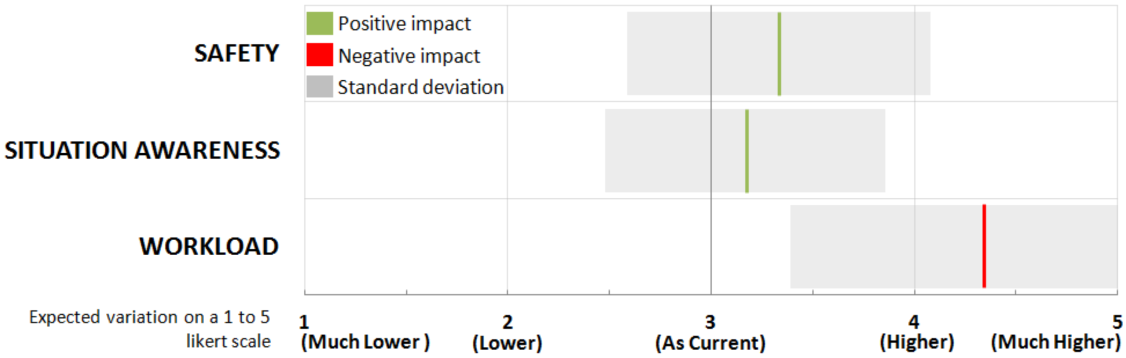


Figure 21: Questionnaires results for EXE-02.09-D-001 (Approach Samedan).
Flight Trials Pilots' expected impact of the new procedures on safety (subjective feedback), situation awareness and workload, compared with the current ones (answers' average).

Flight crew situation awareness

The average value of pilots' answers about situation awareness was rated 3,17/5 (see indicator in Figure 21) and a slight increase has been reported with respect to current operations.

Flight crew workload

An increase of workload has been experienced, due both to the natural additional workload related to IFR flight (when compared with VFR flight) and to the specific design of the procedures, as stated in the comments below. This result is in line with the workload value 4,33/5 (see indicator in Figure 21), gathered from pilots' questionnaire.

The expected increment depends on the need of some new interactions with the helicopter system and on the complexity of some points of the procedures, as reported by pilots, in particular due to the different descent angles used along the legs of the approach procedure before the FAF segment.

Flight track adherence

The adherence to the designed flight track has been quantitatively evaluated in terms of Cross-track Total System Error estimated by the on board flight inspection system. The TSE statistics are reported in terms of the 95th percentile in Figure 22.

In the first campaign, the evaluation for each flight has been performed from BIVIO waypoint to the MAPt, with the exception of approach trial #11 where the flight procedure has been joined in following waypoint, in details:

Flight trial number[4]	Registration number	Range of processed data
1	#11	BIVIO - MAPt
2	#02	BIVIO - MAPt
3	#04	BIVIO - MAPt
4	#14	BIVIO - MAPt
5	#16	BIVIO - MAPt
6	#18	BIVIO - MAPt
7	#24	BIVIO - MAPt
9	#07	BIVIO - MAPt
10	#09	BIVIO - MAPt
12	#16	BIVIO - MAPt
13	#18	ZS001 - MAPt
14	#20	BIVIO - MAPt

Table 21: EXE-02.09-D-001 (first campaign) - Range of processed data

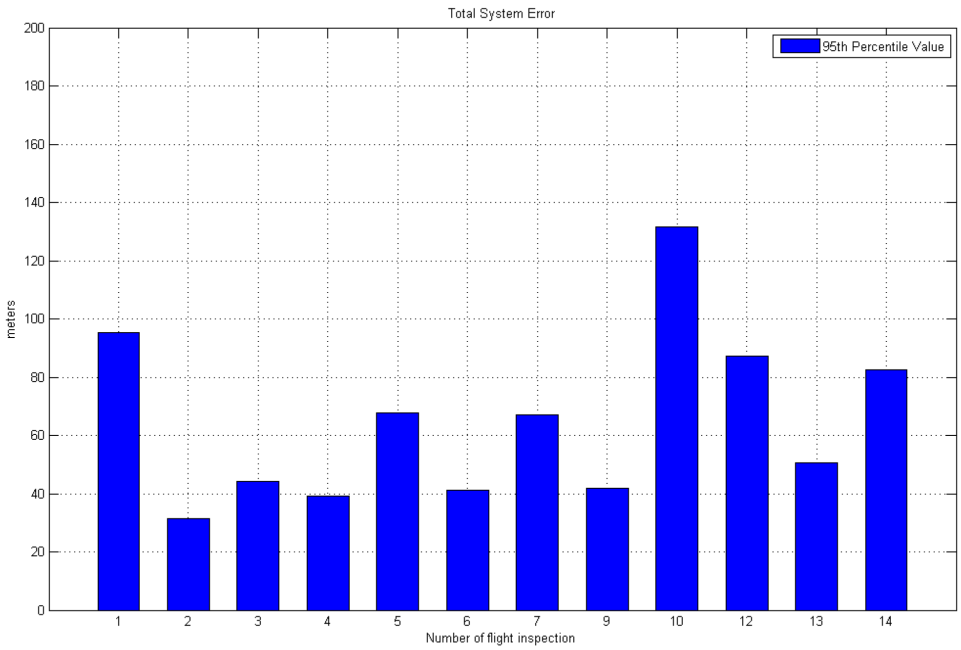


Figure 22: EXE-02.09-D-001 (first campaign) – Statistical evaluation of TSE cross track (REGA flight helicopter data) performed along Samedan approach procedure

[4] Number is aligned with the one reported in Table 14

Detailed results related to helicopter navigation performances along each approach trial are reported in Appendix K, in terms of GNSS performances and signal quality, FTE and TSE error components. An extract of results of Flight Track # 11, in terms of Cross Track of FTE/TSE error components, for Samedan approach procedure (Figure 23), is reported Figure 24.

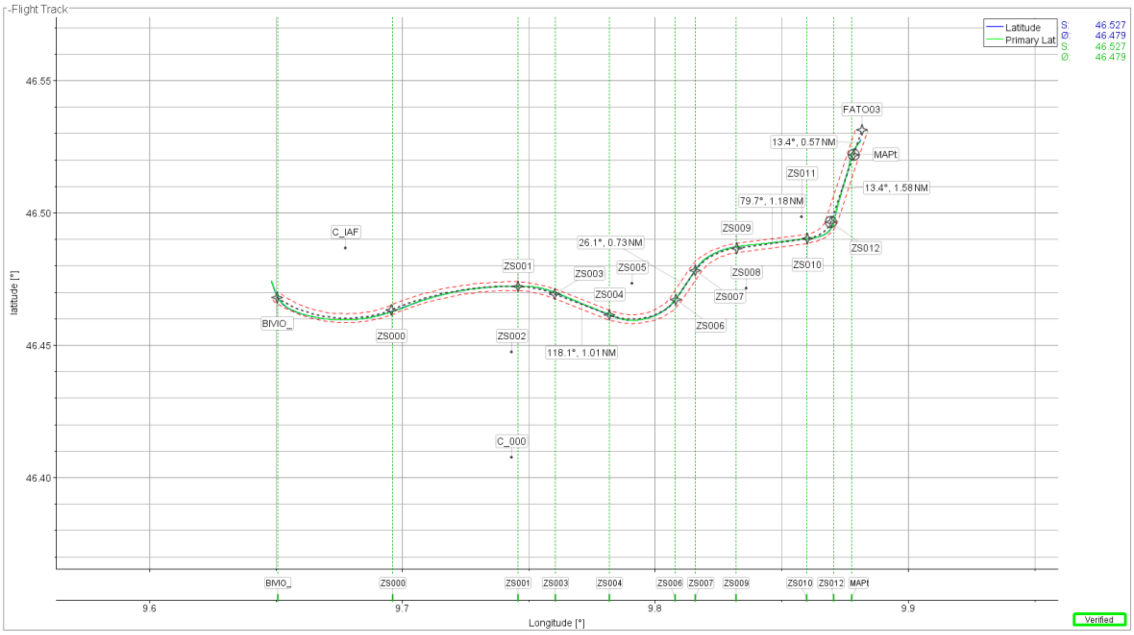


Figure 23: EXE-02.09-D-001 (first campaign) – Flight Track # 11 (Approach flight trial n.1) Samedan approach procedure

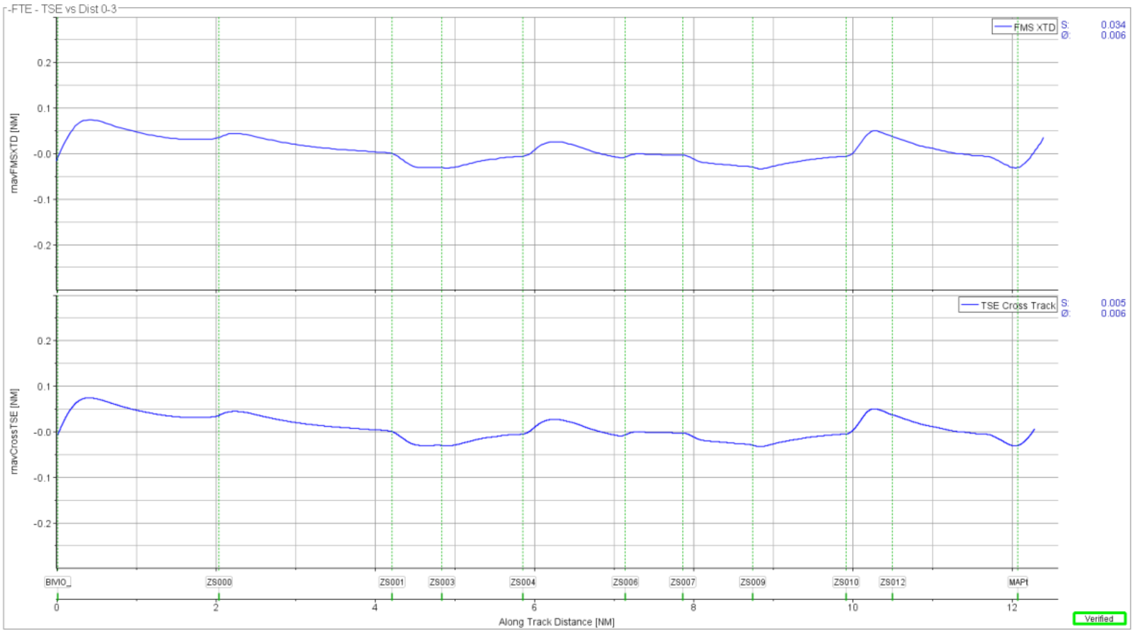


Figure 24: EXE-02.09-D-001 (first campaign) – Cross Track FTE/TSE of Flight Track # 11 (Approach flight trial n.1) Samedan approach procedure

According to PBN manual ([5] - see 6.3.3.2.3), all aircraft operating on RNP AR APCH procedures must have a cross-track TSE navigation error no greater than the applicable RNP navigation accuracy requirement (0.1 NM to 0.3 NM) for 95 per cent of the flight time.
In the first Samedan campaign, for some approach flight trials (e.g. n.1 and n. 9) significantly higher values of TSE cross-track error have been recorded which is supposedly attributable to manual pilot

intervention. Moreover, during some approaches the entry into the first RF leg has contributed substantially to the TSE, since it was not always properly entered tangentially.
The overview of the lateral navigation performance, however, shows the compliance with RNP 0.1NM lateral accuracy requirements. For details and performance parameters for all performed flight trials, refer to [3].

6.1.3.1.1.2 Accessibility

For the evaluation of site accessibility using the new approach procedures, the flight crew subjective feedback indicator has been used.

According to pilots' feedback, the accessibility will increase about 23% (see Figure 25) using the new procedures. This means, in other words, that pilots expect that the number of approaches could increase of that figure respect to the current number. Details can be found in the answers of the questionnaires (see Appendix G).

The average value of the pilots' feedback demonstrates that the new procedures will permit to fly through a cloud or fog layer, when there are bad weather conditions and they will allow landing to the dedicated places.

The flight trials pilots' expected impact (in %) of the new procedures in terms of Predictability, Efficiency, Availability, Accessibility, compared with the current ones (answers' average) is shown in the following figure. The results shown in the figure refers to all the Swiss procedures performed in the 2015 Swiss campaign, including approach, departure and en-route phases of flight experienced within PROuD project.

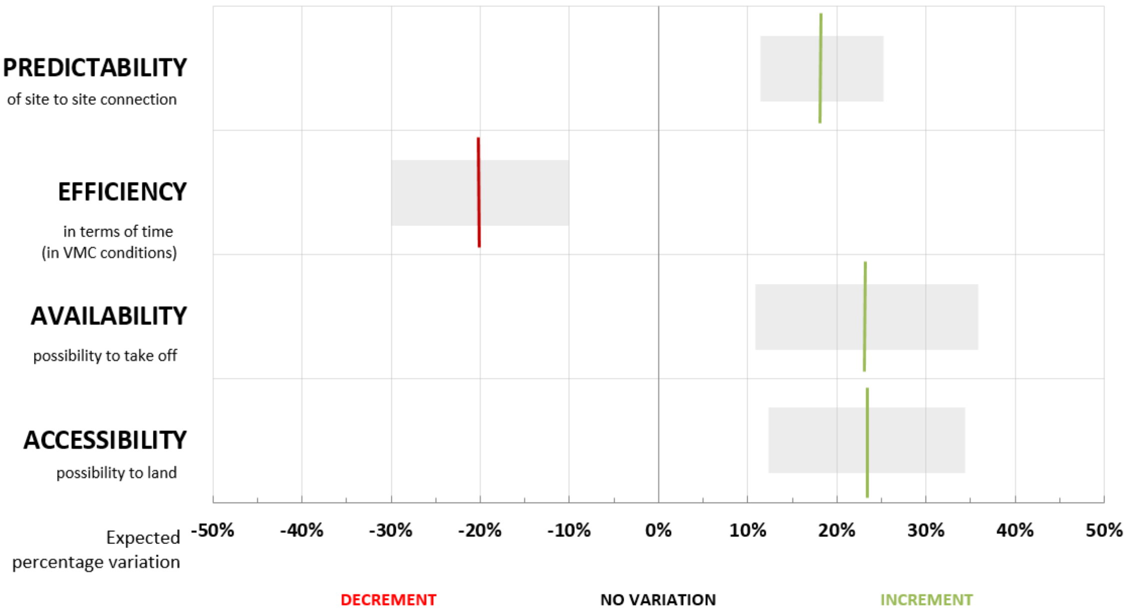


Figure 25: Questionnaires results for EXE-02.09-D-001 (first campaign), EXE-02.09-D-002, EXE-02.09-D-003, EXE-02.09-D-007, EXE-02.09-D-008. Flight Trials Pilots' expected impact (in %) of the new procedures compared with the current ones (answers' average).

6.1.3.1.1.3 Environmental Sustainability

The flight track for the RNP AR procedure is longer and the approach speed is slower compared to VFR approach. The environmental impact is not reduced but the accessibility to and from the airport will increase in bad weather.

6.1.3.1.1.4 Efficiency

The impact of the new procedures on Efficiency has been qualitative estimated in terms of miles flown and time needed to perform the approach on Samedan airport. The KPI selected to measure this KPA is fight crew subjective feedback.

The questionnaire results provided an average value of -20% (see Figure 25), the new procedure has a negative impact on efficiency, as the IFR approach requires more miles to be flown and takes more time with respect to current VFR operations.

Nevertheless, pilots consider this value acceptable because the current procedure cannot be flown in bad visibility conditions, so its efficiency, during bad weather, is zero; with the new procedure, even if the flight time increases, pilots will be able to operate in adverse weather conditions, thus increasing the number of missions performed.

6.1.3.1.1.5 HP (Operating methods)

The impact on Human Performance in terms of Operating methods has been measured collecting the flight crew subjective feedback.

The average result of 2,83/5 (see Appendix G for Swiss first campaign questionnaire results), demonstrates that there is a slight impact on operating methods, which is considered feasible and not significant for pilots' performance.

The justification of the expected impact lies in the shift of pilots' attention from the outside to the inside of the helicopter due to the use of the instruments inside the cockpit, differently from what happens when flying in VFR. The foreseen change on the operating methods can be handled with regular training of pilots on the new procedures.

In pilots' view, an acceptable level of feasibility has been achieved, and it can even increase if little changes in some technical aspects will be improved.

6.1.3.1.1.6 HP (Pilots' task performance)

The KPIs measures used for Pilots' task performance are:

- Flight crew subjective feedback;
- Error propensity;
- Flight crew workload;
- Flight crew situation awareness.

Flight crew subjective feedback

Pilots provided their opinion regarding how much the changes introduced by the adoption of the new procedures are expected to impact their performance, in terms of workload, situation awareness and errors. Here below some issues are reported while for more detailed information is provided in Appendix G.

The potential issues that could negatively affect pilots' performance are related to circumstances that can produce a high workload or that can lead to errors in programming the system.

These issues are considered common to all IFR procedures.

Error propensity

In regard to pilots' task performance, some potential hazards related to the interaction with the system have been identified. The causes of these hazards are represented by a high level of workload, inadequate training and errors in interacting with the system (i.e. the possibility to insert the wrong waypoint as start and end of the airway).

Flight crew workload

A slight increase in flight crew workload has been experienced (see Figure 25) mainly due to new tasks that pilots have to perform to fly IFR and that today are not part of their work routine. Training and practice should mitigate this risk.

Flight crew situation awareness

No significant impact has been experienced.

6.1.3.1.1.7 HP (Performance of the technical system)

For the evaluation of the impact on the Human Performance of system failures or degradation, the following indicators (KPIs) have been selected:

- Flight crew subjective feedback on performance of the technical system;
- Navigation System Error (NSE);
- Total System Error (TSE) cross track.

Flight Crew Subjective feedback

For this exercise and for all the Swiss exercises, the autopilot failure and the system degradation due to GNSS performance have been identified as potentially hazardous. The mitigations proposed for these issues are redundancy of the installed system(s), training for pilots and flying in VFR that in the pilots' view could support them in getting outside of the cloud with the remaining system.

According to pilots, in order to avoid pilot's error, the procedure itself should be simplified.

Navigation System Error (NSE)

The following figure reports the statistics on Navigation System Error component for each approach. The use of EGNOS augmentation allows reaching high level navigation performance both in the horizontal and vertical dimensions.

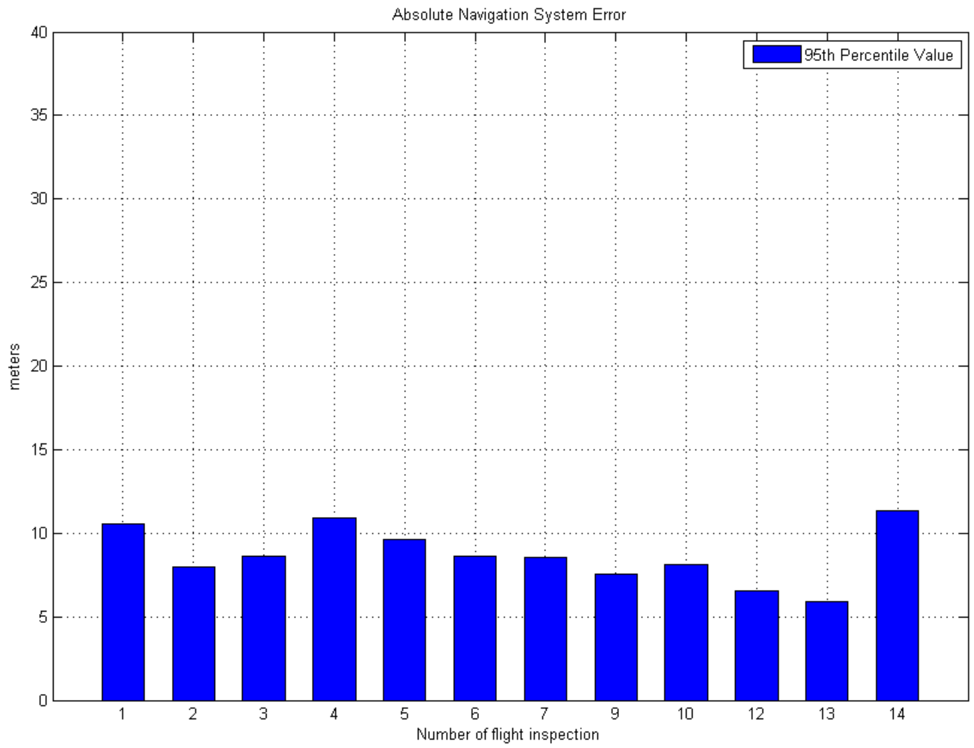


Figure 26: EXE-02.09-D-001 (first campaign) – Statistical evaluation of absolute NSE (REGA flight helicopter data) performed along Samedan approach procedure between IAF and MAPt

Total System Error (TSE) cross track

See Figure 22.

6.1.3.1.2 Results per KPA – Second Campaign

6.1.3.1.2.1 Safety

The impact of the new procedures on safety has been evaluated using the following Key Performance Indicators (KPIs):

- Flight crew subjective feedback;
- Flight crew workload;
- Flight crew situation awareness;
- Flight track adherence.

The first three indicators have been evaluated using feedback collected through pilot's questionnaires (see section G.1 to have a look to the Swiss first flight campaign questionnaire results), the last one using the data collected by the on board flight inspection system.

Flight crew subjective feedback

The data collected for this KPI during the second campaign show that the safety value does not decrease with respect to the safety of the first flight campaign and with the current operations; in fact the average value is 3,25/5.

Moreover, pilots reported some examples of potential hazardous circumstances that could lead to safety issues. Those situations are listed here below:

- Loss of GNSS or system malfunction during turns;
- GNSS unavailability;
- Malfunction of one engine associated with strong winds in a mountainous region.

In the first campaign's results, the same examples of system malfunction, GNSS unavailability in critical weather conditions, raised.

Flight crew workload

In regard to the workload perceived by pilots during the flight trials, the average value collected from their comments is 3 out of 5 (see Appendix G to have a look to the Swiss second flight campaign questionnaire results). The value demonstrates that pilots considered the potential implementation of the new procedures as feasible and they do not foresee any significant impact on this KPI with respect to the current operations.

Flight crew situation awareness

The situation awareness was rating 2,75 out of 5 (see Appendix G to have a look to the Swiss second flight campaign questionnaire results), meaning that according to pilots, the IFR procedures are expected to have basically no impact on pilots' situation awareness.

Flight track adherence

The adherence to the designed flight track has been quantitatively evaluated in terms of Cross-track Total System Error estimated by on board flight inspection system. The TSE statistics are reported in terms of the 95th percentile in Figure 29 and Figure 32.

RNAV (RNP) RWY 03

In the second campaign, for each flight performed for RWY 03 collected data has been evaluated from ZS700 to ZS706.

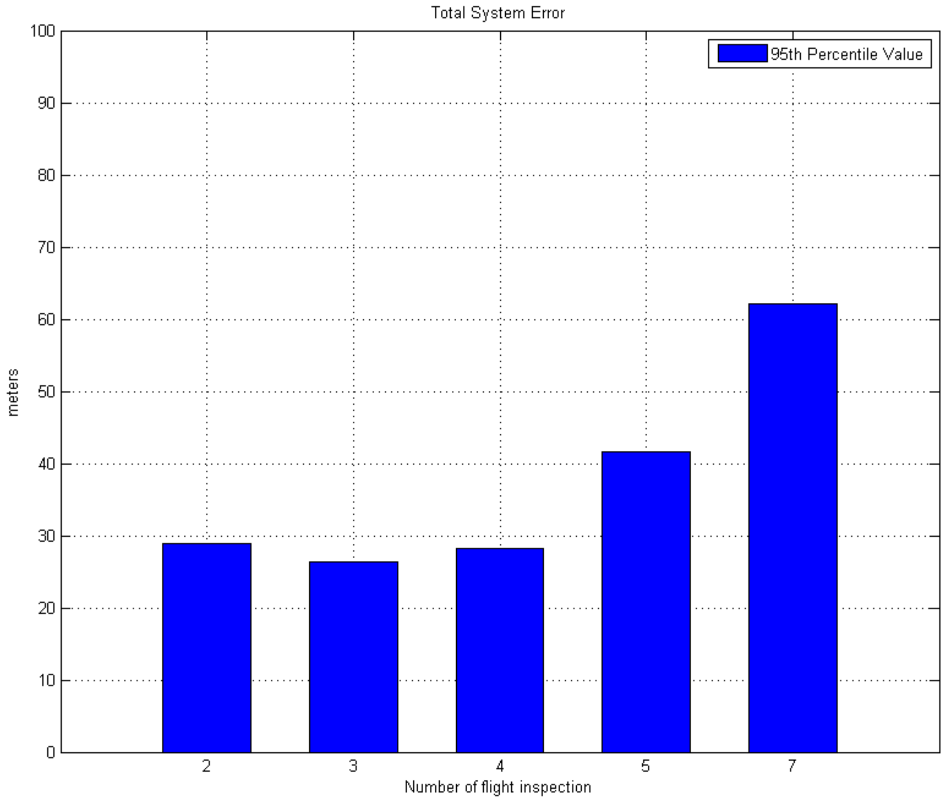


Figure 27: EXE-02.09-D-001 (second campaign - RWY 03) – Statistical evaluation of TSE cross track (REGA flight helicopter data) performed along Samedan approach procedure

Detailed results related to helicopter navigation performances along each approach trial are reported in Appendix K, in terms of GNSS performances and signal quality, FTE and TSE error components.

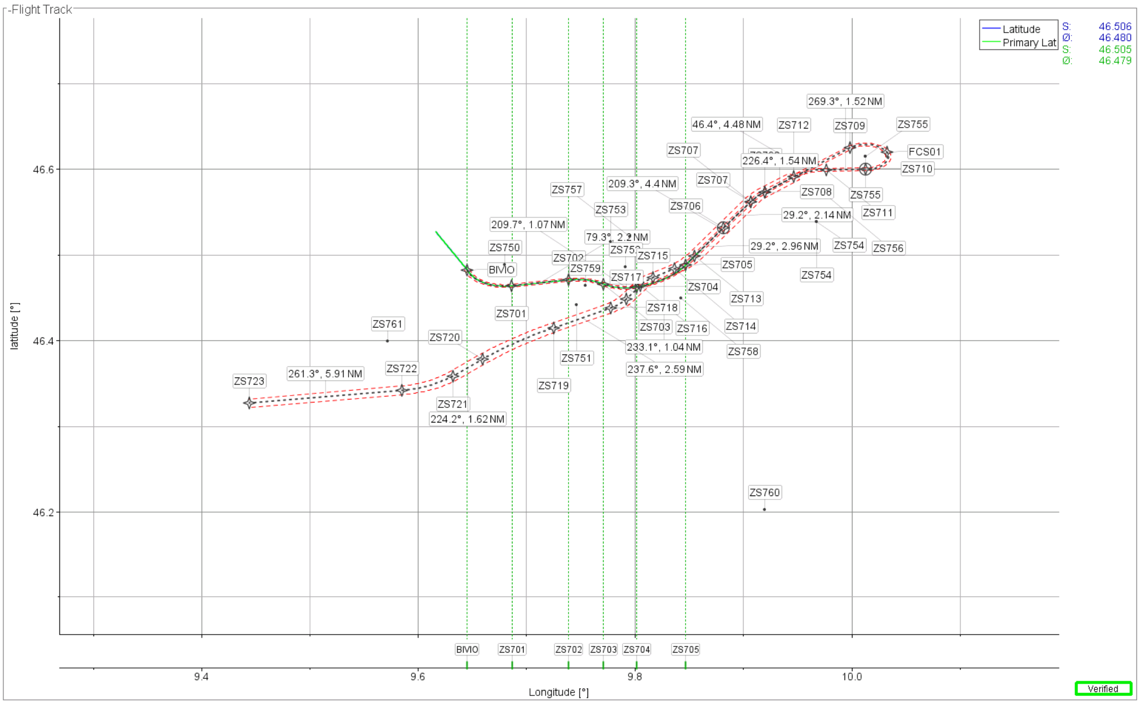


Figure 28: EXE-02.09-D-001 (second campaign – RWY 03) – Flight Track # 2 (Approach flight trial n.1) Samedan approach procedure

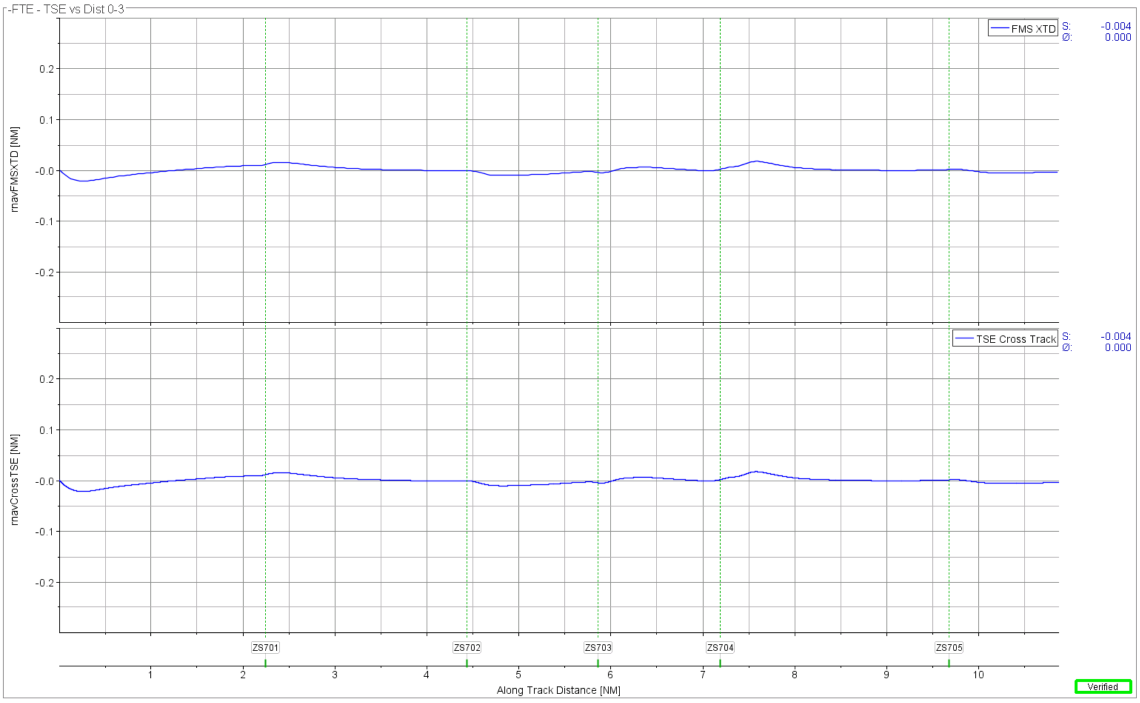


Figure 29: EXE-02.09-D-001 (second campaign – RWY 03) – Cross Track FTE/TSE of Flight Track # 2 (Approach flight trial n.1) Samedan approach procedure

According to PBN manual ([5] - see 6.3.3.2.3), all aircraft operating on RNP AR APCH procedure must have a cross-track TSE navigation error no greater than the applicable RNP navigation accuracy requirement (0.1 NM to 0.3 NM) for 95 per cent of the flight time.

The overview of the lateral navigation performance, shows the compliance with RNP 0.1NM lateral accuracy requirements. For details and performance parameters for all performed flight trials, refer to [4].

RNAV (RNP) RWY 21

In the second campaign, for each flight performed for RWY 21 collected data has been evaluated from ZS781 to ZS706 waypoints.

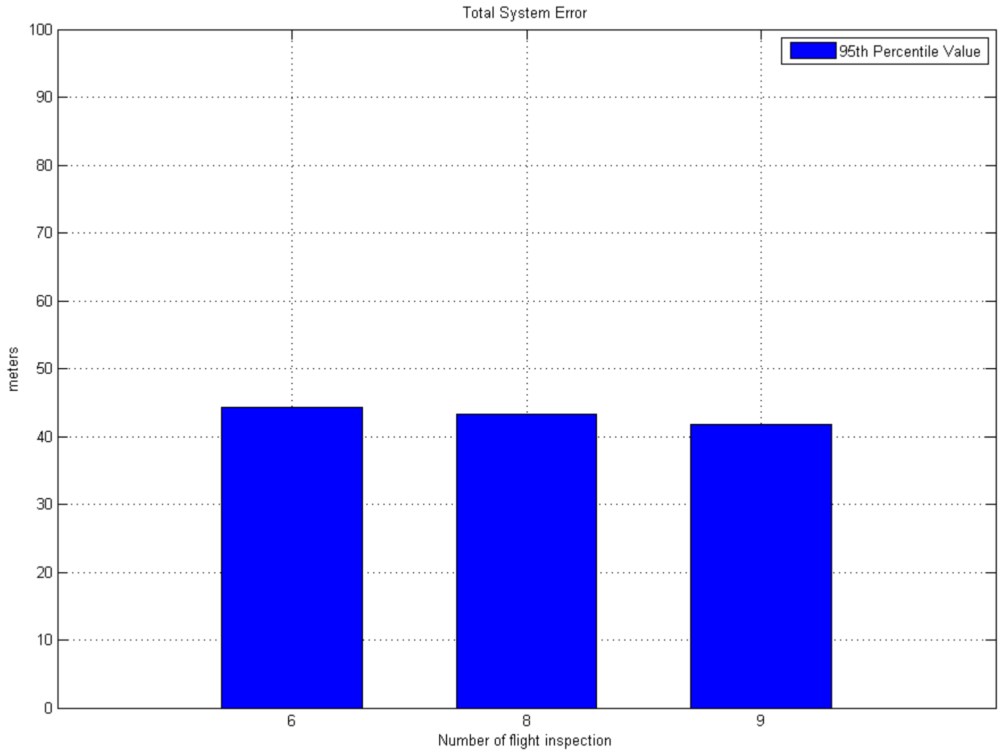


Figure 30: EXE-02.09-D-001 (second campaign – RWY 21) – Statistical evaluation of TSE cross track (REGA flight helicopter data) performed along Samedan approach procedure

Detailed results related to helicopter navigation performances along each approach trial are reported in [5], in terms of GNSS performances and signal quality, FTE and TSE error components.

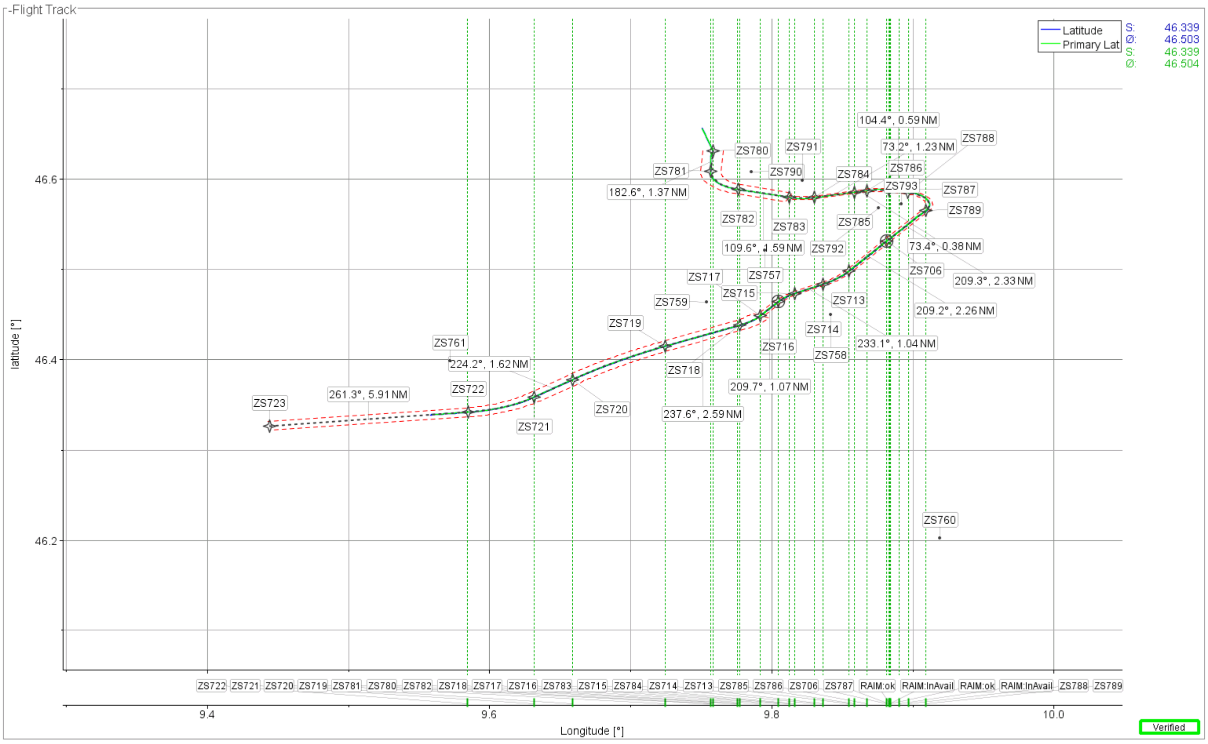


Figure 31: EXE-02.09-D-001 (second campaign – RWY 21) – Flight Track # 6 (Approach flight trial n.1) Samedan approach procedure

Figure 32: EXE-02.09-D-001 (second campaign – RWY 21) – Cross Track FTE/TSE of Flight Track # 6 (Approach flight trial n.1) Samedan approach procedure

According to PBN manual ([5] - see 6.3.3.2.3), all aircraft operating on RNP AR APCH procedures must have a cross-track TSE navigation error no greater than the applicable RNP navigation accuracy requirement (0.1 NM to 0.3 NM) for 95 per cent of the flight time.

The overview of the lateral navigation performance shows the compliance with RNP 0.1NM lateral accuracy requirements. For details and performance parameters for all performed flight trials, refer to Appendix K.

6.1.3.1.2.2 Accessibility

For the evaluation of site accessibility using the new approach procedures, the flight crew subjective feedback indicator has been selected.

According to the pilots, the new procedures will increase the value of the accessibility of the landing site of more than 33% (see Appendix G to see Swiss second campaign questionnaire results) in case of adverse weather conditions, which do not allow to fly manually. In other words pilot expect an increment of landings that is 1/3 more than the current number per year.

The average value of the pilots' feedback demonstrates that the new procedures will permit to fly through a cloud or fog layer, when there are bad weather conditions and they will allow landing to the dedicated places.

This result is higher than the accessibility value of the first campaign and thus, thanks to the second cycles of flights it has been possible to improve the procedures.

6.1.3.1.2.3 Environmental Sustainability

See 6.1.3.1.1.3.

6.1.3.1.2.4 Efficiency

The impact of the new procedures on Efficiency has been qualitative estimated in terms of miles flown and time needed to perform the approach on Samedan airport. The KPI selected to measure this KPA is fight crew subjective feedback.

The questionnaire results highlight that for this KPA the average value of -15% (see Appendix G for Swiss second campaign questionnaire results), as for the efficiency value in the first campaign, the new procedures are expected to have a negative impact on efficiency, as the IFR route is considered to take more time with respect to the VFR route.

Considering that HEMS operations are not allowed in IFR in class G Swiss airspace, in case of adverse weather conditions missions are aborted; with the new procedures, even if the flight time is longer, it will be possible at least to perform those operations that otherwise will be cancelled.

So it is important to highlight that the number is negative because pilots are comparing the efficiency of the new procedures with VFR flight. When visibility conditions are bad (but within the new procedures minima), there is no reference to compare the efficiency of the new procedures as VFR flights are not possible.

6.1.3.1.2.5 HP (Operating methods)

For this KPA the flight crew subjective feedback has been selected as measure to evaluate the impact of the new procedures.

The average result of pilots' answer is 2,5/5 (see Appendix G for Swiss second campaign questionnaire results), which means that the introduction of the IFR procedures is not expected to have a small negative impact on the operating methods. The aspects impacting most are the same already presented for the first campaign (see paragraph 6.1.3.1.1.3).

Considering that HEMS operations are not allowed in IFR in class G Swiss airspace, as stated for the first campaign, also the procedures flown in the second one will have an impact on the current operating methods. Those potential changes are considered to be feasible and acceptable with respect to the current operating methods and to the overall operational environment.

6.1.3.1.2.6 HP (Pilots' task performance)

For the evaluation of the Pilots' task performance, the following indicators (KPIs) have been selected:

- Flight crew subjective feedback on Pilots' task performance;

- Error propensity;
- Flight crew workload;
- Flight crew situation awareness.

Flight crew subjective feedback

Some potential hazards have been identified with regard to Pilots' Task Performance also during these second flights and pilots identified errors regarding malfunction of autopilot or loss of GNSS. However, the circumstances in which the new procedures and the related activities can lead to make errors are considered not more than any other IFR procedure.

Error propensity

See 6.1.3.1.1.6.

Flight crew workload

No impact on Workload. See 6.1.3.1.1.6.

Flight crew situation awareness

No significant impact. See 6.1.3.1.1.6.

6.1.3.1.2.7 HP (Performance of the technical system)

The key performance indicators selected for the evaluation of this KPA are the following one:

- Flight crew subjective feedback;
- Navigation System Error (NSE);
- Total System Error (TSE) cross track.

Flight Crew Subjective feedback

For this KPI pilots affirmed that in case of system degradation, the impact on the technical system is negligible and that they would be able to manage the situation without jeopardising the safety level of the operations. According to them the factors that could enable the handling of critical situations are training, company procedures and "*a 'good' OEI Service ceiling*".

These results are quite similar to the answers reported during the first campaign; no significant differences have been reported.

Navigation System Error (NSE)

The following figure reports the statistics on Navigation System Error component for each approach. The use of EGNOS augmentation allows reaching high level navigation performance both in the horizontal and vertical dimensions.

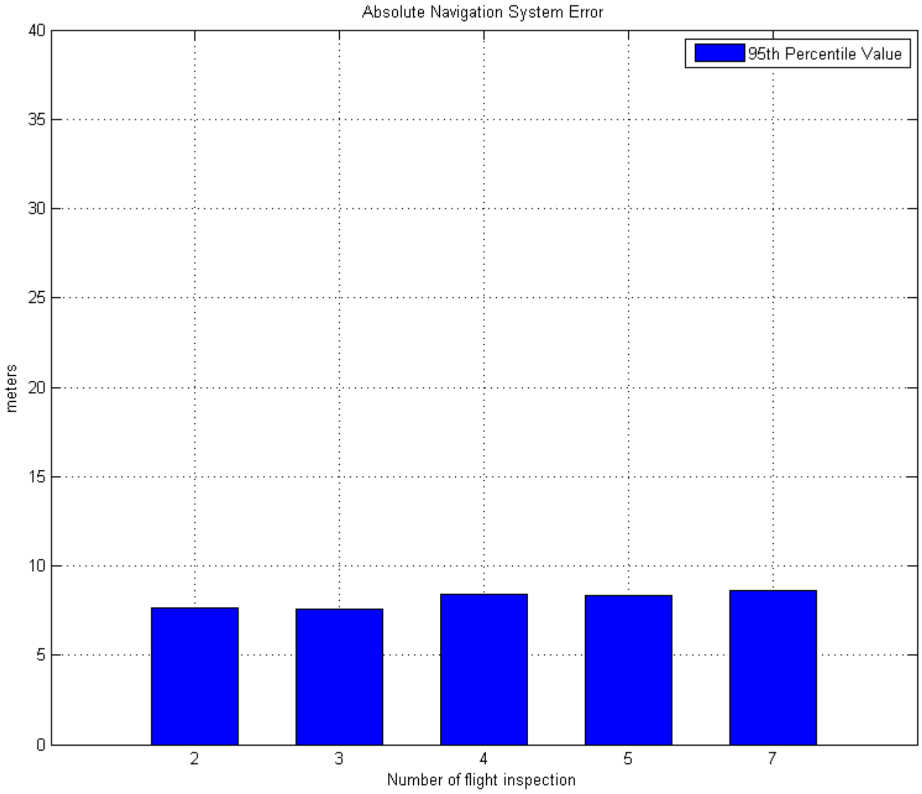


Figure 33: EXE-02.09-D-001 (second campaign - RWY 03) – Statistical evaluation of absolute NSE (REGA flight helicopter data) performed along Samedan approach procedure (between BIVIO and ZS706)

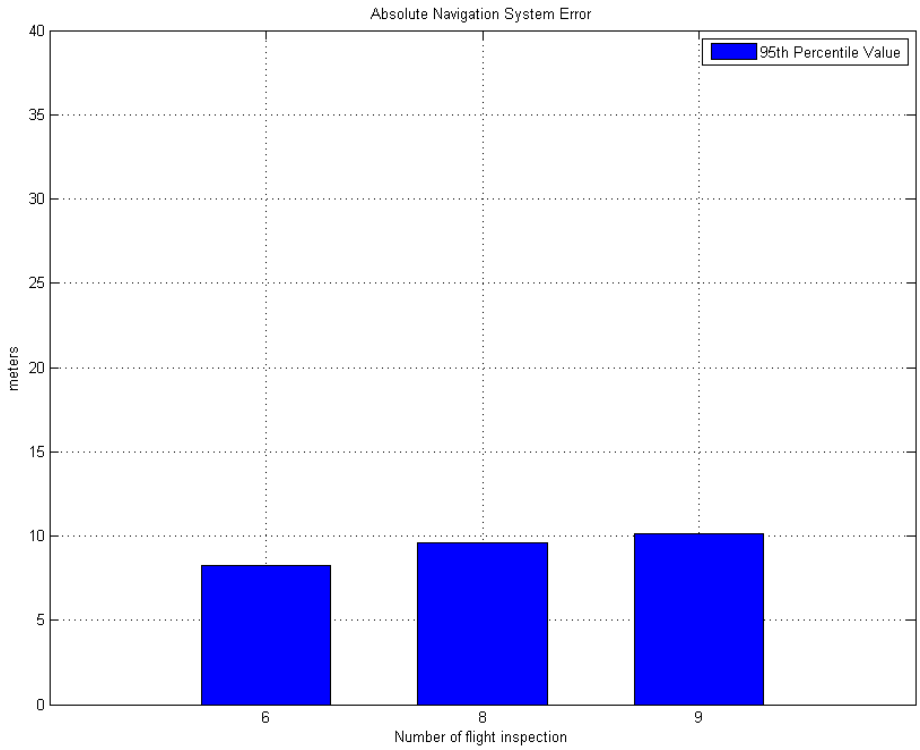


Figure 34: EXE-02.09-D-001 (second campaign - RWY 21) – Statistical evaluation of absolute NSE (REGA flight helicopter data) performed along Samedan approach procedure (between ZS781 and ZS706)

Total System Error (TSE) cross track

See Figure 27 and Figure 30.

6.1.3.1.2.1 Detailed flight track adherence analysis

For the second campaign flight procedures, an additional flight track analysis was performed by Skyguide based on 13 RNP AR approaches in Samedan. All Rega AW109SP helicopters are equipped with miniQAR recording units which store on-board GPS/EGNOS/FMS and flight plan information. Moreover, on the helicopters HB-ZRP and HB-ZRR that were used during the second campaign, a geodetic JAVAD SIGMA receiver was installed to record GPS and GLONASS dual-frequency data. These recordings are independent of the on-board avionics and allow the determination of the true flight path based on GNSS differential phase measurements with an accuracy of usually better than a decimetre. As the helicopters were operating on the designed RNP AR procedures and FMS and flight plan data were recorded, the desired flight path as well as the navigation system flight path are known. Based on that, the corresponding deviations, i.e. the total system error, the navigation system error and the flight technical error were determined.

6.1.3.1.2.1.1 RNAV (RNP) RWY 03 Samedan

Flight track data of 8 approaches to RWY 03 was available for the flight track adherence analysis.

The plan and the lateral deviations view illustrate that the largest deviations from the desired track occur at the entry into the procedure (i.e. at ZS700 and shortly thereafter). This is attributable to the fact that the first RF leg was normally not properly entered tangentially, resulting in an over- or undershoot that the navigation system was only able to correct with some delay.

In general, a certain overshoot tendency can be observed at the entry of each RF segment which the navigation system slowly corrected in the course of the RF leg.

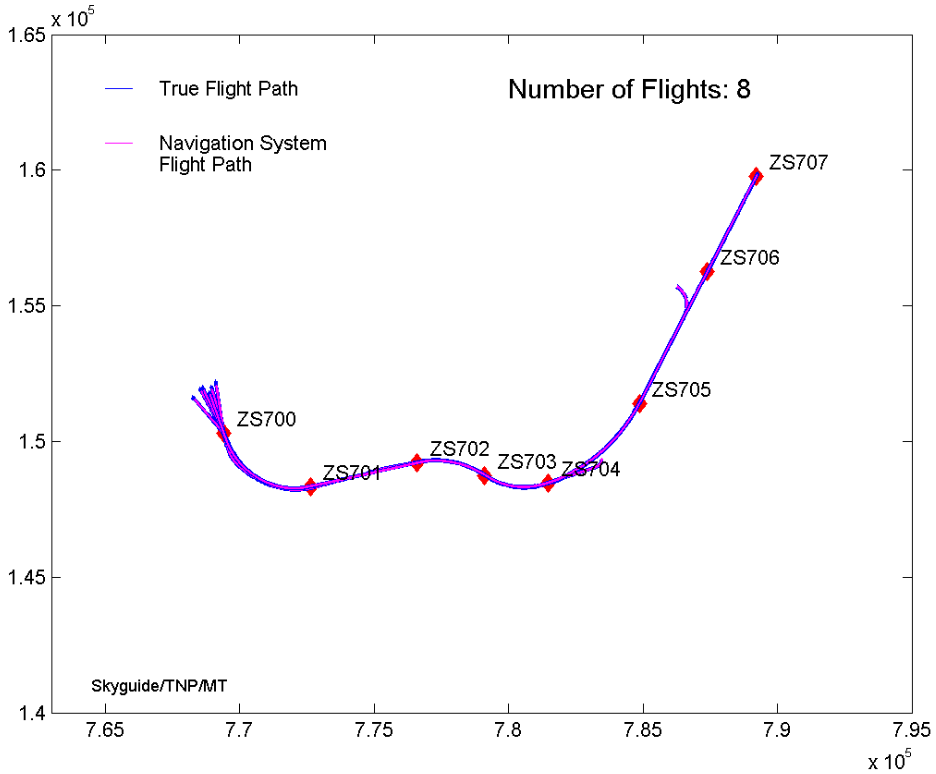


Figure 35: Skyguide flight track analysis – RNAV (RNP) RWY 03 Samedan – Plan view

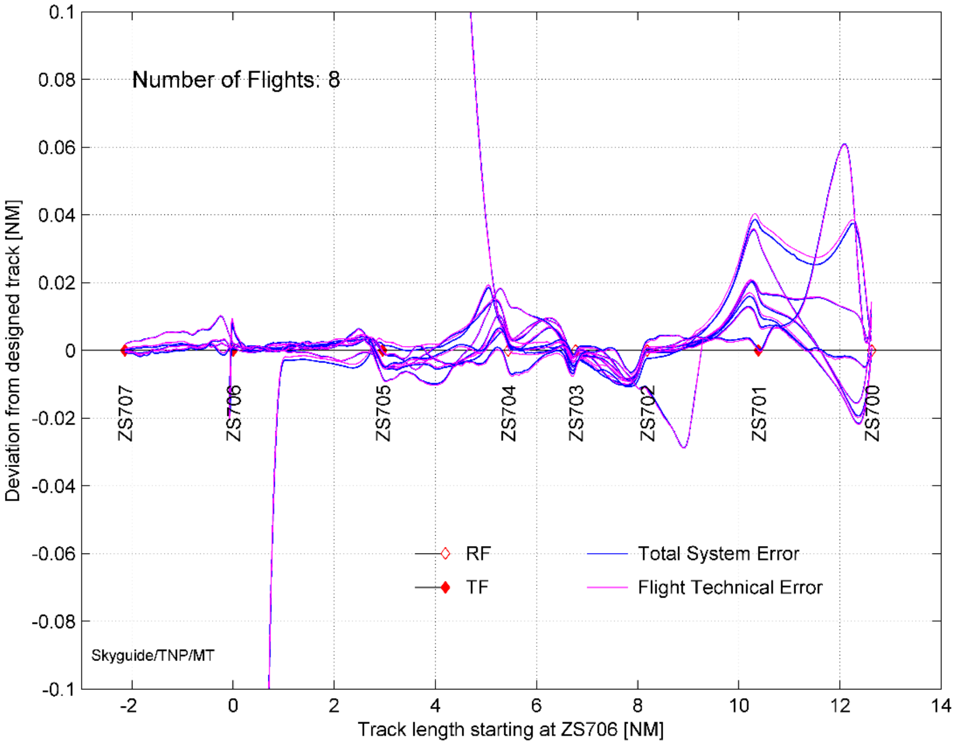


Figure 36: Skyguide flight track analysis – RNAV (RNP) RWY 03 Samedan – Lateral deviations

The profile view shows that the navigation system and true flight paths of all flights are situated slightly above the nominal procedure altitude (10000 ft) between ZS700 and ZS704 (IF). This can be attributed to the barometric altimeter, which is used for vertical navigation during this phase of flight, in above-standard temperature conditions, and represents a normal system behaviour.

However, the 5 flights where the vertical path was not automatically captured at ZS704 (IF) can also be clearly identified: 2 flights were subsequently aborted, while on 3 flights the vertical profile was manually captured from above.

Finally, even for those flights that successfully captured the vertical path, a slight overshoot of the nominal vertical path can be observed which is then followed by an interception from above.

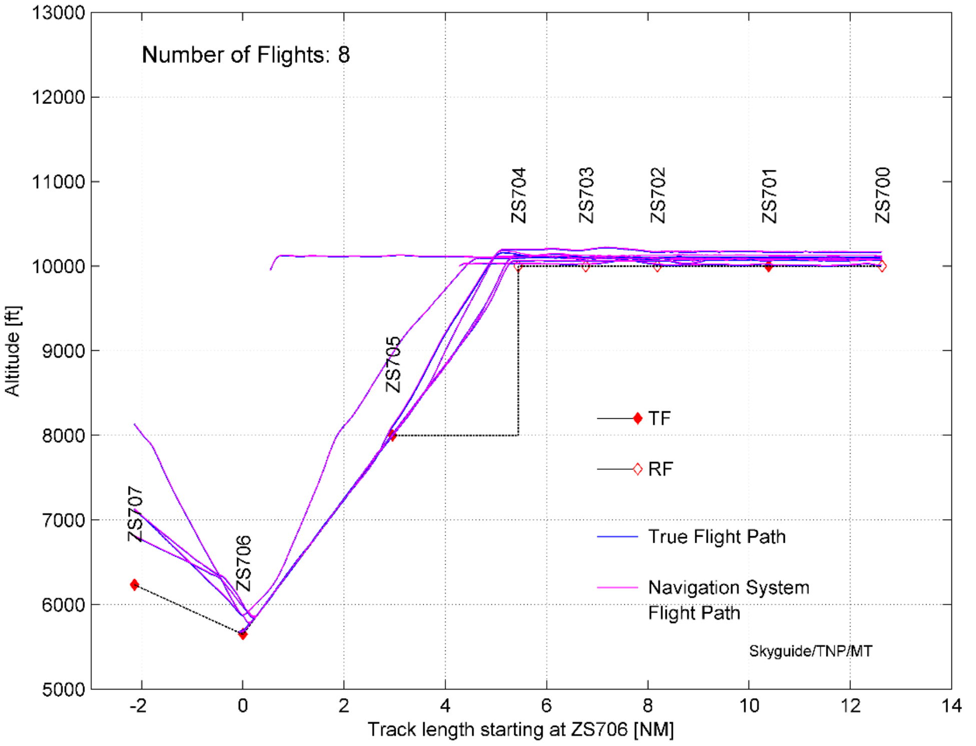


Figure 37: Skyguide flight track analysis – RNAV (RNP) RWY 03 Samedan – Profile view

The horizontal and vertical protection level plots show that EGNOS augmentation was unavailable for several parts of the flights. During these EGNOS unavailability periods, a fall-back to GPS/RAIM occurred resulting in a slight increase of the protection levels.

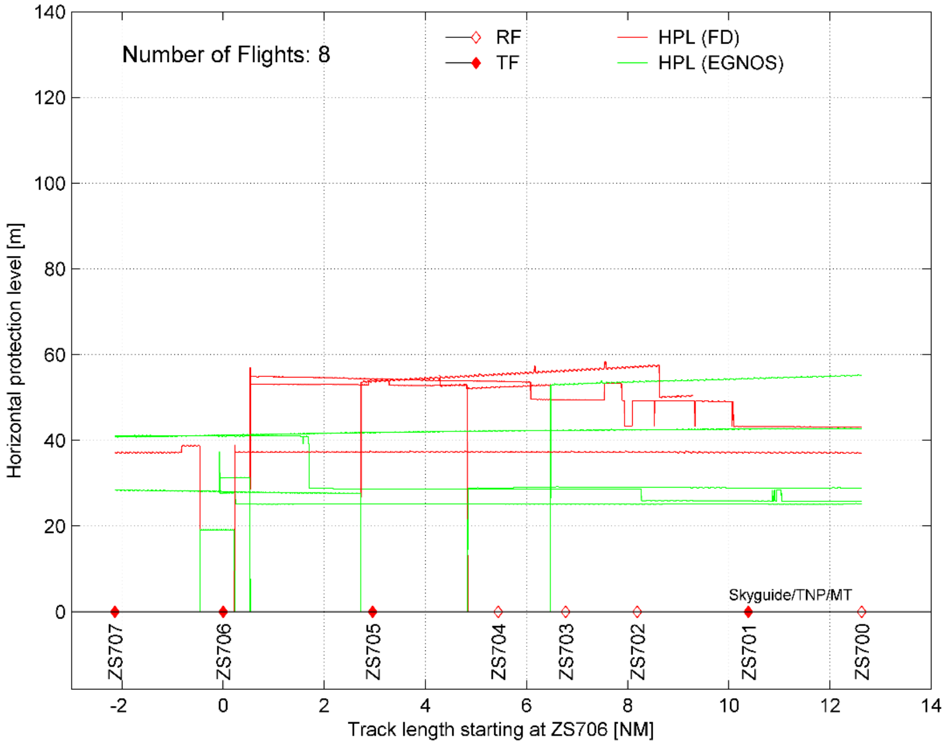


Figure 38: Skyguide flight track analysis – RNAV (RNP) RWY 03 Samedan – Horizontal protection level

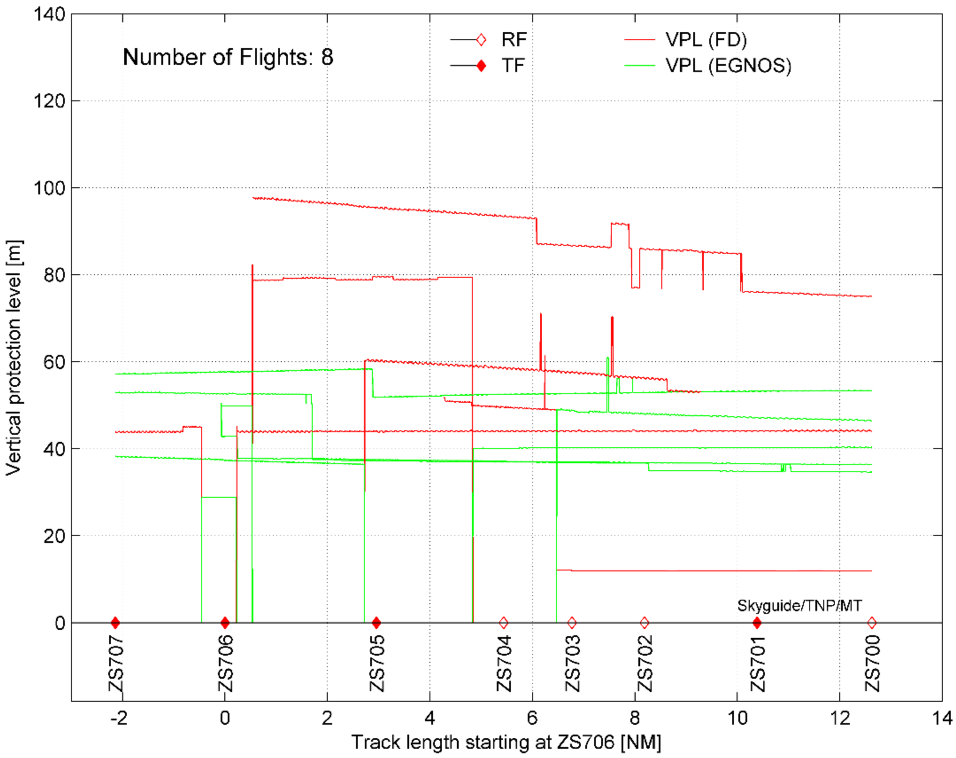


Figure 39: Skyguide flight track analysis – RNAV (RNP) RWY 03 Samedan – Vertical protection level

6.1.3.1.2.1.2 RNAV (RNP) RWY 21 Samedan

Flight track data of 5 approaches to RWY 21 was available for the flight track adherence analysis.

The plan view and the lateral deviations view illustrate that the largest deviations from the desired track occurred at the entry into the procedure (i.e. at ZS780 and shortly thereafter). Again, this is attributable to the fact that the first leg was normally not properly entered fully aligned, resulting in an over- or undershoot that the navigation system corrected with some delay.

In general, a certain overshoot tendency can be observed at the entry of each RF segment which the navigation system then slowly corrects in the course of the RF leg.

As opposed to the RWY 03 approach, a distinct increase in TSE/FTE can be observed shortly after ZS706 (FTP). This is rather unexpected, since there is no track change between the last final approach and the first missed approach segment.

It is also worth noting that the navigational performance during the remainder of the missed approach is significantly better than during the approach phase. It is expected that this is due to the less demanding design of the RF legs in the missed approach with larger turn radii and smaller track changes.

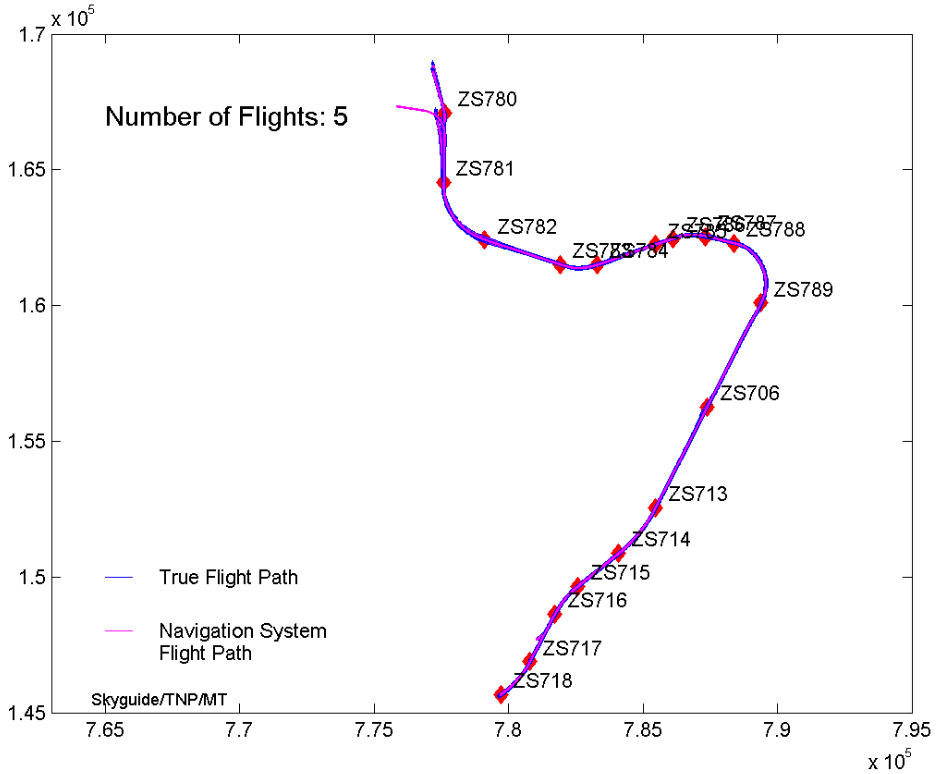


Figure 40: Skyguide flight track analysis – RNAV (RNP) RWY 21 Samedan – Plan view

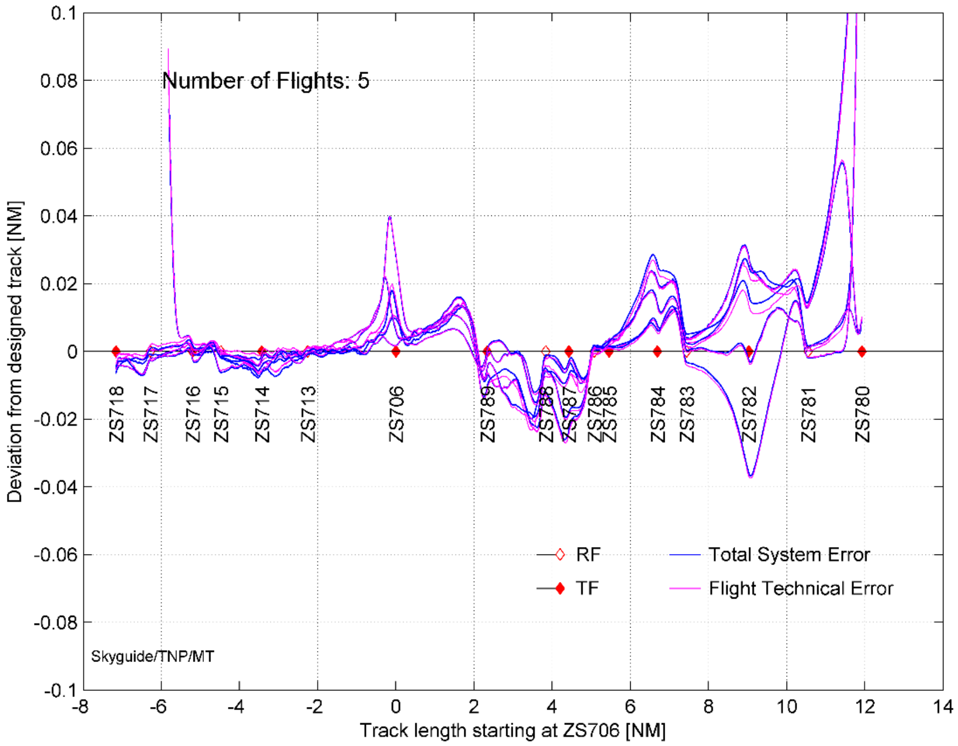


Figure 41: Skyguide flight track analysis – RNAV (RNP) RWY 21 Samedan – Lateral deviations

The profile view shows that the navigation system and true flight paths of most of the flights are situated slightly above the nominal procedure altitude (10000 ft) between ZS780 and ZS785 (FAP). This can be attributed to the barometric altimeter, which is used for vertical navigation during this phase of flight, in above-standard temperature conditions, and represents a normal system behaviour.

Moreover, during most of the flights the intercept of the vertical path at ZS785 (FAP) occurred with some delay, resulting in a slight overshoot of the nominal descent profile followed by an interception from above.

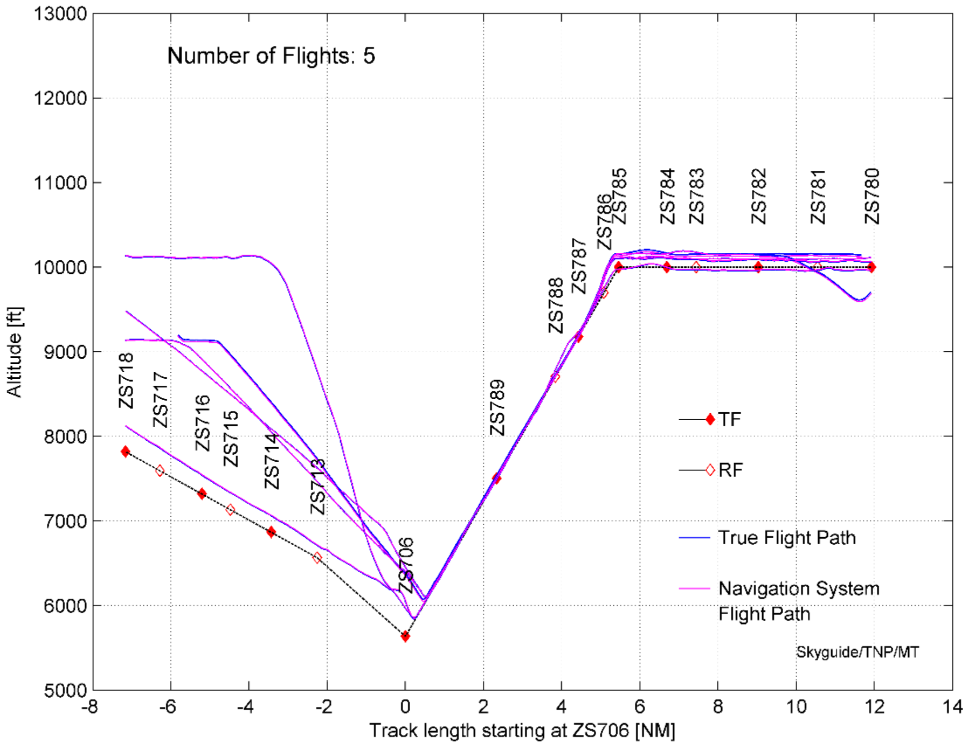


Figure 42: Skyguide flight track analysis – RNAV (RNP) RWY 21 Samedan – Profile view

The horizontal and vertical protection level plots show that EGNOS was unavailable for several parts of the flights. During these EGNOS unavailability periods, a fall-back to GPS/RAIM occurred resulting in an increase of the protection levels.

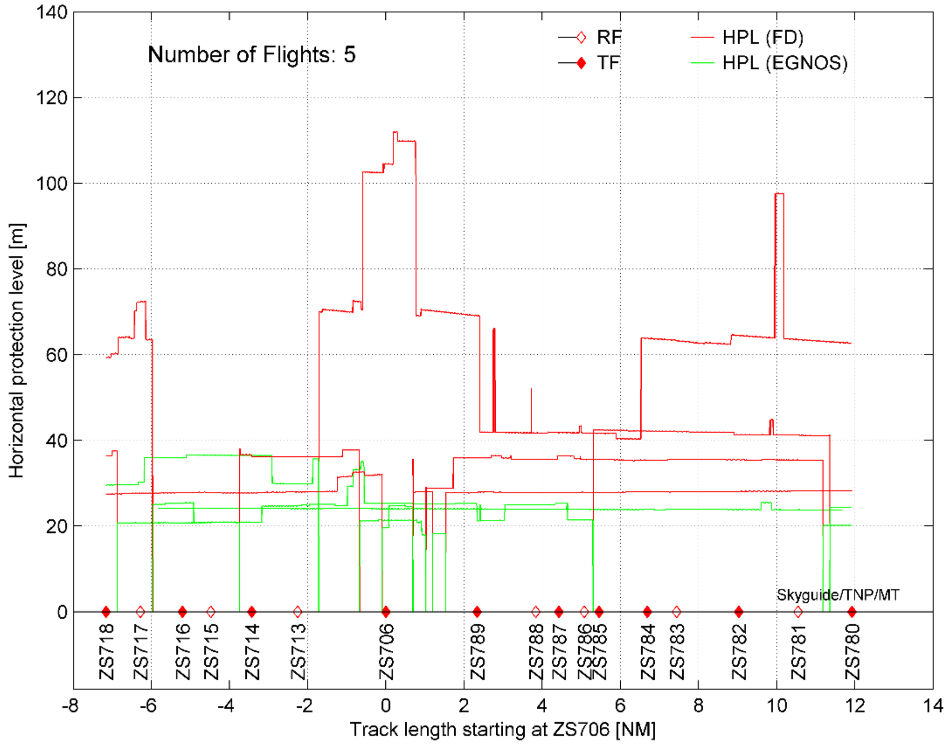


Figure 43: Skyguide flight track analysis – RNAV (RNP) RWY 21 Samedan – Horizontal protection level

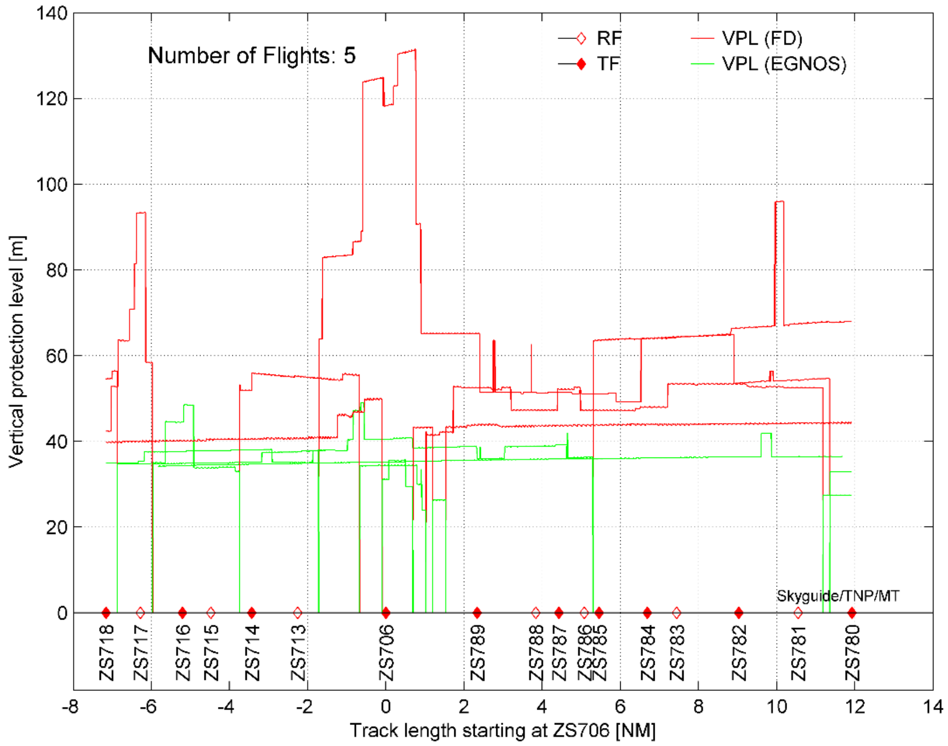


Figure 44: Skyguide flight track analysis – RNAV (RNP) RWY 21 Samedan – Vertical protection level

6.1.3.1.3 Results impacting regulation and standardisation initiatives

The experience gained during the procedure design process indicates that in a demanding terrain environment like the Swiss Alps, operationally acceptable approach minima may not be achieved with PinS LPV procedures for helicopters. Dedicated helicopter RNP AR procedures criteria must be established to achieve that. The capabilities of modern light weight avionic systems must be taken in consideration for redundant requirements.

Experience gathered with the RNP AR procedure in Samedan is fed into the ICAO IFPP for improvement of the current RNP AR design criteria and their extension to support helicopter PinS type of procedures.

6.1.3.1.4 Unexpected Behaviours/Results

For the Samedan scenario, a new type of procedure has been designed and flown: helicopter RNP AR APCH procedure. (PinS APCH to LPV minima foreseen in the demonstration plan did not allow to reach the operational solutions due to a very challenging environment). This new type of procedures can provide significant benefits to the HEMS community and this is a good opportunity for the project and the team to demonstrate these benefits.

The adoption of this more demanding procedure during the first Samedan campaign highlighted the need to perform some software adaptations to the flight inspection platform in order to allow the required processing activities for the evaluation of the on-board navigation performance.

Indeed, a second flight campaign has been performed to fly additional RNP AR APCH procedures in Samedan scenario using the updated Flight Inspection console in April 2016.

An additional post-processing of the big data set acquired in Switzerland during the first 2015 Samedan campaign with the updated flight inspection functionality (RF leg) were performed after the second 2016 Samedan campaign.

6.1.3.1.5 Quality of Demonstration Results

The flight campaigns at Samedan airport were performed using Rega’s AW109SP helicopter. This helicopter is equipped with ETSO-C146 certified GPS/SBAS receivers and is already approved by FOCA for operational procedure under RNP 0.3 and RNP APCH operations (as per the following documents: FAA AC 20 138D and ICAO DOC 9613 PBN, Chapter 7).

The main capabilities of the Rega AW109SP helicopter are:

- RNP/RNAV
- RNP 0.3 in all phases of flight (demonstrated only)
- LP (demonstrated only)
- LPV with GPA up to 9°
- LNAV/VNAV (Baro/SBAS)
- LNAV
- ILS with GPA up to 7°
- RF with turn radius down to 800ft (missed approach down to 1500ft)

Even if the operator does not yet hold an operational approval for RNP AR APCH, the equipment on board allowed to execute without any risk the procedure with an RNP navigation accuracy requirement of 0.1 NM (and the performance obtained might be also an input to foster the helicopter certification process for RNP 0.1).

Moreover, the helicopter was equipped with a certified ADS-B device out for the demonstration trial execution.

Flight data was collected on board the Rega helicopter from a geodetic JAVAD receiver and a set of additional flight inspection equipment provided by Flight Calibration Service GmbH.

FCS Flight Calibration Services GmbH carries out flight inspection in accordance with the following regulations or approvals:

- ICAO Doc 8071
- ICAO Annex 10/14
- BAF – Bundesaufsichtsamt für Flugsicherung (Germany)
- DFS Deutsche Flug-sicherung GmbH
- AENA (Spain)
- NATO STANAG A Et P-1
- skyguide (Switzerland)
- Austro Control (Austria)
- IS-BAO (International Standard for Business Aviation Operations)

FCS also is certified as a Continuing Airworthiness Management Organization (CAMO) as referred to in Commission Regulation (EU) No. 2042/2003, Part M Section A Subpart G, and thereby approved to manage the maintenance of airworthiness and to issue Airworthiness Review Certificates as specified in § M.A.710 for the King Air 350 aircraft employed by FCS.

Therefore, all data collected during the flight trials can be considered highly reliable and provide accuracy of results and the confidence in the results.

6.1.3.1.6 Significance of Demonstration Results

The results collected during the flight trials of this exercise have a good significance from an operational point of view since they were executed during different times and by different pilots. The number of performed flights allowed elaboration of meaningful statistics. The new procedures were flown with advanced avionic equipment and flight data gathered and processed with state of the art flight inspection console.
It is worth noting that some trials present some distortions of FTE/TSE statistics, due to unknown manual pilot input and/or an improper interception of the first leg of the approach procedure.

6.1.3.2 GNSS Operative Monitoring Equipment (GNOME) System outcomes – First Campaign

In the first Samedan campaign, one GNOME sentinel has been installed in Samedan for the real time monitoring of GPS and EGNOS performance during flight validation trials as well as off-line performance assessment and GNSS environment characterization (e.g. EM horizon due to terrain masking, interference).

6.1.3.2.1 Samedan airport GNSS

At the time of this report the status of GPS is briefly summarized below.

- Nominal GPS constellation (*space segment*) is made up of 24 satellites. Nevertheless, the current status is: **32 satellites of blocks IIA/IIR/IIR-M/IIF**.
- Every GPS satellite transmits at least 2 signals respectively at L1 (1575.42 MHz) and L2 (1227.6 MHz) frequencies, each one provided with different spreading codes. More in detail, the L1 carrier is modulated by C/A (for civil applications) and P(Y) (only for military applications) codes. Conversely, the L2 carrier can be modulated by only one code that is typically a P(Y) code.
- The selective availability on C/A code was ***turned off*** at midnight ***May* 1st, 2000**.
- The GPS modernization is currently ongoing. This process includes the transmission of new signals, which are included in the new blocks as indicated below.
    - The **block IIR-M** satellites transmit a second civil signal L2C on the L2 frequency and the military M signal on the L1 and L2 frequencies.
    - The **block IIF** satellites transmit all signals including on the L5 frequency, intended for *safety-of-life* applications.

6.1.3.2.1.1 Radio-Horizon Analysis

The analysis of *local radio horizon* is essential to identify any possible *manmade* or *orographic* obstacles which can reduce the *GPS satellite visibility*. Indeed, such undesired effect shall be minimized, in order to avoid long periods of poor satellite geometry (high xDOP levels) that can lead to a general degradation of the GPS performance.

This analysis is carried out by analysing a set of daily sky plots which collect all trajectories produced by the tracked GPS satellites. IN this way such graphs provide a reliable reconstruction of the ***horizon line*** (the skyline over which GPS satellites are visible) around the site, that hosts the GNSS antenna.

Then, by comparing the so achieved horizon with the elevation threshold of 5° (see Sect. 2.2.2), it is possible to detect possible obstructions (those sectors in which the horizon line largely exceeds the elevation threshold) due to masking effects produced by the local orography or by large manmade obstacles.

The achieved results are shown in the following plots:

- Figure 45: radio horizon of 20/07/2015.
- Figure 46: radio horizon of 21/07/2016.

Both these graphs show that the airport of Samedan is affected by 2 main masking effects due to the presence of mountains in the azimuth sectors: 60°÷145° and 240°÷330°. Such obstructions reach elevations of 20°.

Conclusions. Large masking effects have been detected in the azimuth sectors 60°÷145° and 240°÷330°. Such obstructions are due to the local orography and they reach elevations of 20°.

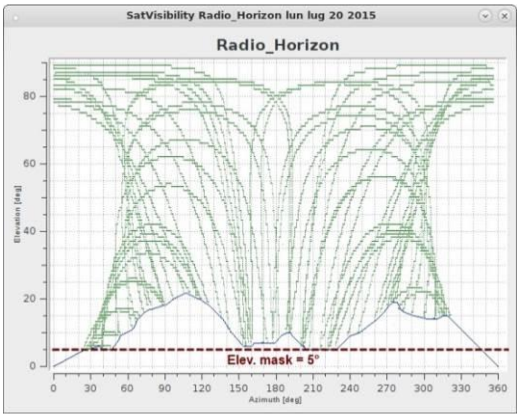


Figure 45: Radio horizon 20/07/2015

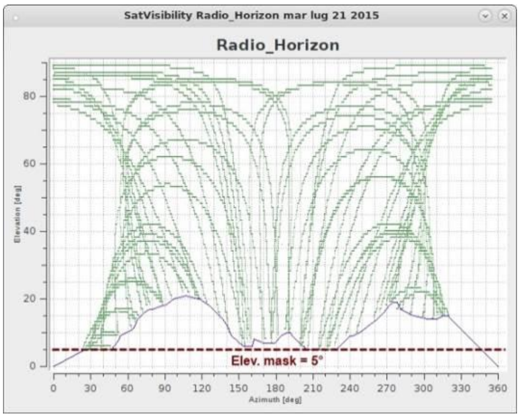


Figure 46: Radio horizon 21/07/2015

6.1.3.2.1.2 Satellite Availability & DOP

The previous radio horizon analysis (See 6.1.3.2.1.1) has shown the presence of two main blocks that can have a relevant impact on the GPS satellite visibility. Therefore, a more detailed analysis is needed in order to better understand what is the real obstruction effect generated by the local orography.

Figure 47 and Figure 48 provide 2 daily plot of the number GPS satellites used in the PVT computation. It is worth noting that such number is always larger than 4 (minimum number of GPS satellites to have a fix). Indeed, the minimum is 5 satellites, the maximum is 11, and the mean is about 7-8.

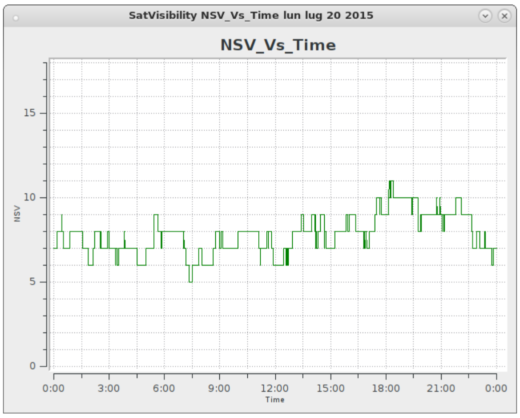


Figure 47: Number of used satellite, 20/07/2015

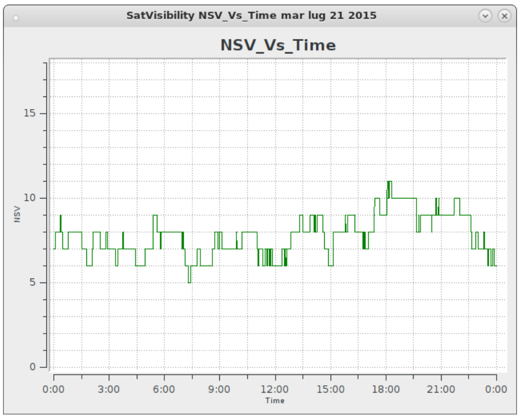


Figure 48: Number of used satellite, 21/07/2015

Such results are also confirmed by the plots of satellite availability which are shown in Figure 49 and Figure 50. Indeed, by excluding the only unhealthy PRN-8, all other visible GPS satellites are correctly tracked and used in the PVT computation.

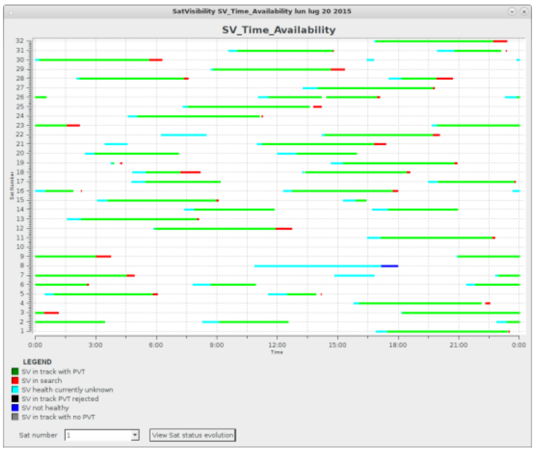


Figure 49: – SV availability, 20/07/2015

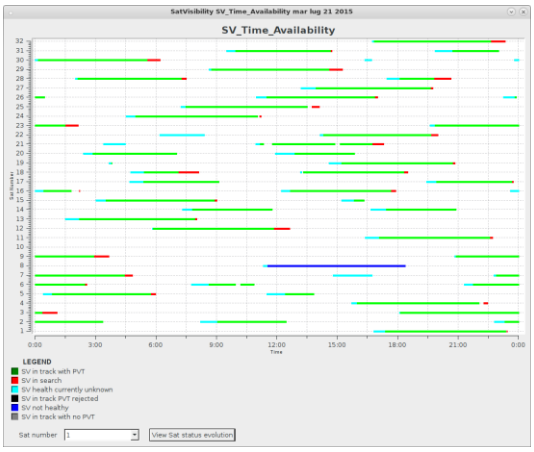


Figure 50: – SV availability, 21/07/2015

HDOPs and VDOPs are reported in the figures below. All pictures show quite low levels of xDOPs (typical HDOP < 2 and VDOP < 4) and the maximum values occur only when the number of used satellites go down to 5.

Therefore, the typical satellite geometry, visible from the Samedan airport, can be considered good enough to guaranteeing adequate accuracy levels of position. Nevertheless, it is strongly suggested a continuous monitoring of GPS performance, because any unscheduled anomaly can strongly compromise the availability of the positioning service.

Conclusions. The analysis of GPS satellite availability has shown that the number of used satellites is always ≥ 5 and xDOP levels are typically low enough to guarantee good levels of positioning accuracy. Nevertheless, a continuous monitoring of GPS performance is strongly recommended.

From the preliminary results in terms of radio horizon masking and related impact on GNSS performance, it is highly recommended to include topographical 3D models within GNSS prediction tools in order to predict potential GNSS unavailability (e.g. FD/FDE) due to significant environmental masking in challenging scenario where RNP APCH and RNP APCH AR procedures are implemented.

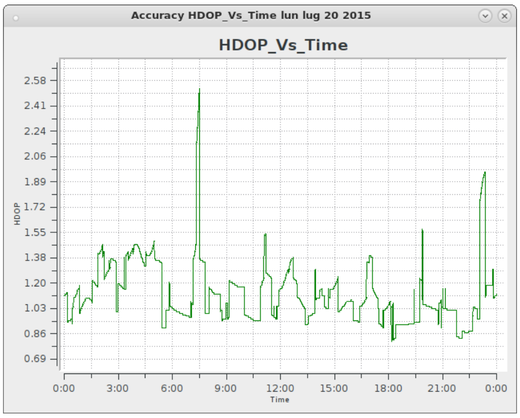


Figure 51: HDOP daily plot, 20/07/2015

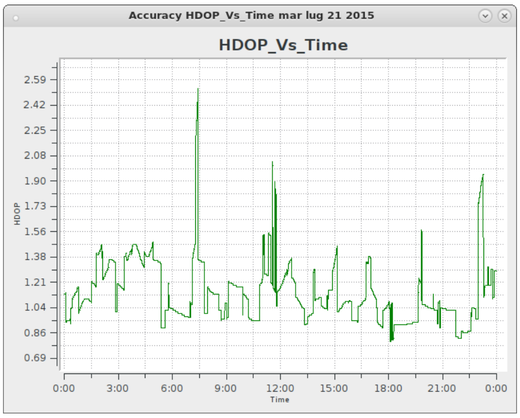


Figure 52: HDOP daily plot, 21/07/2015

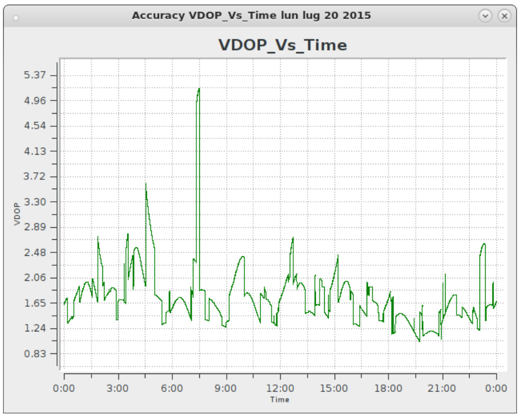


Figure 53: VDOP daily plot, 20/07/2015

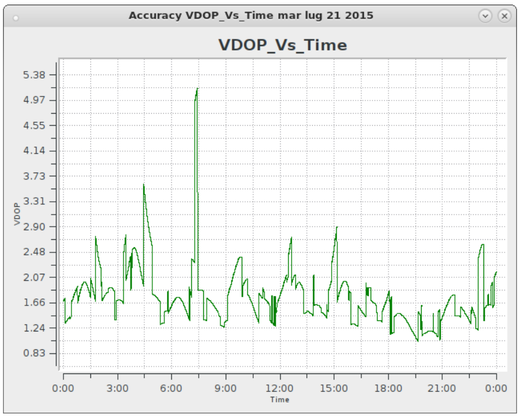


Figure 54: VDOP daily plot, 21/07/2015

6.1.3.2.2 ADS-B performance

This section provides the cross track distance estimated, comparing ADS-B positions against the flight procedure nominal path. The use of the APM tool fed by ADS-B position data allowed to monitor on ground in real time the adherence of flights against the nominal path and to contribute to the statistical evaluation of cross track distance between rotorcraft position and nominal path.

This data have been acquired during flight trial execution by the APM tool. Samedan approach procedure is characterized by several turns and segments reported in table below:

Samedan approach procedure		
Connection Type	**Start WP**	**End WP**
Turn_1	BIVIO	ZS000
Turn_2	ZS000	ZS001
Turn_3	ZS001	ZS003
Segment_1	ZS003	ZS004
Turn_4	ZS004	ZS006
Segment_2	ZS006	ZS007
Turn_5	ZS007	ZS009
Segment_3	ZS009	ZS010
Turn_6	ZS010	ZS012
Segment_4	ZS012	ZS013
Turn_7	ZS013	ZS015
Segment_5	ZS015	ZS016
Segment_6	ZS016	ZS017

Table 22: Samedan approach procedure

Figure 55: Samedan approach reference path (Google Earth view)

The cross track distance evaluation has been performed starting from Segment_1 until Segment_4 (see table), where ADS-B coverage is available due to environment masking.
In picture below, it is reported:

- red line: the helicopter trajectory (provided by ADS-B)
- white line: the reference path in APM tool

Figure 56: Samedan approach reference path (white line) and ADS-B plots (red line)

ADS-B data acquisition has been performed during the performed approach flights:

Number of flight trial[5]	ADS-B Registration number	Flight Inspection Registration number
1	RUN1	#11
2	RUN2	#02
3	RUN 3	#04
4	RUN 6	#14
5	RUN 7	#16
6	RUN 8	#18
7	RUN 9	#24
9	RUN 10	#07
10	RUN 11	#09
12	RUN 13	#16
13	RUN 14	#18
14	RUN 16	#20

Table 23: ADS-B acquisitions vs Flight Inspection acquisition performed between 20/07/15 and 22/07/2015 for Samedan Approach procedure

The achieved statistic results are shown in the following plot (starting from ZS003 until MAPt). This picture shows statistical evaluation for all ADS-B data. For each registration, it has been calculated the 95th Percentile.

[5] Number is aligned with the one reported in Table 14

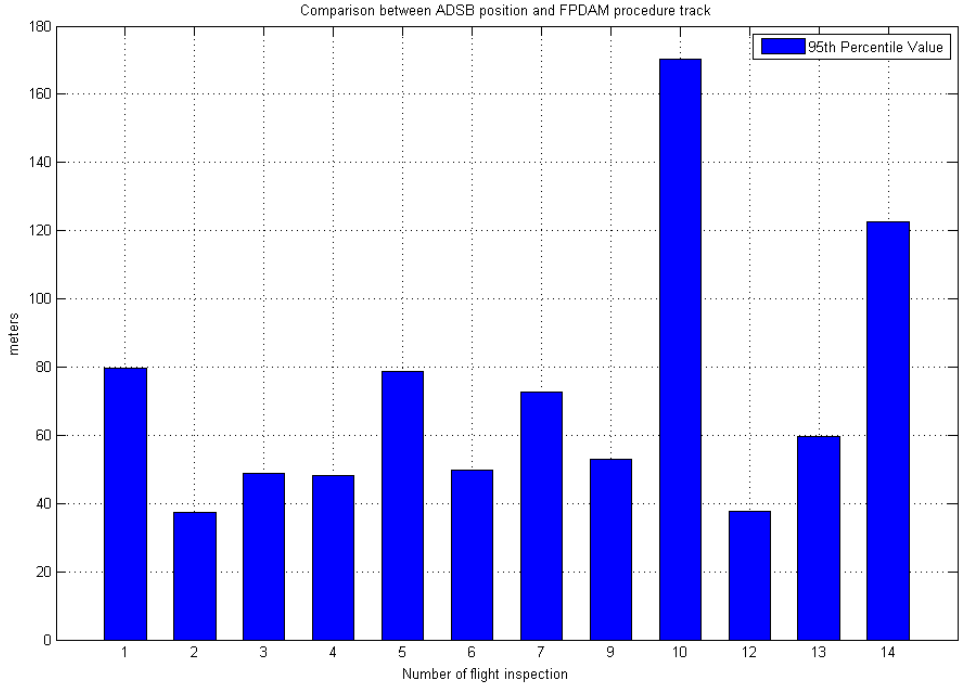


Figure 57: Comparison between ADS-B position and nominal track

Flight number n.10 and n.14 show higher values of the 95th percentile. The flight inspection report – first campaign – (see Appendix K) also shows a relevant increase of FTE/TSE cross track component immediately after ZS010 in correspondence of the turn.
Furthermore, cross track deviation statistics estimated using ADS-B position data, are heavily impacted by this error contribution, due to the shorter number of samples (the acquisition starts from ZS003 until MAPt) in comparison with the FTE/TSE error statistics.
The use of ADS-B data for the quantification of the deviation from nominal flight track is not an alternative means for the FTE assessment. The use of the ADS-B in the approach trials has two main purposes:

- preliminary assessment of the APM tool operational capability for real time approach path monitoring using ADS-B data;
- use ADS-B data to make post analysis statistics aiming at quantifying the deviations from the nominal path monitored in real time.

6.1.4 Conclusions and recommendations

6.1.4.1 Conclusions

6.1.4.1.1 First Campaign

The design trials with both RNP APCH and standard (fixed wing) RNP AR procedures resulted in operationally unacceptable approach minimums. From a procedure design perspective, the development of an RNP AR procedure tailored to helicopter performance characteristics in terms of speed and climb/descent profiles has proven its benefit in a demanding terrain environment.

In regard to this first exercise, the results demonstrate that even if the procedures will produce slight changes in the operating methods and a slight increment of the workload, the implementation of the new procedures is considered a benefit for pilots and operations.

A medium increase of safety is noted, compared to the VFR/VMC condition in day operations.
Significant safety improvements are expected in marginal weather situations and during night operations.

Mitigation means for potential hazardous situations and for the decrement of the negative impact on operating methods and workload have been identified.

Pilots provided their view about the impact of the new procedure on safety, comparing it with the procedures they are currently using (VFR procedures).

The circumstances that made the new procedures safer than the current ones are especially marginal weather situations and night operations. Pilots highlighted the risk, in good weather, to shift the pilot's attention from outside of the cockpit to inside, with the possibility to produce air to air collisions.

6.1.4.1.2 Second Campaign

The results of the second campaign demonstrate an increment of the positive values collected for each KPAs, thus further supporting the expected benefits of the new IFR procedures.

The detailed flight track adherence analysis performed by Skyguide generally confirmed that the navigational performance remained within the limits of RNP AR with RNP navigation accuracy requirement of 0.1NM at all times. The detected navigation systems errors were found to be significantly smaller than the flight technical errors. However, it should be noted that the interception of the first leg of the procedure, which normally is not properly entered tangentially in case of an RF leg or fully aligned in case of a TF leg, distorts any FTE/TSE statistics.

On 9 out of 13 approaches that were considered in the analysis, EGNOS guidance was not available during the full approach. Moreover, on 5 out of 13 approaches, the automatic capture of the vertical path prior to the final descent was not successful, all of which were approaches to RWY 03. No correlation between cases of successful automatic capturing and EGNOS availability could be established and it would need to be demonstrated whether the situation could be improved with minor design modifications. However, also in case of the automatically captured approaches, the data shows the general trend of an overshoot of the vertical path followed by an interception from above.

Finally, the flight track data of the RWY 21 approach revealed a distinct increase in the flight technical and total system error at ZS706 (FTP). Based on the received pilot feedback, this may be due to the reversion from the autopilot navigation mode to heading mode during the initial missed approach. However, the reason cannot be conclusively assessed without further investigations.

6.1.4.2 Recommendations

The design trials with procedures based on the RNP APCH and RNP AR APCH (with the existing fixed wing criteria) navigation specifications resulted in operationally unacceptable approach minima. This could only be improved with the adoption of deviations from the current design standards. From a procedure design perspective, the development of an RNP AR procedure tailored to helicopter performance characteristics in terms of speed and climb/descent profiles has proven its benefit in a demanding terrain environment.

Based on the conclusions of the detailed flight track adherence analysis, it is recommended to further investigate the autopilot behaviour at the interception of the vertical path and to implement design modifications to support the automatic capturing of the final descent. It is also recommended to analyse the detected deterioration in navigational performance at ZS706 (FTP) on the RWY 21 approach in detail. Finally, although limited EGNOS availability has been observed, the inclusion of an EGNOS requirement should be considered in order to support the navigational performance on both approaches.

Finally, the importance of a detailed aircrew initial and recurrent training on RNP AR procedures, as stipulated in ICAO Doc 9613 PBN Manual, was demonstrated.

6.2 Demonstration Exercise EXE-02.09-D-002 Report

6.2.1 Exercise Scope

The second demonstration exercise covers the concept of PinS “non-standard” departure at Samedan airport and the adoption of the RNP 0.3 navigation specification making use of the optional RF leg functionality.

The term “non-standard” is used to highlight that the design criteria used are partially not compliant with ICAO PANS-OPS criteria. The orographic environment did not allow to design a fully compliant PinS departure with an operational usable procedure design gradient. The “non-standard” solution adopted ignores the secondary protection areas in the obstacle assessment in order to exclude more penalizing obstacles.

The exercise level corresponds to the E-OCVM level V4, since the exercise encompasses live trials in operational environment.

The adoption of the RNP 0.3 navigation specification in the departure phase and the design of a PinS departure making use of with the RF functionality increases site availability in terms of IFR departures allowance, in particular during poor visibility with a reduced departure minimum cloud ceiling and minimum visibility. Moreover an increased safety level for helicopter departure operations is expected in comparison with the current VFR/VMC operations in terms of improved pilot situational awareness and workload reduction.

6.2.2 Conduct of Demonstration Exercise EXE-02.09-D-002

6.2.2.1 Exercise Preparation

In relation to the preparation of the exercise EXE-02.09-D-002, several activities have been performed according to the ICAO regulations and criteria. The following list summarises these activities that were previously mentioned in the D01 PROuD Demonstration Plan:

- <u>Input data and operational requirements collection</u>
  - No ad-hoc survey will be performed. Aeronautical Data and Metadata acquisition and import into the design environment: DTM/DSM, Airport/Heliport data, Obstacle data, ATS environment, Other data/information
  - Definition of the operational requirements for the design of the new PinS departure procedure
- <u>Landing site assessment and PinS departure procedure design</u>
  - Obstacle and terrain surfaces modelling and assessment for landing site suitability verification to support IFR PinS departure procedures
  - Design of one PinS departure procedure
- <u>Flight Procedure Ground Validation and avionic database preparation</u>
  - Verification of accuracy of the data used for flight procedure design
  - Verification of the correct application of ICAO PANS OPS criteria for flight procedure design
  - Full flight simulations using the Rega AW109 full flight simulator for flight procedure fly ability assessment
  - Navigation DB preparation and upload on the FMS
- <u>On board platform adaptation</u>
  - Data acquisition and recording platform
- <u>Coordination between ATS units</u>

- In parallel to the activities listed above, a proper coordination between all the involved stakeholders will be need to be set up in order to guarantee the necessary coordination with the ATS units involved during flight trial execution (AFIS)

- Procedure preparation:
  - Preparation and fulfilment of an in-house Rega SAFE (safety analyses in front of engagement)
  - Preparation of timely briefing for all participants for the flight validation trial invitation and flight validation execution plan.
  - Reservation and preparation of the installation of the dedicated flight inspection kit in the helicopter

- Pilot training
  - Training of pilots with Rega full flight simulator

6.2.2.2 Exercise execution

The execution of the exercise has been structured in pre-flight activities, the demonstration flights performance and post-flight activities.

Below the exercise's steps are listed as they have been executed:

- Pre-flight activities:

  Preparation of timely briefing for all participants for the flight trial (airport authority Samedan, local AFIS, local residents, regulator, flight crew) and flight trial execution plan

- Flight trials execution:

  Execution of new PinS departure procedure: 13 flights using the Helicopter and 2 flights using the FFS executed with the new PinS non-standard departure.

  During the execution of the exercise, data have been collected on board Rega helicopters.

  Moreover on ground equipment have been used during flight execution for real time monitoring of GPS and EGNOS performance in the signal and navigation domain

  Qualitative techniques of data collection have been also used during the trials and they included over-the-shoulder non-intrusive observations of pilots and system behaviour during the trials, together with the think aloud methodologies.

- Post-flight activities:

  Immediately after the flight, a debriefing has been held between involved stakeholders (local AFIS, flight crew, procedure designers, safety experts).

  At the end of the exercise the following activities have been executed:

  - Extraction of flight data records from helicopter on board equipment;
  - Processing of navigation data acquired on board and elaboration of data acquired on ground;
  - Performance assessment and anomaly investigation execution.

  The information gathered during the exercise served as a description of the system performance when using the PBN procedures. Quantitative and qualitative measures contributed to the final assessment of the flight trials.
  Regarding the navigation performance assessment it is worth mentioning that Rega Flight inspection console, used during the flight trials allows the recording of all the necessary navigation parameters for the post processing activities.
  For detailed description, please refer to section 4.1.3.4.

REFERENCE SCENARIO

The reference scenario for this exercise is today's operational scenario in Samedan airport. The airport overview, airspace classification, weather minima and current operations are detailed in B.1.1.
At Samedan (ICAO code LSZS) airport only VFR operations are currently allowed for both fixed wing and rotary wing aircraft.
No IFR departure procedure is available hence departure operations are only possible in VMC.

The airport overview, airspace classification, weather minima and current operations are detailed in B.1.1.

SOLUTION SCENARIO

The implementation of PinS "non-standard" departure has been identified by Rega as an effective solution to overcome current existing limitations in terms of safety and IFR departures allowance, in particular during poor visibility with a reduced departure minimum cloud ceiling and minimum visibility, and in challenging environment (the deviation of the solution scenario from the one reported in the demonstration plan is explained in 6.2.2.3).

PROuD flight trials at Samedan airport will be conducted in VFR/VMC conditions during both the flight validation phase and in the demonstration phase.

In the Table 14, the list of helicopter flights performed for this exercise (EXE-02.09-D-002) on the Samedan departure procedure is reported:

6.2.2.3 Deviation from the planned activities

A PinS non-standard departure instead of a PinS departure was designed and evaluated since during the procedure design phase it was agreed ignore the secondary protection areas in the obstacle assessment in order to reduce the procedure design gradient. The design of a PinS departure fully compliant with the procedure design specifications resulted in a PDG beyond the operationally acceptable limits.
A total of 13 flights (additional 2 in the FSS) instead of 20 were performed, and additional flights for the Chur scenario were conducted (inserted an additional exercise EXE-02.09-D-008 – see 6.8).

6.2.3 Exercise Results

6.2.3.1 Summary of Exercise Results

6.2.3.1.1 Results per KPA

6.2.3.1.1.1 Safety

The impact of the new procedures on safety has been evaluated using the following the following Key Performance Indicators (KPIs):

- Flight crew subjective feedback on safety;
- Flight crew workload;
- Flight crew situation awareness;
- Flight track adherence.

The first three indicators have been evaluated using feedback collected through pilot's questionnaires (see Appendix G to have a look to the Swiss first flight campaign questionnaire results), the last one using the data collected by the on board flight inspection system.

Flight crew subjective feedback

The average value gathered from pilots' questionnaire is 3,50/5. The flight trials demonstrate that for the PinS non-standard departure the safety level is expected to slight increase with respect to current operations. It is important to highlight that the average value is a subjective feedback of pilots based on a procedure designed with non-standard criteria. Therefore, this value is purely indicative and the real safety impacted on operation needs to be properly addressed.

Additional identified hazards are system errors or failure on board as for as hazards related to the GNSS unavailability. In order to avoid those critical situations, a mitigation mean identified is to decide if there are the right conditions to fly based on the weather conditions.

The flight trials pilots' expected impact of the new procedure on safety, situation awareness and workload compared with the current ones (answers' average), is shown in the figure below.

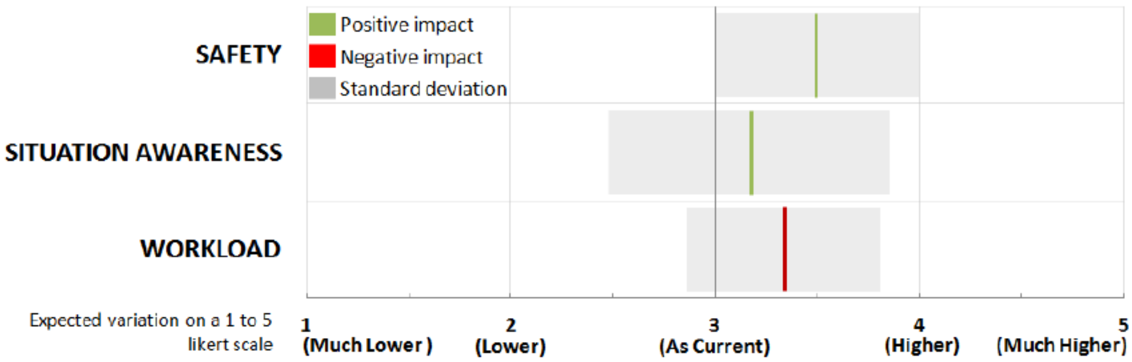


Figure 58: Questionnaires results for EXE-02.09-D-002 (Departure Samedan).
Flight Trials Pilots' expected impact of the new procedures compared with the current ones (answers' average).

Flight crew workload

The average value for this KPI resulting from the questionnaire is 3,33/5.

Workload is expected to slightly increase respect to current procedures, especially before the take off, but to remain within safe margins.

Flight crew situation awareness

The situation awareness was rating 3,17/5; thus according to pilots, the IFR procedures will not have a significant impact on this KPI.

Flight track adherence

The adherence to the designed flight track has been quantitative evaluated in terms of Cross-track Total System Error estimated by on board flight inspection system. The TSE statistics are reported in terms of the 95th percentile in Figure 59.

The evaluation for each flight has been performed from ZS200 to BIVIO, except for the last flight, according the values reported in the table below:

Flight trial number [6]	Date	Registration number	Data processed
1	21/07/2015	#01	ZS200 - BIVIO
2	21/07/2015	#03	ZS200 - BIVIO
3	21/07/2015	#05	ZS200 - BIVIO
4	21/07/2015	#06	ZS200 - BIVIO
5	21/07/2015	#15	ZS200 - BIVIO
6	21/07/2015	#17	ZS200 - BIVIO
7	21/07/2015	#19	ZS200 - BIVIO
8	22/07/2015	#01	ZS200 - BIVIO
9	22/07/2015	#08	ZS200 - BIVIO
10	22/07/2015	#17	ZS200 - BIVIO
11	22/07/2015	#19	ZS200 - BIVIO
12	22/07/2015	#21	ZS200 – ZS204

Table 24: EXE-02.09-D-002 - Range of processed data

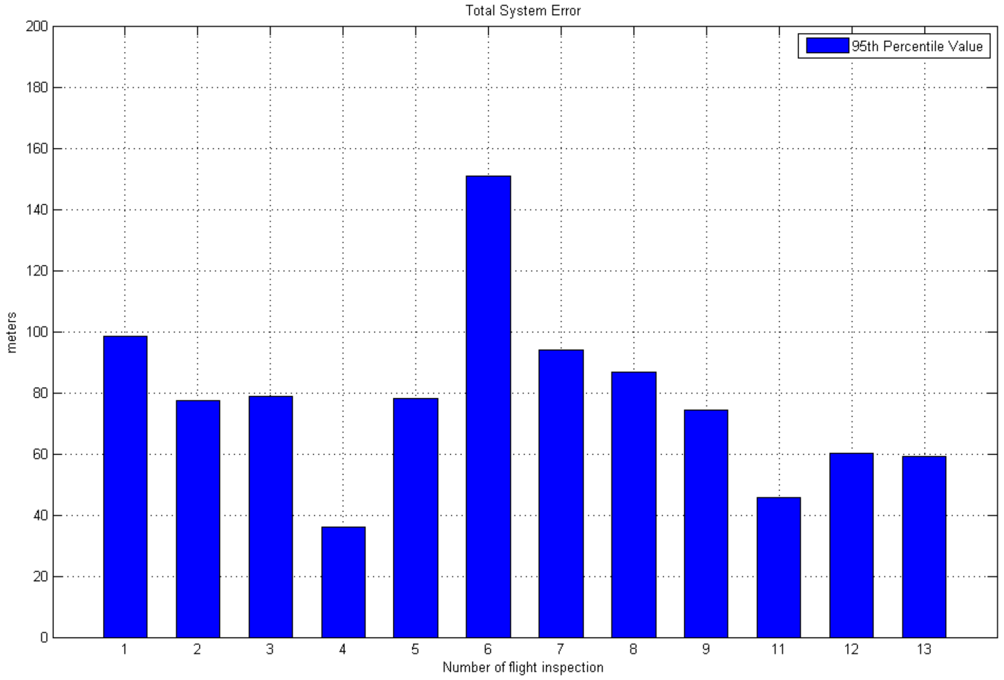


Figure 59: EXE-02.09-D-002 – Statistical evaluation of TSE cross track (REGA flight helicopter data) performed along Samedan departure procedure

Detailed results related to helicopter navigation performances along each approach trial are reported in [3], in terms of GNSS performances and signal quality, FTE and TSE error components.

[6] Number is aligned with the one reported in Table 14

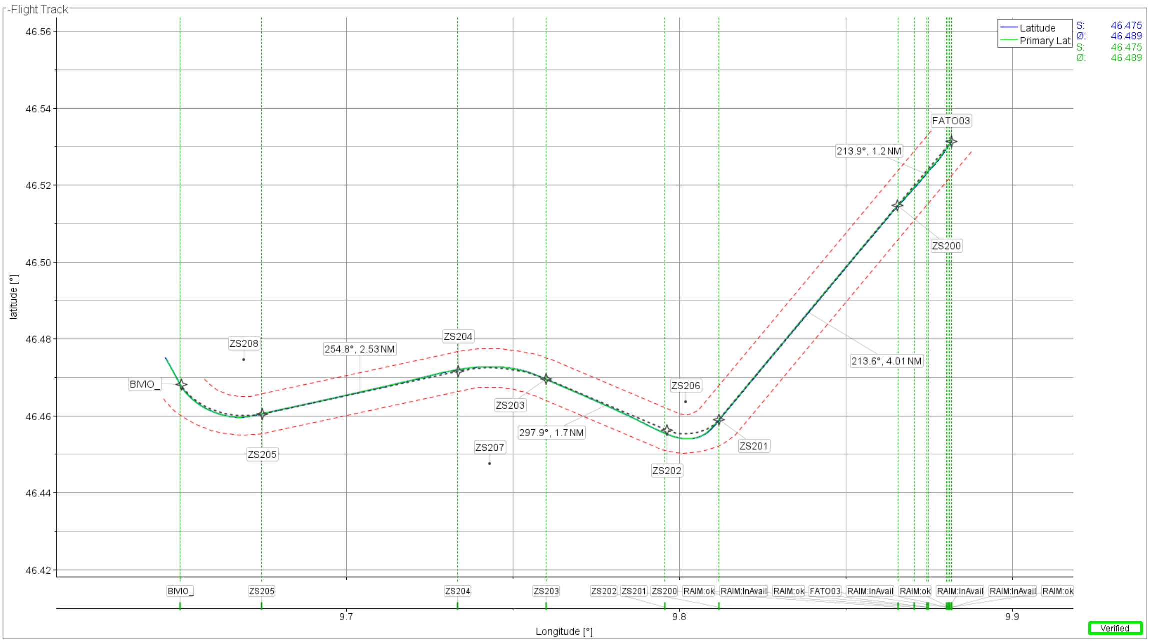


Figure 60: EXE-02.09-D-002 – Flight Track #1 (Approach flight trial n.1) Samedan departure procedure

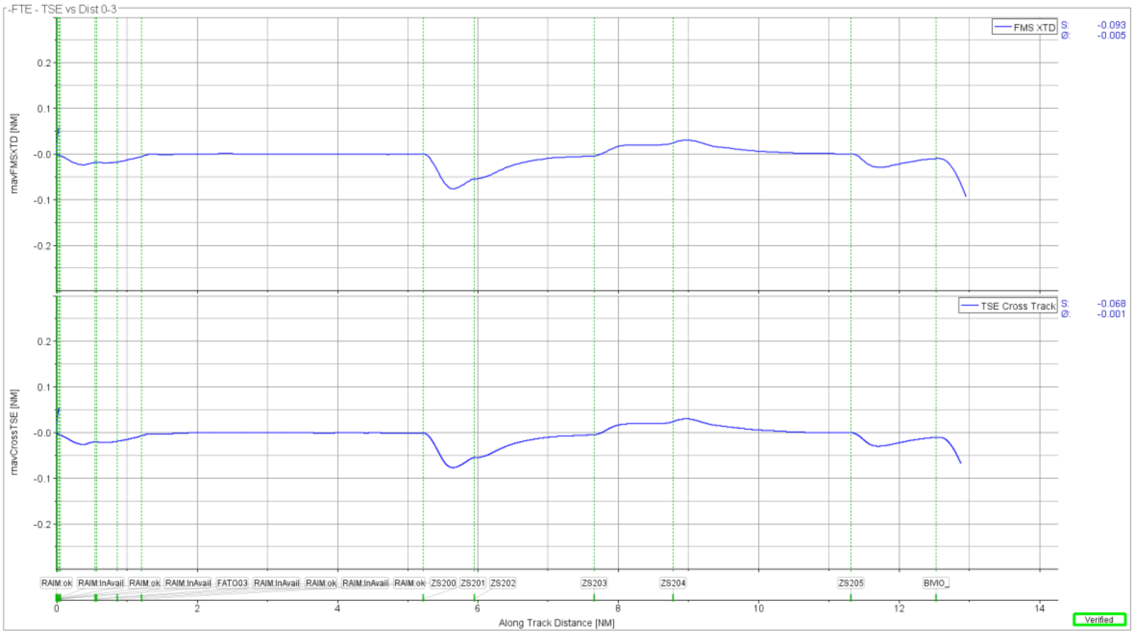


Figure 61: EXE-02.09-D-001 (first campaign) – Cross Track FTE/TSE of Flight Track #1 (Approach flight trial n.1) Samedan departure procedure

According to PBN manual ([5] - see 7.3.3.3.1), During operations in airspace or on ATS routes designated as RNP 0.3, the lateral TSE must be within ±0.3 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±0.3 NM for at least 95 per cent of the total flight time. To meet this performance requirement, an FTE of 0.25 NM (95 per cent) may be assumed.

In the first Samedan campaign, for some departure flight trials (e.g. n.6) higher values of TSE cross-track error have been experimented due to manual pilot intervention.

However, the overview of the lateral navigation performance, shows the compliance with RNP 0.3 NM lateral accuracy requirements. For other details and performance parameters of the performed flight trials, refer to [3].

6.2.3.1.1.2 Availability

For the evaluation of the site availability using the new approach procedures, the flight crew subjective feedback has been selected.

With regard to the availability, the average result +23% represents an increment of the value of this KPI when the new procedures are used for Samedan airport (see Figure 25). In other words pilots expect an increment of the possibility to take off of 23% respect to the current average number.

The reason of the positive impact of the PinS non-standard procedures is related to the current Swiss regulations that obliges to cancel the night operations and in critical weather conditions, when weather is below VFR/VMC minima. Those flights that are not permitted could be performed with the new procedures (once regulations allow their use and design criteria will be defined).

6.2.3.1.1.3 Environmental Sustainability

The flight track for the PinS departure is longer compared to VFR departure. The environmental impact is not necessarily reduced but the airport availability will increase in bad weather.

6.2.3.1.1.4 Efficiency

The impact of the new procedures on Efficiency has been qualitative estimated in terms of miles flown and time needed to perform the departure from Samedan airport. The KPI selected to measure this KPA is fight crew subjective feedback.

In this case, as for the other Swiss exercises where this KPI has been addressed, the average value of the efficiency is negative, -20% (see Figure 25).

An increase in efficiency is only achieved when the VFR-flying is not possible.

As already mentioned, this result depends on the fact that with the new procedures the flight time will be longer than the currently performed flights under VFR. Although flights might be longer, the flights can be conducted even fly in bad visibility and during the nights, resulting in significant economic and humanitarian benefits from performing more missions and saving more lives.

6.2.3.1.1.5 HP (Operating methods)

For the evaluation of the impact on the operating methods for this exercise the flight crew subjective feedback has been selected as key performance indicator.

In regard to this KPI the rating was 2,83/5 meaning that no impact is foreseen by pilots on this KPA. The same explanation was given by pilots as for the other Swiss exercises.

As the causes of the changes in the operating methods are the same as for the other Swiss exercise, also the same mitigation means have been proposed by the pilots. They consist of training pilots regularly and of implementing slight changes in the design of the procedures.

6.2.3.1.1.6 HP (Pilots' task performance)

For the evaluation of the Pilots' task performance the following indicators (KPI) have been selected:

- Flight crew subjective feedback;
- Flight crew workload;
- Flight crew situation awareness.

<u>Flight crew subjective feedback</u>

In regard to the pilots' task performance, the results collected for this KPA demonstrate that the human performance can be negatively impacted by inadequate training, error in programming the system that can lead to an increase of the level of workload. These issues are the same as any other IFR procedure. In this case of non- standard design criteria the possibility of occurrence of hazards needs to be properly deepened.

More information is provided in Appendix G.

Flight crew workload

The very slight expected increase of workload (See paragraph 6.2.3.1.1.1) should not impact Pilots' task performance.

Flight crew situation awareness

No significant impact expected (See paragraph 6.2.3.1.1.1).

6.2.3.1.1.7 HP (Performance of the technical system)

The KPIs selected for the evaluation of the performance of the technical system are:

- Flight crew subjective feedback;
- Navigation System Error (NSE);
- Total System Error (TSE) cross track.

Flight crew subjective feedback

Pilots provided their view about the impact of the new procedures on human performance in case the technical system degrades (e.g. loss of GPS signal); more detailed information is provided in Appendix G.

In regard to the performance of the technical system, two kinds of hazards have been reported by the pilots. As for the other Swiss exercises, they consider any autopilot failure and the degradation of the system due to inadequate GNSS performance.

The mitigations pilots reported to handle these potential critical situations are the redundancy of the installed system, the possibility to revert from IFR to VFR and the training for the pilots.

The results can be summarised as follows: in case of single system failure, there will be a slight impact on this KPA; while the occurrence of a double system failure can produce a very high negative impact.

Navigation System Error (NSE)

The following figure reports the statistics on Navigation System Error component for each departure. The use of EGNOS augmentation allows to reach high level navigation performance both in the horizontal and vertical dimensions.

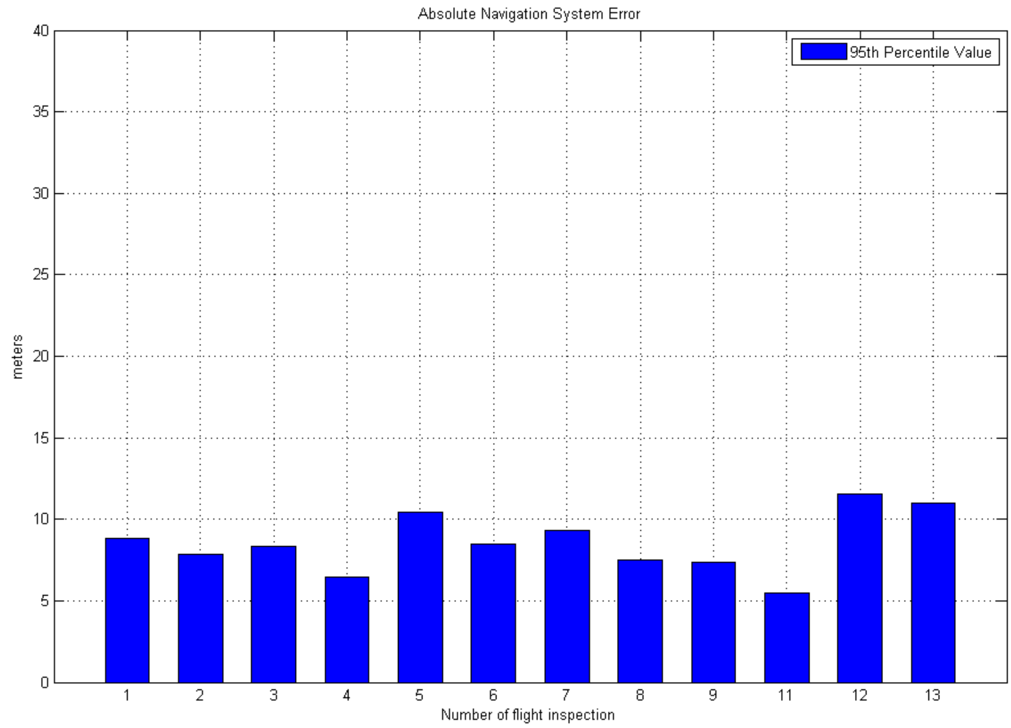


Figure 62: EXE-02.09-D-002 – Statistical evaluation of absolute NSE (REGA flight helicopter data) performed along Samedan departure procedure (between ZS000 and BIVIO)

<u>Total System Error cross-track</u>

See Figure 59.

6.2.3.1.2 Results impacting regulation and standardisation initiatives

The procedure design trials have revealed that, based on today's set of navigation specifications and procedure design criteria, no fully compliant and operationally acceptable departure procedure can be accommodated in certain demanding terrain environments such as the Engadin valley. It is an example of a terrain environment where procedure design criteria based on a more demanding navigation specification could prove its benefit.

The capabilities of modern light weight avionic systems and MTBF capability should be taken in consideration for redundant requirements.

6.2.3.1.3 Unexpected Behaviours/Results

Neither unexpected behaviour nor results has been identified during the execution of flight trials.

6.2.3.1.4 Quality of Demonstration Results

See 6.1.3.1.5.

6.2.3.1.5 Significance of Demonstration Results

See 6.1.3.1.6.

6.2.4 Conclusions and recommendations

6.2.4.1 Conclusions

Despite the application of the RNP 0.3 navigation specification in the PinS departure, the procedure design trials using the standard PANS-OPS criteria resulted in operationally unacceptable procedure design gradients in the demanding terrain environment of the Engadin valley. In the absence of an alternative navigation specification that could improve the situation (e.g. RNP AR covering the departure phase of flight), the chosen solution was the adoption of a deviation from the design standards in the form of a smaller lateral dimensioning of the protection area.

For this second exercise, the results demonstrate that even if the procedures has produced slight changes in the operating methods and a slight increment of the workload, the implementation of the new procedures is considered a benefit for pilots and operations.

The flight trials demonstrate that for the PinS non-standard departure the safety level is expected to slightly increase with respect to current operations.

Mitigation means for potential hazardous situations and for the decrement of the negative impact on operating methods and workload have been identified.

An increase in terms of site availability is expected: from pilots' feedback a significant increment of the possibility to take off respect to the current average number is expected.

With the new procedures the flight time will be longer than the currently performed flights under VFR. Although flights might be longer, the flights can be conducted even in bad visibility and during the nights, resulting in significant economic and humanitarian benefits from performing more missions and saving more lives.

6.2.4.2 Recommendations

The flight trials demonstrate that for the PinS non-standard departure the safety level is expected not to increase with respect to current operations. However taking into account that non- standard design criteria have been adopted, safety implications need to be analysed and potential hazards need to be identified.

It was demonstrated that in a certain demanding terrain environments such as the Engadin valley, and with today's set of navigation specifications, no fully compliant and operationally acceptable departure procedure can be accommodated. It is expected that procedure design criteria based on an RNP AR navigation specification that cover the departure phase of flight would enable a fully compliant and operationally acceptable departure procedure in the given terrain environment.

Need to have regular pilots training on the new procedures, to get them familiar with the procedure.

6.3 Demonstration Exercise EXE-02.09-D-003 Report

6.3.1 Exercise Scope

The third demonstration exercise covers the concept of an IFR connection between Samedan airport and Chur hospital, supported by GPS/EGNOS (SBAS it not a required augmentation for an RNP 0.3 route, at least not as per the ICAO PBN Manual). A complete gate-to-gate IFR connection comprises the execution of a PinS departure, an approach procedure and an Low Level IFR Route connection. The goal is to assess the operational benefits resulting from the above concepts applied between Samedan airport and Chur hospital.

The exercise level corresponds to the E-OCVM level V4, since the exercise encompasses live trials in operational environment.

Rotorcraft IFR heliport-to-hospital connection based on RNP 0.3 ATS route, in conjunction with helicopter PinS departure and approach procedures to/from Samedan/Chur are addressed. Therefore, the connection includes:

- PinS “non-standard” departure in Samedan or PinS departure in Chur;
- Low level ATS route to connect the two locations (Samedan → Chur or Chur → Samedan);
- Approach transition for the connection of low level ATS route with the new designed approach;
- PinS RNP APCH with LPV minima in Chur or RNP AR APCH in Samedan.

6.3.2 Conduct of Demonstration Exercise EXE-02.09-D-003

6.3.2.1 Exercise Preparation

For detailed description, please refer to section 6.1.2.1 and 6.2.2.1.For the en-route segment additional input data collection, procedure design and avionic database preparation activities have been performed.

6.3.2.2 Exercise execution

The execution of the exercise has been structured in pre-flight activities, the demonstration flights performance and post-flight activities.

Below the exercise’s steps are listed as they have been executed:

- <u>Pre-flight activities</u>

  Preparation of timely briefing for all participants for the flight trial and flight trial execution plan
- <u>Flight trials execution</u>

  Execution of IFR heliport to hospital procedure. A number of 12 flights using the Helicopter and 2 flights using the FFS were executed.
- <u>On board data collection and on ground GNSS real time monitoring and data collection</u>

  On board Flight data collected on board the Rega helicopter.
- <u>Post-flight briefing</u>

  Immediately after the flight, a debriefing will be held between involved stakeholders.

The post execution activities that will be performed in this exercise are listed below.

- <u>Data processing and navigation performance assessment</u>
- <u>Qualitative assessment</u>

For details, please refer to section 4.1.3.4.

In Table 14, it is reported the list of helicopter flights performed for this exercise (EXE-02.09-D-003) along en-route (Samedan→Chur) path.

6.3.2.3 Deviation from the planned activities

Within the PROuD project, in addition to the approach and departure procedures planned in the Demonstration Plan, a low level ATS route between Samedan and Chur has been designed and specific objectives (OBJ-0209-116) have been added to address KPA for heliport to hospital exercise.

During the campaign, a total of 12 connection flights (plus additional 2 in the FFS) instead of 20 (as planned in the demonstration plan) were performed. However, the reduced number of en-route flight trials does not have an impact on the heliport-to-hospital outcomes. The number of performed flights and collected data are sufficient to cover the PROuD objectives related to the heliport to hospital connection.

For this exercise, KPAs addressed were focused on safety, efficiency and service availability, predictability and human performance. Environmental sustainability is not addressed in detail in this exercise, since the impact is more relevant with regard to the approach and landing phases.

6.3.3 Exercise Results

6.3.3.1 Summary of Exercise Results

6.3.3.1.1 Results per KPA

6.3.3.1.1.1 Safety

For the evaluation of the impact of the new procedures on safety the following Key Performance Indicators (KPIs) have been selected:

- Flight crew subjective feedback on Safety;
- Flight crew workload;
- Flight crew situation awareness;
- Flight track adherence.

The first three indicators have been evaluated using feedback collected through pilot's questionnaires (see Appendix G to have a look to the Swiss first flight campaign questionnaire results), observations and debriefings; the last one using the data collected by the on board flight inspection system.

Flight crew subjective feedback

Pilots provided their view about the impact of the new procedures on safety, comparing them with the procedures they are currently using (VFR procedures). The high level results are provided in the previous graph, while more detailed information is provided in Appendix G.

The results of the data analysis demonstrate that also in this case, the implementation of the Low Level IFR Route is expected to increase the safety level with respect to the current VFR operations.

However, from the submitted questionnaires and the interviews with the pilots some safety issues with relative mitigation means were identified. Pilots stated that hazards could occur in case of system errors, failure on board or GNSS unavailability.

The mitigation means proposed are:

- Taking an early decision based on the weather conditions;
- Considering a contingency procedure in case of the occurrence of an OEI situation.

In addition, pilots agreed on the fact that there would not be any improvement in case of good weather because in that case the pilot's attention could move from the outside of the cockpit to the inside, on the instrument (air to air collision), with hazardous consequences.

In conclusion, no significant impact is expected in terms of situation awareness and workload. A slight increment of flight safety is expected, especially in bad visibility conditions.

The flight trials pilots' expected impact of the new procedure on safety, situation awareness and workload compared with the current ones (answers' average), is shown in the figure below.

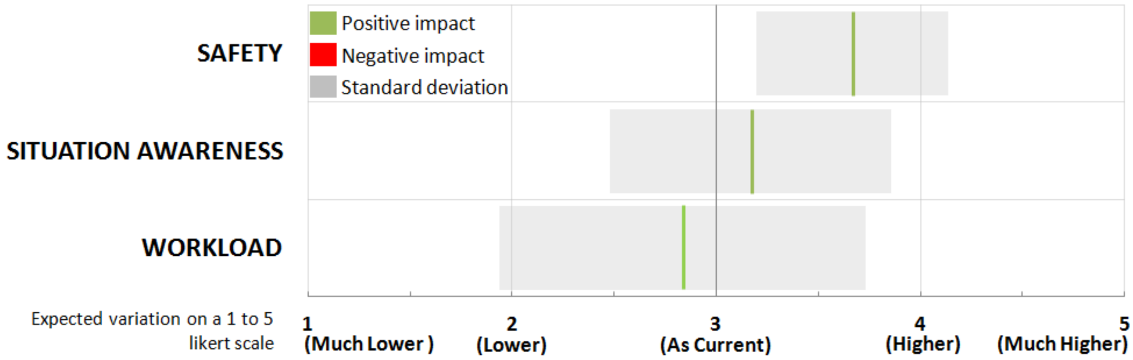


Figure 63: Questionnaires results for EXE-02.09-D-003 (Heliport to Heliport).
Flight Trials Pilots' expected impact of the new procedures on Safety, Situation Awareness and Workload, compared with the current ones (answers' average).

Flight crew workload

In regard to the workload the average value (2,83/5), demonstrates that according to pilots the introduction of the new procedures will not have a significant impact on safety.

Flight crew situation awareness

In regard to the situation awareness the average value (3,17/5), demonstrates that according to pilots the introduction of the new procedures is expected to have a slight positive impact on safety.

Flight track adherence

The adherence to the designed flight track has been quantitative evaluated in terms of Cross-track Total System Error estimated by on board flight inspection system. In the following figures the cross track TSE statistics (from CHU01 to BIVIO) are reported in terms of the 95th percentile.

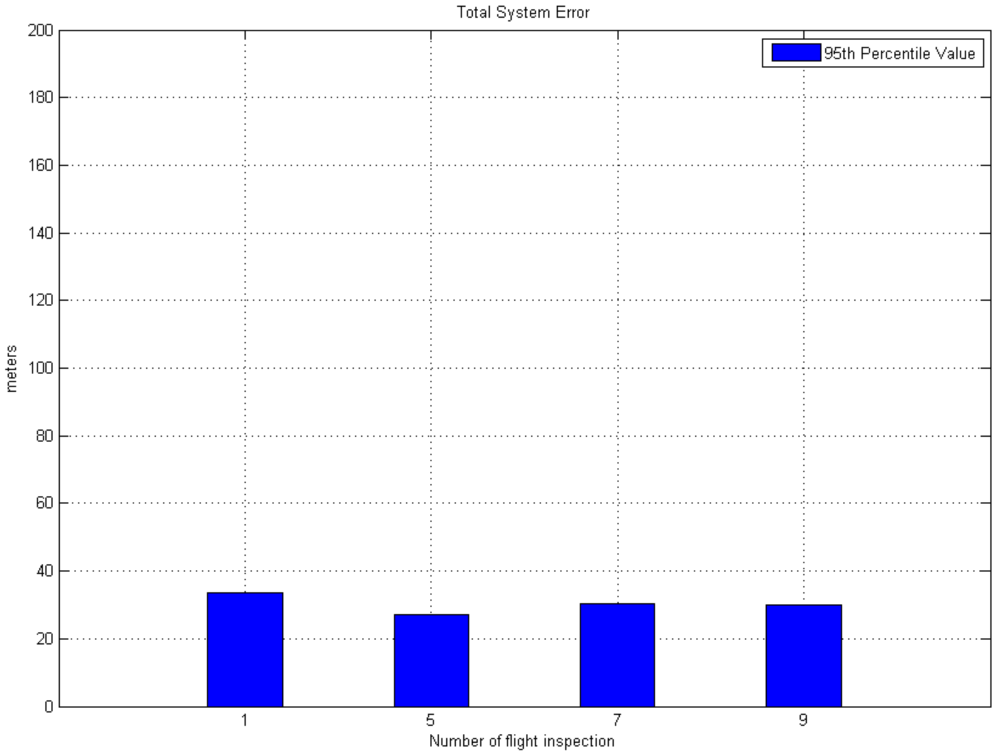


Figure 64: EXE-02.09-D-003 – Statistical evaluation of TSE cross track (REGA flight helicopter data) performed along Chur to Samedan route flights

Detailed results related to helicopter navigation performances along each route trial are reported in [6], in terms of GNSS performances and signal quality, FTE and TSE error components.

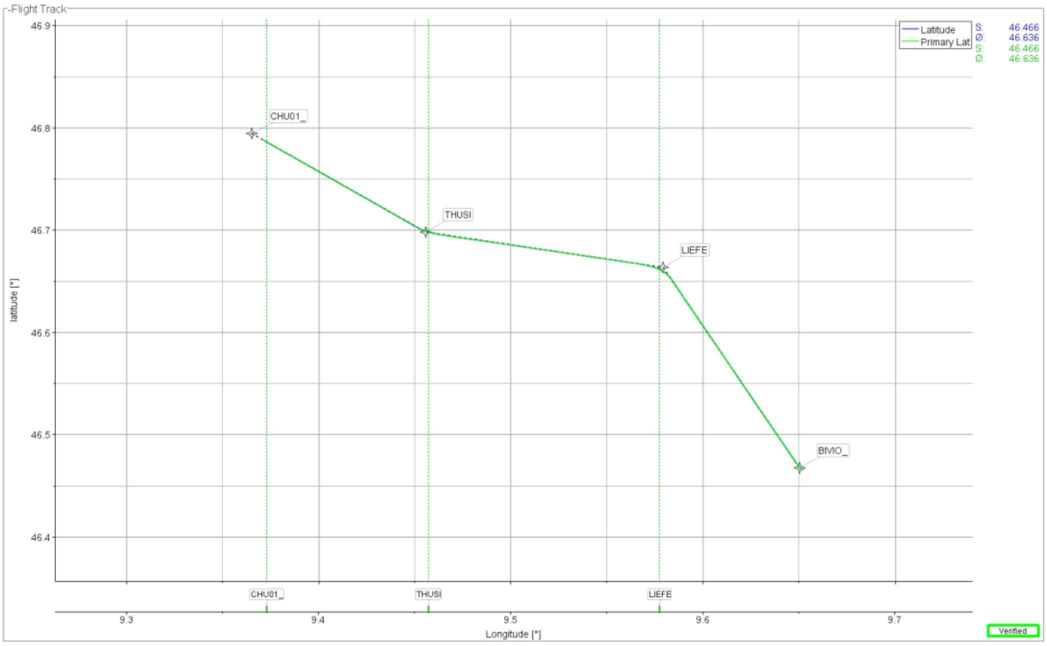


Figure 65: EXE-02.09-D-003 (Chur to Samedan) – Flight Track # 10 (Approach flight trial n.1) Chur to Samedan route flight

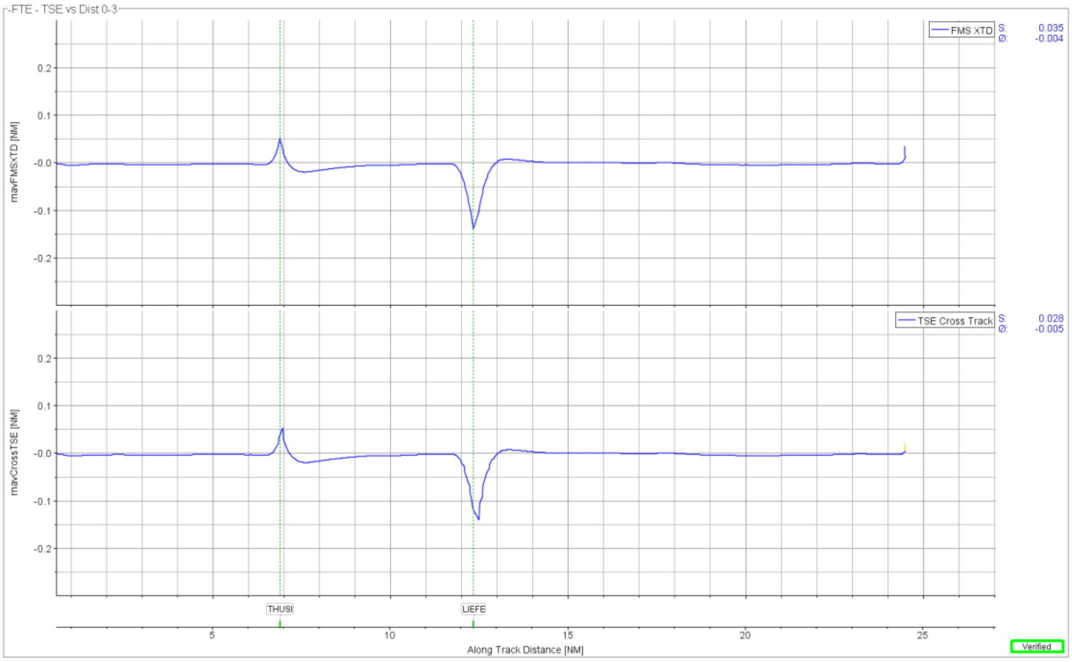


Figure 66: EXE-02.09-D-003 (Chur to Samedan) – Cross Track FTE/TSE of Flight Track # 10 (Approach flight trial n.1) Chur to Samedan route flight

According to PBN manual ([5] - see 7.3.3.3.1), during operations in airspace or on ATS routes based on RNP 0.3, the lateral TSE must be within ±0.3 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±0.3 NM for at least 95 per cent of the total flight time.

The overview of the lateral navigation performance, shows the compliance with RNP 0.3 NM lateral accuracy requirements. For other details and performance parameters refer to [6].

6.3.3.1.1.2 Efficiency and service availability

For the evaluation of Efficiency and service availability introduced by the Low Level IFR Routes, the flight crew subjective feedback KPI has been selected.

As pilots' feedback demonstrates, the new procedures applied at this exercise could give the pilots the possibility to operate also in bad weather conditions, thus significantly increase the HEMS service availability, in particular in bad weather conditions, increasing the number of saved lives.

Exclusively in case VMC conditions, the flight time necessary to operate from/to Samedan to/from Chur, will increase with respect to the time of flight that currently necessary.

6.3.3.1.1.3 Predictability

For the evaluation of the predictability of new approach procedures, the following Key Performance Indicators (KPIs) have been selected:

- Flight crew subjective feedback
- Flight track adherence

Subjective Feedback

The feedback provided by pilots refers to the predictability in terms of possibility to precisely calculate the time needed to perform the procedure (so, in this case, to go from Samedan to Chur or vice versa). They compared the new procedures with the ones they are currently using (VFR procedures). The average percentage collected from pilots' comments is +18,33% and more detailed information is provided in Appendix G.

According to pilots an increment of the predictability with respect to the current operations is expected with the introduction of the new procedures.

Flight track adherence

See Figure 64.

6.3.3.1.1.4 HP (Operating methods)

In regard to the evaluation of this KPA, the selected indicator was flight crew subjective feedback.

Pilots provided their opinion regarding how much the changes introduced by the adoption of the new procedures are expected to be feasible, consistent and acceptable as with respect to current operating methods and to the overall operational environment.

This KPA was rated 2,83/5 that demonstrates that according to pilots, the potential changes would not have any negative impact on the operating methods, comparing them with current operations.
For more detailed information, see Appendix G.

The transition from VFR to IFR could generate changes in terms of potential shifting of pilot's attention from the world out of the window to the instrumentation inside the cockpit. This is consider an issue in case the procedure is flown in good visibility condition.

Regular pilots training on the new procedures was identified as a solution for the above mentioned safety issue

However, also for this exercise, the feasibility of a smooth introduction of the new procedure is considered achievable and according to pilots the implementation of little changes of some technical aspects could increment the level of consistency and acceptability.

6.3.3.1.1.5 HP (Pilots' task performance)

For the evaluation of the Pilots' task performance, the following indicators (KPI) have been selected:

- Flight crew subjective feedback;
- Flight crew workload;
- Flight crew situation awareness.

Flight crew subjective feedback

In regard to this KPA, the values for error propensity, workload and situation awareness are similar to the other exercises. Inadequate pilots training, a high level of workload and a potential error in programming the system have been identified as hazards related to this KPA, but they were not considered highly hazardous.

Despite that, pilots stated that thanks to the design of the procedures, the probability that those kinds of risks can occur is remote.

Flight crew workload

In regard to the workload the average value (2,83/5), demonstrates that according to pilots the introduction of the new procedures will not have a negative impact on the pilots' task performance.

Flight crew situation awareness

In regard to the situation awareness the average value (3,17/5), demonstrates that according to pilots the introduction of the new procedures will not have a negative impact on the pilots' task performance.

6.3.3.1.2 Results impacting regulation and standardisation initiatives

The results can be used to contribute to the regulation and standardization activities related to RNP0.3 adoption for helicopter route operations.

6.3.3.1.3 Unexpected Behaviours/Results

Neither unexpected behaviour nor results has been identified during the execution of flight trials.

6.3.3.1.4 Quality of Demonstration Results

See 6.1.3.1.5.

6.3.3.1.5 Significance of Demonstration Results

See 6.1.3.1.5.

6.3.4 Conclusions and recommendations

6.3.4.1 Conclusions

The results of the exercise demonstrate that the implementation of the Low Level IFR Route provides an increase of safety level with respect to the current VFR operations

Compared to VFR flights, IFR heliport to heliport flights are less efficient in terms of flight time, limited to VMC conditions. However, the new IFR connection provides the possibility to operate also in bad weather conditions, thus significantly increase the HEMS service availability, in particular in bad weather conditions, increasing the number of saved lives.

Possible hazards have been identified to be mitigated by procedures design, training and equipment maintenance. No significant impact on workload on situation awareness has been identified.

6.3.4.2 Recommendations

Need to have regular pilots training on the new procedures, to get them familiar with the procedures.

6.4 Demonstration Exercise EXE-02.09-D-004 Report

6.4.1 Exercise Scope

The EXE-02.09-D-004 is the first exercise performed in the Lørenskog Norwegian scenario and it covers the following concepts:

- RNP APCH PinS approach with LPV minima with GPA < 6.3°.

The scope is to demonstrate the operational benefits coming from these two concepts applied at Lørenskog heliport by designing, validating and demonstrating flight procedures that will be flown by Norsk Luftambulanse (NLA).

Rotorcraft RNP APCH PinS approaches with LPV minima make use of EGNOS augmentation to GPS L1 constellation. SBAS vertical guidance provided by EGNOS allows a precise height control throughout the final descent and the reduction of the risk of collision with terrain (CFIT), particularly at night and/or in adverse weather conditions.

6.4.2 Conduct of Demonstration Exercise EXE-02.09-D-004

6.4.2.1 Exercise Preparation

The following activities have been performed according to the ICAO regulations and criteria:

- Input data and operational requirements collection
  - No ad-hoc survey has been used. Aeronautical Data and Metadata acquisition and import into the design environment: DTM/DSM, Airport/Heliport data, Obstacle data, ATS environment, Other data/information;
  - Definition of the operational requirements for the design of the new PinS approach procedure and arrival procedure.
- Landing site assessment and PinS approach procedure design
  - Obstacle and terrain surfaces modelling and assessment for landing site suitability verification to support PinS approach procedure;
  - Design of one PinS Approach procedure with LPV minima and terminal procedure.
- Flight Procedure Ground Validation and avionic database preparation
  - Verification of accuracy of the data used for flight procedure design;
  - Verification of the correct application of ICAO PANS OPS criteria for flight procedure design;
  - Navigation DB Preparation and upload on the FMS.
- On board platform adaptation

  Data acquisition and recording platform.
- Coordination between ATS units

  In parallel to the activities listed above, a proper coordination between all the involved stakeholders has been set up to guarantee the necessary involvement of the ATS units during flight trial execution (AFIS, APP and ACC units).
- Procedure preparation:
  - Preparation of timely briefing for all participants for the flight validation trial (heliport authority, local ATC, regulator, flight crew) invitation and flight validation execution plan;
  - Reservation and preparation of the installation of the dedicated flight inspection kit in the helicopter.
- Pilot training

  Training of pilots with Norsk Luftambulanse full flight simulator.

6.4.2.2 Exercise execution

During the execution of this demonstration exercise the following activities have been carried out:

- Pre-flight activities

  Preparation of timely briefing for all participants for the flight trial (local ATC, regulator, flight crew) invitation and flight trial execution plan.

- Flight trials execution

  Execution of new PinS Approach procedure with LPV minima.

- On board data collection

  On board Flight data have been collected on board by the Norsk Luftambulanse helicopter.

- Post Flight briefing

  Immediately after the flight, a debriefing has been held between involved stakeholders (heliport authority, local ATC, regulator, flight crew).

At the end of this flight, several activities have been performed and the first data have been collected. More detailed information is provided in the following paragraphs:

- Data processing and navigation performance assessment
  - Extraction of flight data records from helicopter on board equipment;
  - Processing of navigation data acquired on board and elaboration of data acquired on ground;
  - Performance assessment and anomaly investigation execution.

This data is of quantitative nature and they have been used to describe the system performance when using the PBN IFR procedures. To this data, the ad-hoc questionnaires prepared for the pilots have been a useful contribution for the quantitative assessment of the flight trials.

- Qualitative assessment
  - Questionnaires and debriefings have been used for a qualitative assessment of the flight trials:
    - Questionnaires: at the end of each flight trial, flight crew has been requested to fill in the questionnaire to provide their feedback on aspects related to the assessment of the KPAs under investigation;
    - Debriefing: debriefings have been used to address aspects related to the KPAs under investigation.

REFERENCE SCENARIO

The reference scenario for this exercise is today's operation scenario at Lørenskog heliport. Lørenskog heliport (ICAO code ENLX) is the home base for two of the helicopters of NLA fleet. Together with Ullevål heliport, these serve approximately 35% of the Norwegian population when it comes to severe injuries like brain traumas etc.
The heliport is located in the Southern of Norway where a low level routing structure exists for use by the Norwegian Air Ambulance to connect hospital heliports throughout the region.
NLA operations are currently conducted in IFR/IMC conditions and already use PinS approach procedures with LNAV minima for approach course 025°. The airspace is class G underlying OSLO TMA that starts at 2500 FT MSL (see figure below).
The IFR departure practise is to climb out on the opposite direction of the existing procedure(inbound 025° track) or to calculate a direction of travel and required climb rate on an ad hoc basis.
It is an area of relatively dense GA-traffic from time to time. Oslo city area has its own traffic advisory frequency: VHF122.000.

SOLUTION SCENARIO

The solution scenario sees the insertion of new designed PinS approach and STAR procedures in the operational environment surrounding and including Lørenskog heliport. The new flight procedures have been evaluated in the operational context to assess the improvement in the arrival/approach operations.
The flights performed for the PinS RNP APCH approach procedure are reported in Table 15.

6.4.2.3 Deviation from the planned activities

RNP 0.3 was not used for transition segments. RNP1 has been used since this allowed to reach expected benefits. RNP 0.3 would have not further improved operational benefits.
Related objective has been deleted: *OBJ-0209-009 - Assess the impact on efficiency of the adoption of RNP0.3 navigation specification in the arrival phase of flight (STAR) for helicopter operations and its integration with low level route structure and PinS LPV approaches.*

6.4.3 Exercise Results

6.4.3.1 Summary of Exercise Results

6.4.3.1.1 Results per KPA

6.4.3.1.1.1 Safety

For the evaluation of the impact of the new procedures on safety the following Key Performance Indicators (KPIs) have been selected:

- Flight crew subjective feedback;
- Flight crew workload;
- Flight crew situational awareness;
- Flight track adherence.

<u>Flight crew subjective feedback</u>

Pilots provided their view about the impact of the new procedures on safety, comparing it with the procedures they are currently using (LNAV procedures). The high level results are provided in the following graph, while more detailed information is provided in 6.4.4 and Appendix G.

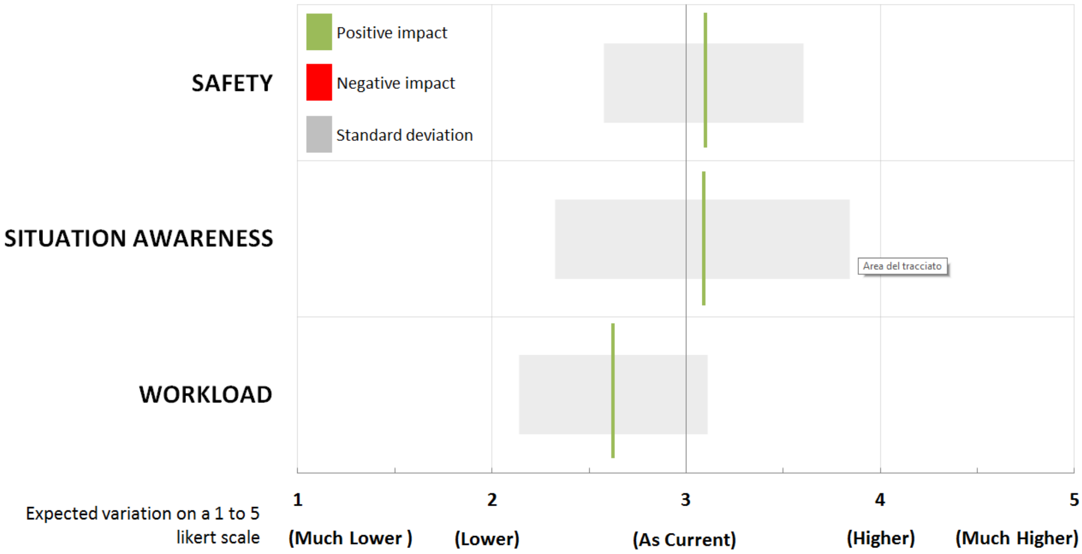


Figure 67: Questionnaires results for EXE-02.09-D-004 (Approach Lørenskog).
Flight Trials Pilots' expected impact of the new procedures on safety (subjective feedback), situation awareness and workload, compared with the current ones (answers' average).

The average result of safety, gathered from pilots' comments to the questionnaire is 3,09/5; basically, pilots foresee slight improvements of the new procedure in terms of Safety, Situation Awareness and Workload.

In particular pilots stated that a greater positive impact on safety is expected in bad visibility conditions. Significant safety improvements have been reached through the adoption of the 3D final segment up to a lower landing minima (LPV minima – see Figure 14), using the service augmentation provided by EGNOS system and the related ILS-like vertical guidance for a more precise final approach.

Pilots identified some circumstances in which the new procedure help them to better manage the situation, the better lightning at the approaches and also the new go around with climb straight ahead instead of direct turns.

Pilots appreciated the way an LPV allows a more precise and safer approach with lower minima, allowing a closer to destination MAPt than the regular LNAV approach.

Some issues related to safety and possible hazardous situations have been identified by the pilots, in particular these hazards refer to the "plate layout" and the fact that pilots during the approach see just one side of the destination site (not straight in landing - 70° turn at the PinS). A new version of the IAC approach procedure has been produced including the modifications highlighted, thus improving the feedback on safety aspects.

Flight crew workload

In regard to the workload the average value (2,63/5), demonstrates that according to pilots the introduction of the new procedure produces basically no impact on this KPI.

Flight crew situation awareness

In regard to the situation awareness the average value (3,08/5), demonstrates that according to pilots the introduction of the new procedure has no impact on this KPI..

<u>Flight track adherence</u>

The adherence to the flight track has been quantitative evaluated in terms of Cross-track Flight Technical Error estimated by on board computer. In the following figures the FTE statistics are reported in terms of the 95th percentile.

The evaluation for each flight has been performed from different starting and ending waypoints, as shown in the following table, and described in detail in [10]:

Flight trial number	Registration number	Data	Range of data processed
1	#Run1	08/06/2015	LX830 - LX801
2	#Run2	08/06/2015	LX810 - LX801
3	#Run3	08/06/2015	LX820 - LX802
4	#Run 4	08/06/2015	LX800 - LX802
5	#Run 6	08/06/2015	LX820 - LX802
6	#Run 8	08/06/2015	LX810 - LX802
7	#Run 9	08/06/2015	LX830 - LX802
8	#Run11	09/06/2015	LX820 - LX802
9	#Run 13	09/06/2015	LX820 - LX802
10	#Run 15	09/06/2015	LX810 - LX802
11	#Run 16	09/06/2015	LX830 - LX802

Table 25: EXE-02.09-D-004 - Range of processed data

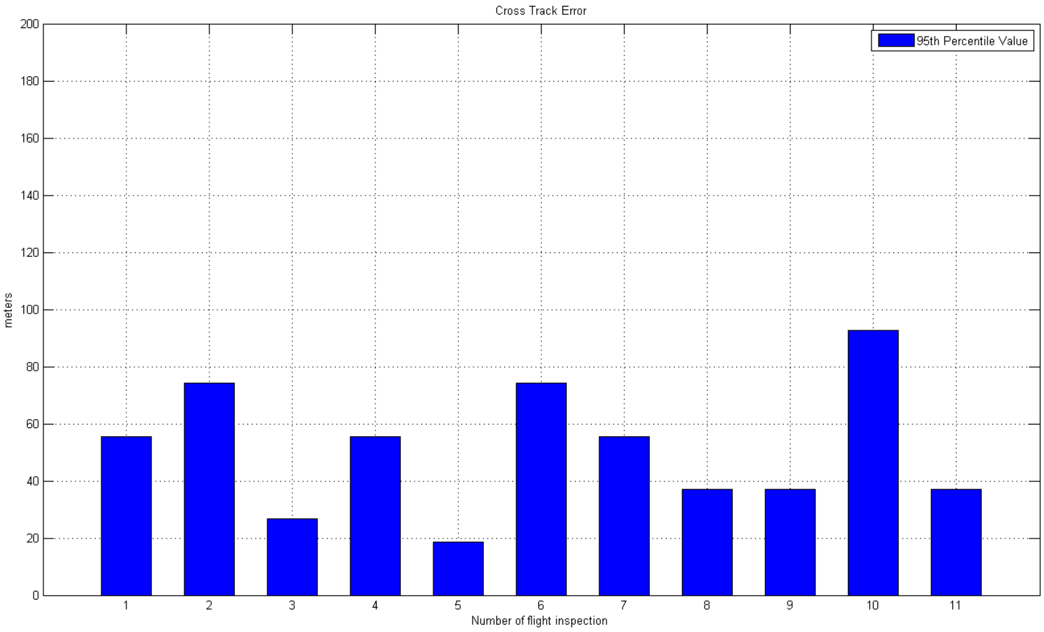


Figure 68: EXE-02.09-D-004 – Statistical evaluation of FTE cross track performed along Lørenskog Approach procedure

Detailed results related to helicopter navigation performances along each approach trial are reported in [10].

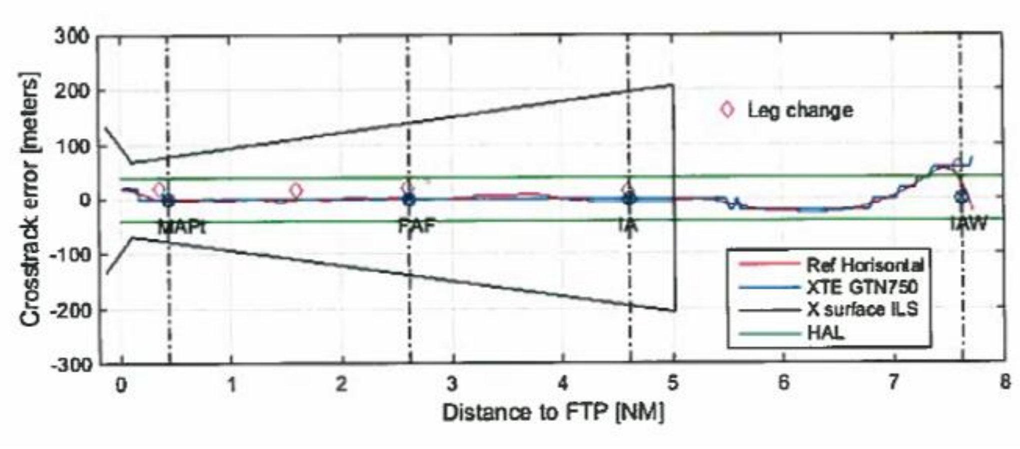


Figure 69: EXE-02.09-D-004 – Flight Track # 3 (Approach trial n.3) and cross track FTE – Lørenskog Approach procedure

According to PBN Manual (see section 5.3.3.1) to satisfy the accuracy requirement of an RNP APCH, the 95 per cent FTE should not exceed 0.5 NM on the initial and intermediate segments. The 95 per cent FTE should not exceed 0.25 NM on the FAS of an RNP APCH.
Considering the data collected during the flight trials, statistical evaluation of cross track error shows that cross track error 95 per cent is always less than 0.25 NM (the most critical constraint in the final segment).

6.4.3.1.1.2 Accessibility

For the evaluation of site accessibility using the new approach procedures, the following indicators have been selected:

- Flight crew subjective feedback;
- Meteo data analysis

Flight crew subjective feedback

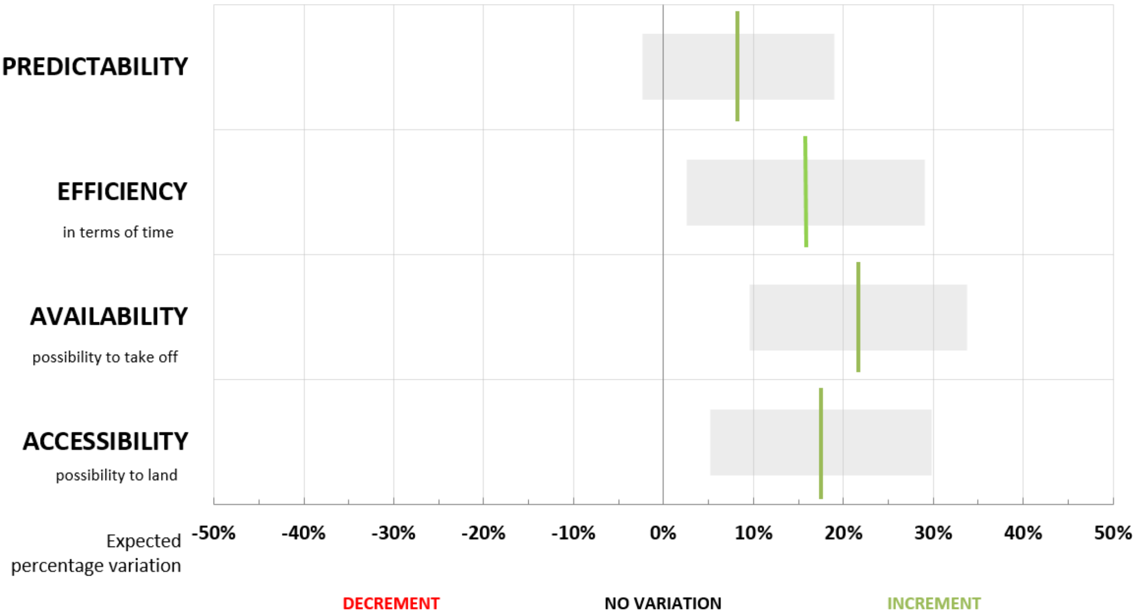


Figure 70: Questionnaires results for EXE-02.09-D-004, EXE-02.09-D-005, EXE-02.09-D-006, Flight Trials Pilots' expected impact (in %) of the new procedures compared with the current ones (answers' average).

Pilots provided their view about the impact of the new procedure on accessibility, comparing it with the procedures they are currently using (LNAV procedures). The high level results are provided in the following graph, while more detailed information is provided in Appendix G.

The average value for this KPA is 18%. According to pilots, the accessibility increases respect to the existing procedures; one of the benefits they identified was the possibility to arrive closer to the landing point, avoiding unnecessary long flights from MAPt to the heliport thus diminishing the time of flight. Moreover it was also stated that thanks to the new procedures it will be easier to land during night's missions, which means that a shortest possible visual segment is favourable.

Meteo data analysis

METAR data have been analysed to estimate the impact of the new procedures (see paragraph 4.1.3.6 for more details on data source and the analysis performed). The minima values used for the analysis are reported in Appendix H.

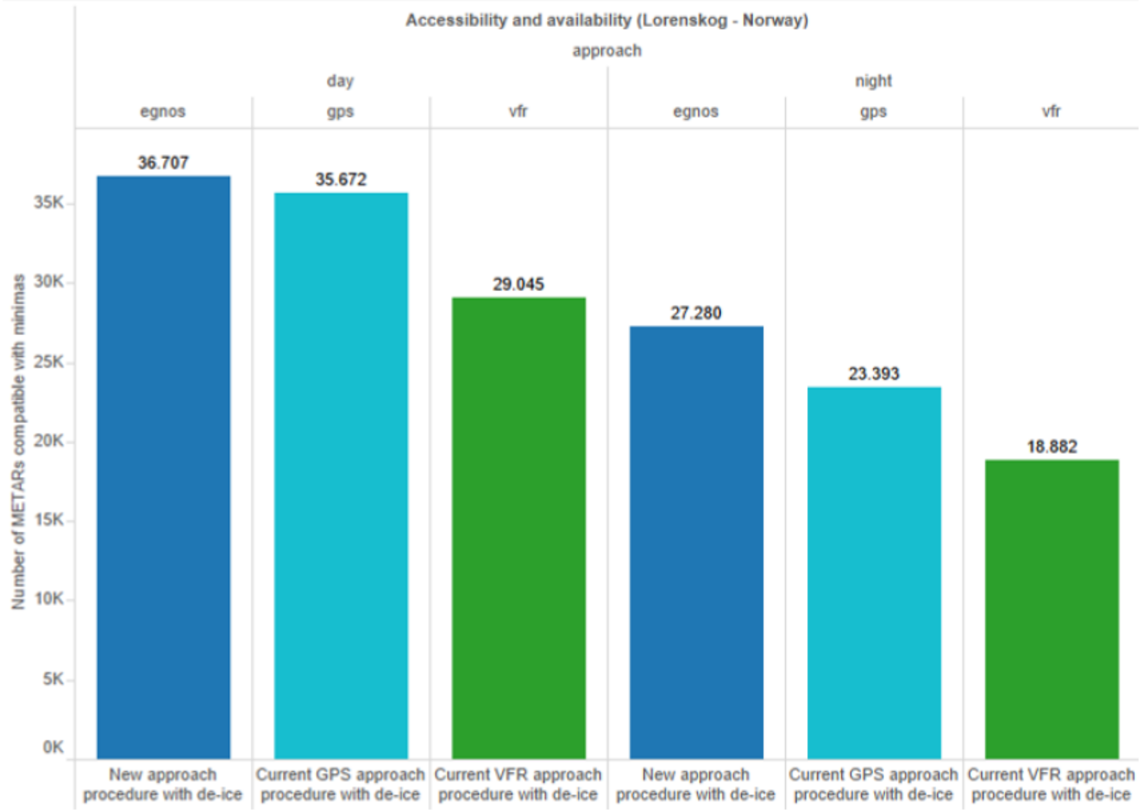


Figure 71: Analysis of meteo data from Oslo, Gardermoen (ENGM), close to Lørenskog: number of 2012-2015 METAR reports with visibility and ceiling conditions respecting day and night minima for the VFR procedures, LNAV procedures and the new RNP APCH PinS approach with LPV minima ones.

	VFR (half hours)	LNAV (half hours)	LPV (half hours)	% (vs VFR)	Flight hours (vs VFR)	% (vs LNAV)	LPV Flight hours (vs LNAV)
Day	29.045	35.672	36.707	+26,38	+3.831,00	+2,90	+517,50
Night	18.882	23.393	27.280	+44,48	+4.199,00	+16,62	+1.943,50

Table 26: Comparison of accessibility with VFR procedures VS LNAV procedures VS new RNP APCH PinS approach with LPV minima procedures, based on the analysis of 2012-2015 Oslo METAR reports.

According to the analysis, the new procedures would have allowed, in the past 4 years, an increase of the accessibility of the Lørenskog site respect to the current LNAV procedures (2,90% during day, 16,62% during night) and respect to VFR procedures (26,38% during day, 44,48% during night).

The following figure shows the impact of the presence of de-ice equipment on helicopters.

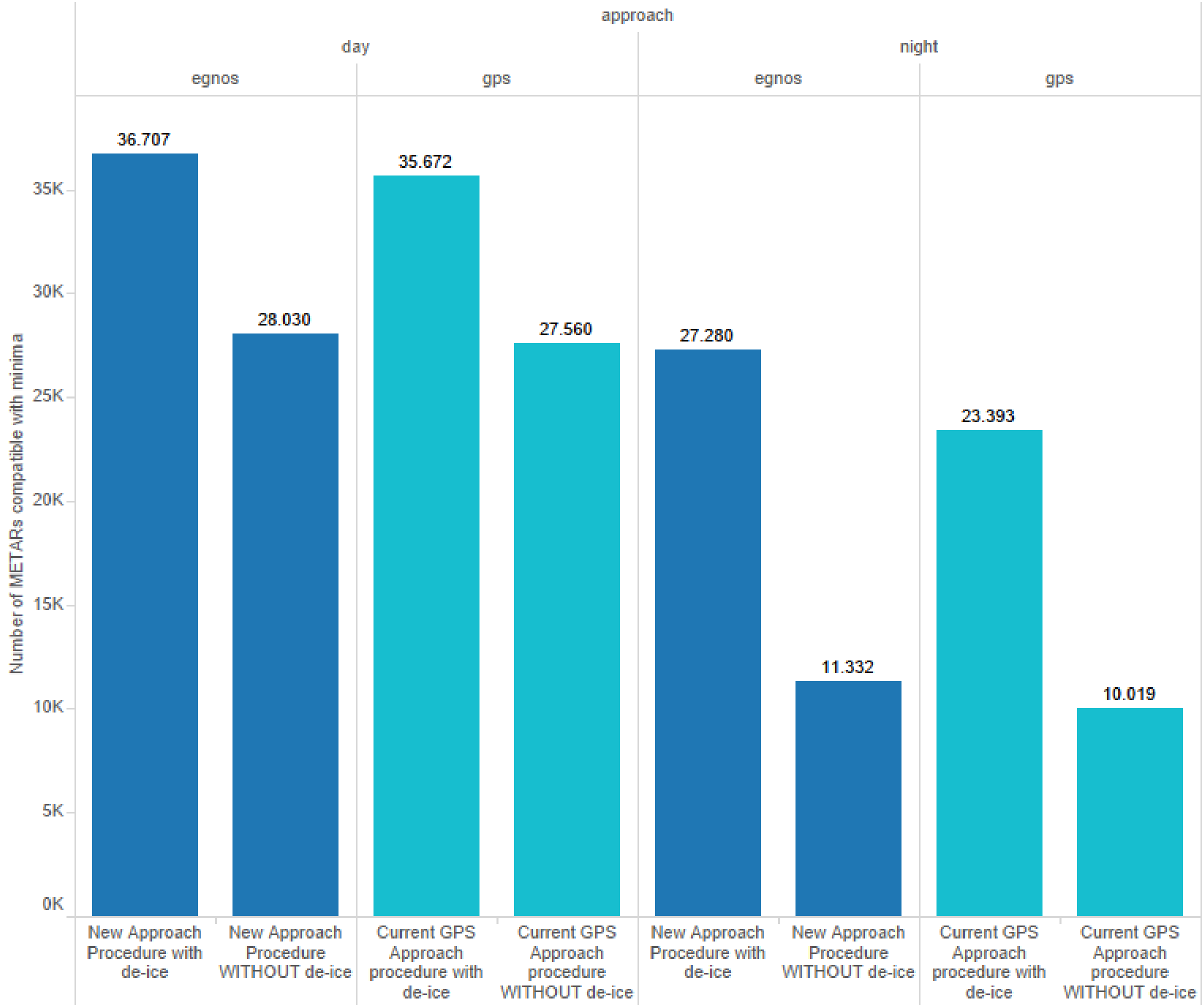


Figure 72: Impact of the availability of helicopters de-ice equipment on the Accessibility of the Lørenskog site using IFR procedures

According to the results, the presence of de-icing equipment increase the impact on accessibility of LPV approach procedures by +31% during day and +141% during night.

The impact on LNAV approach procedures is +29% (day) and +133% (night).

6.4.3.1.1.3 Environmental Sustainability

For the evaluation of the environmental sustainability, the following considerations have been produced:

Emissions per flight

The procedure itself does not introduce a more environmental friendly operation, but the fact that the pilot can chose a direct routing in clouds instead of flying around the terrain when weather is below VFR minimum, can bring a benefit from an environmental point of view. An almost negligible effect of lower fuel consumption is only theoretical, and cannot be proven. This effect increases when the difference in chosen altitude between VFR and IFR flying is more than 2000 feet.

Noise footprint

Considering the direction of the other type of procedures performed in that heliport, IFR procedures in general will have a lesser noise level footprint since they are flown at higher altitudes and the descent is designed over areas that tolerate noise better. For Lørenskog the final approach track was chosen parallel and right on top of a heavily trafficked highway, and hence the noise from the helicopters tend to mix inn with existing noise.

6.4.3.1.1.4 Efficiency

For the evaluation of the efficiency, the following considerations have been produced:

- Mileage;
- Time to land;
- Fuel consumption;
- Flight crew subjective feedback.

Mileage

When the weather is marginal VFR the tendency is to navigate around weather and showers. This generally increases the mileage, and the alternative is to fly a direct track at higher altitudes to where the approach starts. It depends from where the flight is coming from if the total mileage spent will be more or less than the alternative. If the alternative was not to fly, obviously IFR will increase the mileage indefinitely, but then you get to do the job better.

Time to land

Generally an IFR procedure will take more time than the straight in VFR procedure if you look at the procedures isolated. As the VFR weather approaches marginal conditions related to visibility and ceiling, the total time spent will for many IFR procedures be less compared to VFR since the flying can be more direct.

Fuel consumption:

Fuel consumption will in many cases be less if the alternative is to circumnavigate in marginal VFR conditions due to the fact of more track miles. If altitudes were chosen a lot higher than the VFR low level alternative, it could be decreased by approximately 10%, but since the EMS operation in Norway is very often limited by the freezing level the difference in altitude is estimated to 2000 feet, and hence the fuel savings is not significant.

Flight crew subjective feedback

The average percentage gathered for this KPI is 16% (see Figure 70). According to pilots there is a slight increase of the efficiency with respect to current operations.
The benefits identified by them are related to:

- the possibility to perform more direct approaches, especially from different sectors where it was not possible previously;
- the possibility to perform easier approaches once the procedures are connected to the en-route segment;
- the possibility to save time during the flights.

The efficiency is, then, exclusively linked to the fact that when VFR is not possible – IFR is an alternate approach to getting the job done; but compared to VFR when this is possible, IFR operations will in most cases extend the duration of a flight and hence decrease efficiency.

For the evaluation of the efficiency for STAR, the flight crew subjective feedback has been selected as KPI.
Three different transitions (i.e. STARs) have been designed and flown in order to connect each initial segment of the approach flight procedure to the low-level route infrastructure. The trials demonstrated an efficient and smooth transition from the en-route phase of flight to the approach procedure. The improvement provided by the STARs contributed to the overall efficiency result reported in Figure 70.

6.4.3.1.1.5 HP (Operating methods)

For the evaluation of the impact of the new procedure on the operating methods the identified key performance indicator is flight crew subjective feedback.

The resulting average value from pilots' comments is 2,82/5, this means that there will not be a negative impact on this KPA:

Pilots' comments on the impact on new procedures on the current operating methods are not homogenous; it was affirmed that these procedures will not increase the functionality of the approach plates, but it was also state that with the implementation of the procedures the operating methods will be positively impacted, as it will be easier (to land) when pilots get LPV so the glide slope takes care of vertical navigation.

6.4.3.1.1.6 HP (Pilots' task performance)

For the evaluation of the Pilots' task performance impact of new approach procedures the following indicators (KPI) have been selected:

Flight crew subjective feedback;

Flight crew workload;

Flight crew situation awareness;

Error propensity.

Flight crew subjective feedback

With regard to pilots' task performance, pilots identified some potential hazards that can occur during the interaction with the system. The causes of these hazards are represented by issues related to the colours of some information that can confuse the pilot, as he is used to a different colour coding; In addition, also a different way of writing the procedures respect to the way they are currently written can lead to hazardous situation, as well as a wrong programming of the system, including a different minima (LNAV, LPV and also climb out performance). These considerations raised during the flight campaign. After that a new version of the IAC approach procedure chart has been produced including the modifications highlighted, thus improving the feedback on pilots' task performance.

Flight crew workload

In regard to the workload the average value (2,63/5, see Figure 67), demonstrates that according to pilots the introduction of the new procedures will not have a negative impact on pilots' task performance.

Flight crew situation awareness

In regard to the situation awareness the average value (3,08/5 see Figure 67), demonstrates that according to pilots the introduction of the new procedures will not have a negative impact on pilots' task performance.

Error propensity

See Flight crew subjective feedback.

6.4.3.1.1.7 HP (Performance of the technical system)

For the evaluation of the performance the technical system impact of new approach procedures the following indicators (KPI) have been selected:

- Flight crew subjective feedback;
- Flight Technical Error (FTE) cross track.

Flight crew subjective feedback

Pilots provided their view about the impact of the new procedures on Human Performance in case the technical system degrades. Detailed information is provided in Appendix G.

For the performance of the technical system, pilots affirmed that in case of a system failure they will be able to save the situation without compromising safety. The mitigations proposed are to use contingency procedures, to have warnings in case of loss of signals and also to regularly train pilots in order to be able to fly the new procedures.

Being that, in case of singles system failure, there will be a slight impact on this KPA; while the occurrence of a double system failure can produce a very high negative impact.

<u>Flight Technical Error (FTE) cross track.</u>

See Figure 68.

6.4.3.1.2 Results impacting regulation and standardisation initiatives

Not relevant results for regulation and standardization are provided.

6.4.3.1.3 Unexpected Behaviours/Results

Neither unexpected behaviour nor results has been identified during the execution of flight trials

6.4.3.1.4 Quality of Demonstration Results

The flight campaign at Lørenskog heliport was performed using the AIRBUS EC135T3 helicopter. A qualified flight validation pilot was riding along together with test flight pilot and test flight engineer from Airbus helicopters.
Regarding the on board equipment for data acquisition and analysis, the Trimble and NAVSCOPE 7.0 were mounted on-board the helicopters for the design validation. The operational data acquisition was retrieved from the GARMIN GNSS GTN 750.

6.4.3.1.5 Significance of Demonstration Results

The results collected during the flight trials of this exercise have a good significance from an operational point of view since they were executed in different time and by different pilots. The number of performed flights allowed elaboration of meaningful statistics, considering that are based of data highly reliable.

6.4.4 Conclusions and recommendations

6.4.4.1 Conclusions

The KPAs results collected for this exercise demonstrate despite the negative value collected for the efficiency, and the potential changes in the operating methods, the implementation of the new procedures is considered a benefit for pilots and operations.

Mitigation means have been identified to handle potential hazardous situations that the new procedures could lead to.

Pilots stated that a greater positive impact on safety is expected in bad visibility conditions. Significant safety improvements have been reached through the adoption of the 3D final segment up to a lower landing minima (LPV minima – see Figure 14), using the service augmentation provided by EGNOS system and the related ILS-like vertical guidance for a more precise final approach.

The accessibility increases respect to the existing procedures too; one of the benefits they identified was the possibility to arrive closer to the landing point, avoiding unnecessary long flights from MAPt to the heliport thus diminishing the time of flight. Moreover it was also stated that thanks to the new procedures it will be easier to land during night's missions, which means that a shortest possible visual segment is favourable. Terrain and obstacle data were collected by NLA project member and uploaded to FPDAM design tools as basis for the procedure design.

The reconnaissance was done by NLA expert and the suggested final approach track of 350 was chosen. Relevant stakeholders, i.e. ATC and the City council were contacted for inputs. ATC had no concerns about the procedure as long as they were in line with the existing ones. The City Council were a bit worried about noise footprint, but the conclusion was that the amount of traffic will not increase much and the fact that a procedure from a different direction to the same hospital will diverse the noise to other areas.

AVINOR, the ANSP of Norway was contacted for allocation of EGNOS channels and informed about activities for possible future publication of procedures in National AIP. There is an ongoing process to issue a helicopter route manual as a supplement to the National AIP. It is still in progress and is expected to be issued ultimo 2016. Procedures used by selected services will be published.

6.4.4.2 Recommendations

The following recommendations have been identified:

- The selection of final approach track should be carefully selected by analysing possibilities for straight in approach in a lit up area if possible.
- It is in the interest of safety to keep the visual segment as short as possible to avoid long level segments to the FATO.
- An increase in efficiency is only achieved when the VFR-flying is not possible. To have approaches from different directions to the same destination will save track miles in most cases. If the procedures are connected to a low-flight network the need for planning is less and a safer approach.
- The pilots prefer standardized approach charts with only the necessary information portrayed.
- The contingency procedures serves as a confidence builder that an emergency situation will not compromise safety.
- There is a need for the pilots to stay confident and this is achieved through regular training flights and checks in simulator.
- The designers should have seen the area in real life before starting design.

6.5 Demonstration Exercise EXE-02.09-D-005 Report

6.5.1 Exercise Scope

The fifth demonstration exercise, the second one for Norwegian Flight Campaigns, covers the following concept:

- PinS departure at Lørenskog heliport using RNP 0.3 Navigation Specification.

The exercise level corresponds to the E-OCVM level V4, since the exercise encompasses live trials in operational environment.

The adoption of RNP 0.3 navigation specification in the departure phase and the design of PinS departure increase site availability in terms of IFR departures allowance, in particular during poor visibility with a reduced departure minimum cloud ceiling and minimum visibility.

6.5.2 Conduct of Demonstration Exercise EXE-02.09-D-005

6.5.2.1 Exercise Preparation

The following activities have been carried out for the preparation of this exercise, according to the ICAO regulations and criteria:

- Input data and operational requirements collection
  - No ad-hoc survey has been performed. Aeronautical Data and Metadata acquisition and import into the design environment: DTM/DSM, Airport/Heliport data, Obstacle data, ATS environment, Other data/information;
  - Definition of the operational requirements for the design of the new PinS departure procedure.
- Landing site assessment and PinS departure procedure design
  - Obstacle and terrain surfaces modelling and assessment for landing site suitability verification to support IFR PinS departure procedures;
  - Design of one PinS departure procedure.
- Flight Procedure Ground Validation and avionic database preparation
  - Verification of accuracy of the data used for flight procedure design;
  - Verification of the correct application of ICAO PANS OPS criteria for flight procedure design;
  - Navigation DB Preparation and upload on the FMS.
- On board platform adaptation
  - Data acquisition and recording platform.
- Coordination between ATS units

In parallel to the activities listed above, a proper coordination between all the involved stakeholders has been set up to guarantee the necessary involvement of the ATS units during flight trial execution (APP and ACC units).

- Procedure preparation and execution Flight Validation/Inspection

Preparation of timely briefing for all participants for the flight validation trial (heliport authority, local ATC, regulator, flight crew) invitation and flight validation execution plan;

Reservation and preparation of the installation of the dedicated flight inspection kit in the helicopter;

Flight validation/inspection trials execution and data recording;

Preparation and execution of post flight processing;

Post Flight briefing (aircrew, flight engineer, flight procedure designer) and Flight Validation reporting.

- Pilot training
    - Training of pilots with Airbus Helicopters training department full flight simulator in Donauwørth.

6.5.2.2 Exercise execution

The activities listed below have been performed during the demonstration flight:

- Pre-flight activities
    - Preparation of timely briefing for all participants for the flight trial (local ATC, local residents, regulator, flight crew) invitation and flight trial execution plan.
- Flight trials execution
    - Execution of new PinS departure procedure.
- On board data collection
    - On board Flight data has been collected on board by the Norsk Luftambulanse helicopter.
- Post Flight briefing
    - Immediately after the flight, a debriefing will be held between involved stakeholders (heliport authority, local ATC, local residents, regulator, flight crew).

Once the exercise ended, several activities have been conducted in order to gather the first data and to prepare the following data analysis:

- Data processing and navigation performance assessment
    - Extraction of flight data records from helicopter on board equipment;
    - Processing of navigation data acquired on board and elaboration of data acquired on ground;
    - Performance assessment and anomaly investigation execution.

The following information is of quantitative nature and it served as a description of the system performance when using the PBN IFR procedures. In addition the ad-hoc questionnaire to pilots contributed to collect subjective additional feedback to have a more complete overview of the exercise performance.

- Qualitative assessment
    - Questionnaires and debriefings have been used for a qualitative assessment of the flight trials.
        - Questionnaires: at the end of flight trials, flight crew filled in the questionnaire to provide their feedback on aspects related to the assessment of the KPAs under investigation.
        - Debriefing: debriefings have been used to address aspects related to the KPAs under investigation.

REFERENCE SCENARIO

The reference scenario for this exercise is today’s operation scenario at Lørenskog heliport (ICAO code ENLX).

The practise is to climb out on the opposite direction of the existing procedure or to calculate a direction of travel and required climb rate by the pilot on an ad hoc basis.

SOLUTION SCENARIO

The solution scenario sees the insertion of new designed PinS departure procedure in the operational environment surrounding and including Lørenskog heliport. The new flight procedure has been evaluated in the operational context to assess the improvement in the approach operations.

The list of helicopter flights performed on the Lørenskog departure procedure is reported in Table 15.

6.5.2.3 Deviation from the planned activities

No deviation from planned activities.

6.5.3 Exercise Results

6.5.3.1 Summary of Exercise Results

6.5.3.1.1 Results per KPA

6.5.3.1.1.1 Safety

For the evaluation of this KPA, the following Key Performance Indicators (KPIs) have been selected:

- Flight crew subjective feedback;
- Flight crew workload;
- Flight crew situational awareness;
- Flight track adherence.

Pilots provided their view about the impact of the new procedures on Safety, comparing them with the procedures they are currently using (VFR departure). The high level results are provided in the following graph, while more detailed information is provided in 4.1.3.4 and Appendix G.

The first three indicators have been evaluated using feedback collected through pilot's questionnaires (see Appendix G to have a look to the Swiss first flight campaign questionnaire results), the last one using the data collected by the on board flight inspection system.

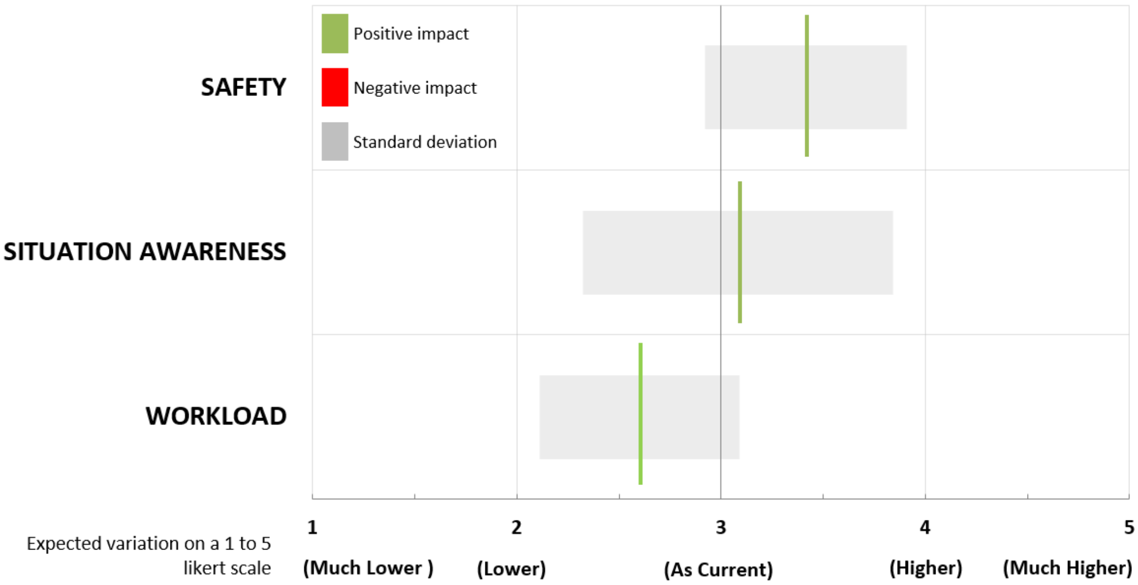


Figure 73: Questionnaires results for EXE-02.09-D-005 (Departure Lørenskog).
Flight Trials Pilots' expected impact of the new procedures on Safety, Situation Awareness and Workload, compared with the current ones (answers' average).

Flight crew subjective feedback

The data collected for this indicator show that a slight increase in safety level has been experienced (the average value is 3,42/5) with respect to the safety of current VFR operations. Detailed information is provided in Appendix G.

The possibility of having predefined routes is considered one of the benefits of the implementation of the new procedures, especially when pilots have to hurry up.

Flight crew workload

The average value of the workload is 2,60/5, meaning that no impact is foreseen for this KPI.

Some issues impacting workload have been identified, mostly related to the pre-flight phase, when according to pilots the procedures require more effort than the ones currently flown.

In addition, pilots complained that the bright colours used are a distraction, making vital information hard to read and added that no information of conventional navaids are given for position verification; those factors have been considered as potential hazards during the flights.

A new version of the IAC approach procedure has been produced including the modifications highlighted, thus improving the feedback on safety aspects (Figure 15).

Flight crew situation awareness

The average value collected for this KPI is 3,08/5 and it demonstrates that a slight increase in safety level has been experienced pilots on the situation awareness for this exercise.

Flight track adherence

The adherence to the flight track has been quantitative evaluated in terms of Cross-track Flight Technical Error estimated by on board computer. In the following figures the FTE statistics are reported in terms of the 95th percentile.

The evaluation for each flight has been performed from LX950 (IDF) to UH 340.

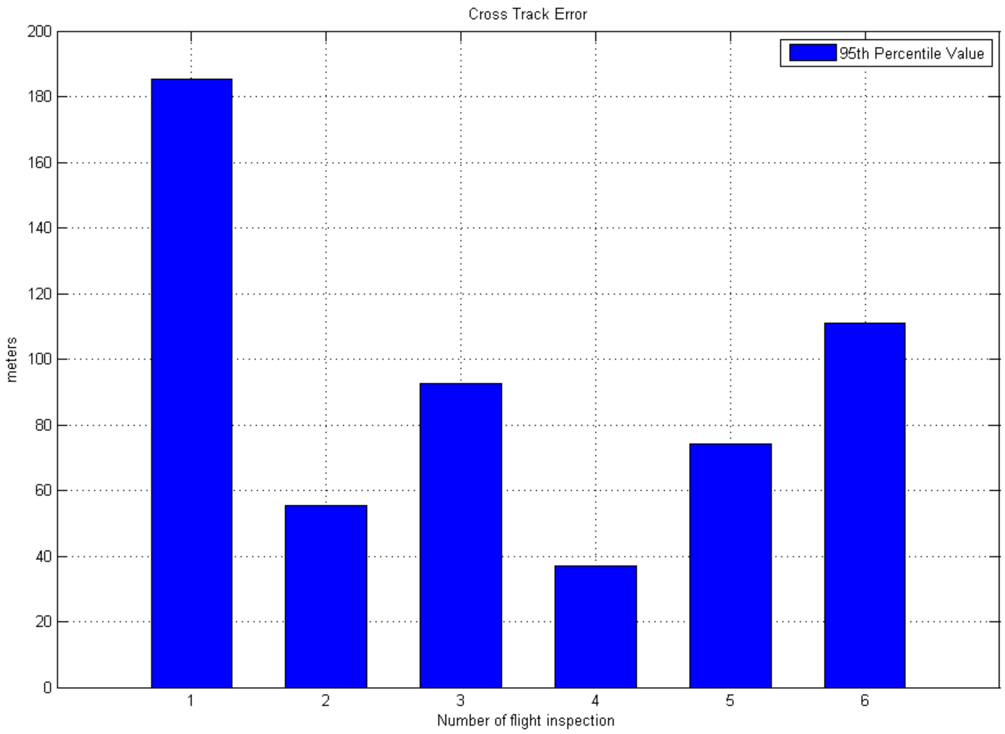


Figure 74: EXE-02.09-D-005 – Statistical evaluation of FTE cross track performed along Lørenskog departure procedure

On the first run an incorrect use of the autopilot occurred that caused an increment of FTE error 95% (for details see [11]). An extract of results of Flight Track # 2, in terms of FTE cross track error is reported.

Detailed results related to helicopter navigation performances along each departure trial are reported in [11].

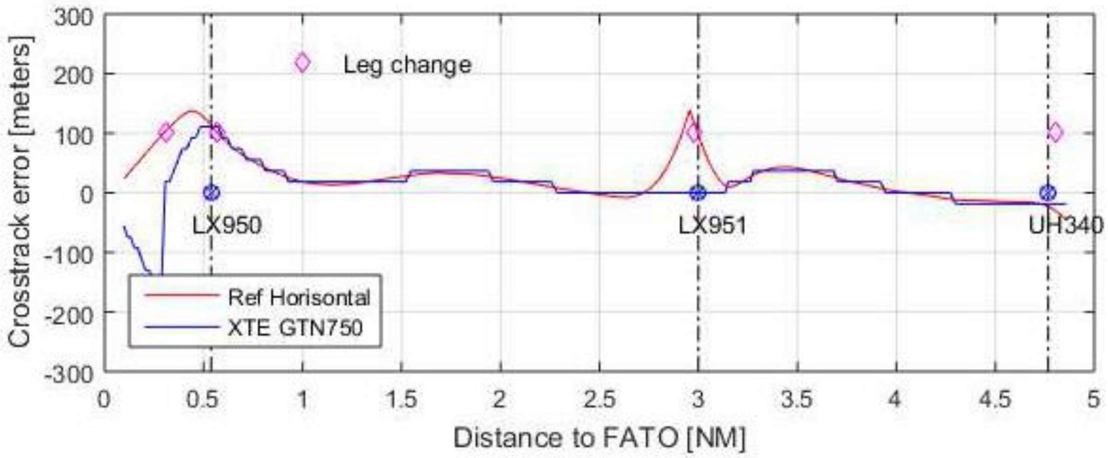


Figure 75: EXE-02.09-D-005 – Flight Track # 2 (Departure flight trial n.2) and cross track FTE – Lørenskog Departure procedure

According to PBN Manual, the accuracy during operations in airspace or on ATS routes designated as RNP 0.3, the lateral TSE must be within ±0.3 NM for at least 95 per cent of the total flight time. The along-track error must also be within ±0.3 NM for at least 95 per cent of the total flight time. To meet this performance requirement, an FTE of 0.25 NM (95 per cent) may be assumed.
Considering the data collected during the flight trials, statistical evaluation of cross track error shows that cross track error 95 per cent is always less than 0.25 NM.

6.5.3.1.1.2 Availability

For the evaluation of the site availability using the new approach procedures, the following indicators have been selected:

- Flight crew subjective feedback;
- Meteo data analysis.

Flight crew subjective feedback

Pilots provided their view about the impact of the new procedures on Availability, comparing them with the procedures they are currently using (Opposite approach track and ad hoc calculations).

For what concern this KPA, the average result of +22% (see Figure 70) demonstrates that an increment of the availability of the site is expected; in fact according to pilots, no procedure for departures have so far been published and, thus, having ad-hoc procedures for the departure will facilitate the operations as it is better to have a departure rather than flying the approach reversed.

More detailed information on pilots' feedback is provided in Appendix G.

Meteo data analysis

METAR data have been analysed to estimate the impact of the new procedures (see paragraph 4.1.3.6 for more details on data source and the analysis performed). As the minima for the departure procedures during day are the same (see Appendix H for further information on the values used for the analysis), only the results for night use are provided in the graph.

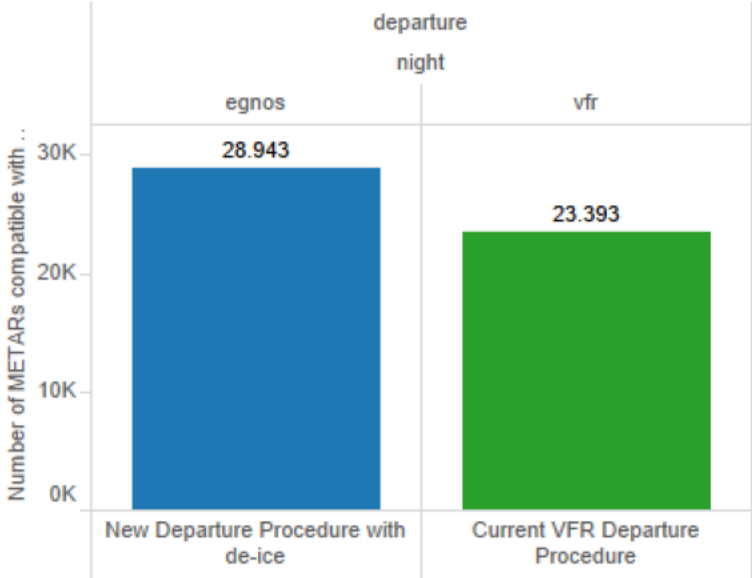


Figure 76: Analysis of meteo data from Oslo, Gardermoen (ENGM), close to Lørenskog: number of 2012-2015 METAR reports with visibility and ceiling conditions respecting minima for the VFR procedure and the new PinS departure one.

	VFR (half hours)	PinS (half hours)	% (PinS vs VFR)	Flight hours (PinS vs VFR)
Night	23.393	28.943	+23,73	+2.775

Table 27: Comparison of accessibility with VFR procedure VS new PinS departure procedure, based on the analysis of 2012-2015 Oslo METAR reports.

According to the analysis, the new procedures would have allowed, in the past 4 years, an increment respect to VFR procedures (0% during day, 27.73% during night).

The following figure shows the impact of the presence of de-ice equipment on helicopters.

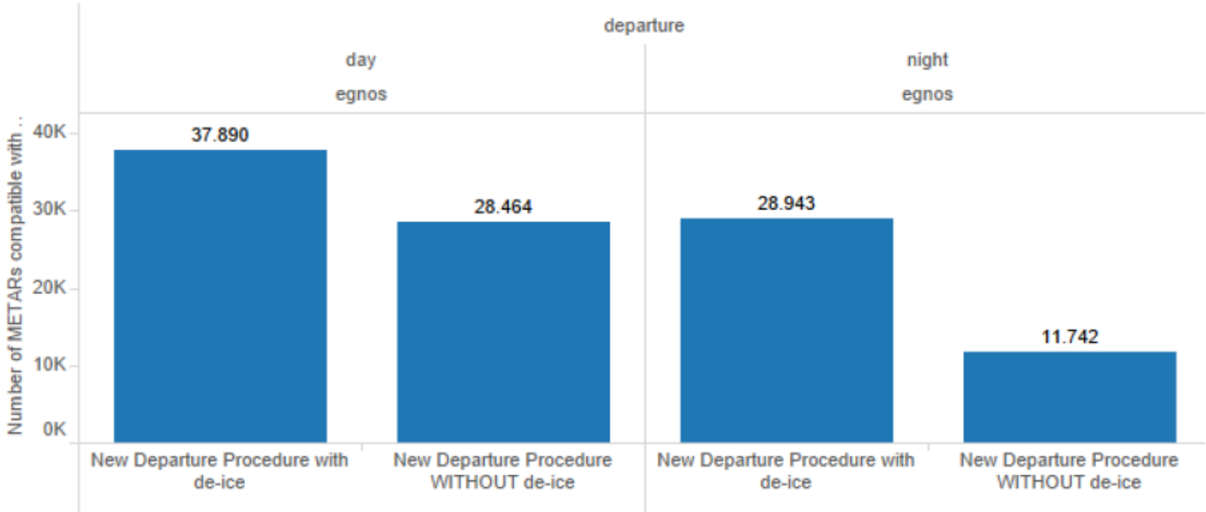


Figure 77: Impact of the availability of helicopters de-ice equipment on the Availability of the Lorenskog site using IFR procedures

According to the results, the presence of de-icing equipment increases the impact on availability of PinS departure procedure by +33% during day and +146% during night.

6.5.3.1.1.3 Environmental Sustainability

A designed departure procedure will in most cases introduce more track miles than flying directly from departure site to destination. However the safety aspect is positive and hence you can depart in weather that was not previously possible.
The procedure was designed in an area of little noise impact with a steep gradient to both clear obstacles but also minimize noise.

6.5.3.1.1.4 Efficiency

Flight crew subjective feedback: Pilots provided their view about the impact of the new procedures on efficiency, comparing the new procedures with the ones they are currently using (VFR departures). According to pilots' opinion, as for the other exercises, the efficiency (+16%) is positively impacted by the new procedure (see Figure 70). If the destination is in the opposite direction, flown track miles will increase and efficiency will decrease. More detailed information is provided in Appendix G.

6.5.3.1.1.5 HP (Operating methods)

The impact of the new procedures on the Operating methods has been analysed using the Flight Crew Subjective feedback as KPI.

The average value for the Operating methods is 2,82/5; this value demonstrates that the pilots who flew the procedures do not foreseen negative impact or degradation with respect to the current operations.

6.5.3.1.1.6 HP (Pilots' task performance)

For the evaluation of the Pilots' task performance impact of new approach procedures the following indicators (KPI) have been selected:

- Flight crew subjective feedback;
- Flight crew workload;
- Flight crew situation awareness;
- Error propensity.

<u>Flight crew subjective feedback</u>

Pilots provided their view about the impact of the new procedures on Human Performance, with a focus on Pilots' task performance. Pilots provided their opinion regarding how much the changes introduced by the adoption of the new procedures are expected to impact their performance, in terms of workload, situation awareness and errors.

For this exercise as for the others, pilots identified some potential hazards that can have a negative impact on their task performance. Those issues are mainly related to the amount of information and the way in which it is provided by the system, as for example the colours on the charts and a different way of writing the procedures in the system.
However a new version of the IAC approach procedure has been produced including the modifications highlighted, thus improving the feedback on these aspects.

More detailed information is provided in Appendix G.

<u>Flight crew workload</u>

In regard to the workload the average value (2,60/5), demonstrates that according to pilots the introduction of the new procedures will have no relevant impact on pilots' task performance.

<u>Flight situation awareness</u>

In regard to the situation awareness the average value (3,08/5), demonstrates that according to pilots the introduction of the new procedures will not have a negative impact on pilots' task performance.

<u>Error propensity</u>

See Flight crew subjective feedback.

6.5.3.1.2 Results impacting regulation and standardisation initiatives

No relevant results heve been identified for regulation and standardisation initiatives.

6.5.3.1.3 Unexpected Behaviours/Results

The procedure behaved as expected. An important issue is that the active waypoint must be selected before departure.

6.5.3.1.4 Quality of Demonstration Results

See 6.4.3.1.4.

6.5.3.1.5 Significance of Demonstration Results

See 6.4.3.1.5.

6.5.4 Conclusions and recommendations

6.5.4.1 Conclusions

The KPAs analysis shows that even if some changes in the operating methods and hazardous issues that have been identified in regard to pilots' performance in interaction with the system, at the same time the relative and necessary mitigation means have been defined by pilots, who at the end of the flight campaigns consider the new procedures to be a benefit for their current and future operations.

The data collected show that a slight increase in safety level has been experienced respect to the safety of current VFR operations.

Moreover an increment of the availability of the site is expected: according to pilots, no procedure for departures have so far been published and, thus, having ad-hoc procedures for the departure will facilitate the operations as it is better to have a departure rather than flying the approach reversed.

6.5.4.2 Recommendations

The following recommendations have been identified:

- Introduction of departure procedures should be emphasized in different directions because of increased safety and to approach the same level of efficiency.
- The PinS departure design criteria were used. The introduction of the IDF can be interpreted as if the pilots are not allowed to enter clouds before the IDF. It should be stated somewhere that this is possible as long as track guidance and vertical profile is met.

6.6 Demonstration Exercise EXE-02.09-D-006 Report

6.6.1 Exercise Scope

The EXE-02.09-D-006 is the exercise performed in the Ullevål Norwegian scenario and it covers the following concepts:

- RNP APCH PinS approach with LPV minima with GPA < 6.3°.

The scope is to demonstrate the operational benefits coming from these two concepts applied at Ullevål heliport by designing, validating and demonstrating flight procedures that will be flown by Norsk Luftambulanse (NLA).

Rotorcraft RNP APCH PinS approaches with LPV minima make use of EGNOS augmentation to GPS L1 constellation. SBAS vertical guidance provided by EGNOS allows a precise height control throughout the final descent and the reduction of the risk of collision with terrain (CFIT), particularly at night and/or in adverse weather conditions.

6.6.2 Conduct of Demonstration Exercise EXE-02.09-D-006

6.6.2.1 Exercise Preparation

Same preparation activities described in 6.4.2.1.

6.6.2.2 Exercise execution

For the general activities performed during the execution of this demonstration exercise, see the list reported in 6.4.2.2.
The reference and solution scenarios for this exercise are reported hereafter:

<u>REFERENCE SCENARIO</u>

The reference scenario for this exercise is today's operation scenario at Ullevål heliport. Ullevål heliport (ICAO code ENUH) is the main trauma center for southern Norway. It serves approximately 35% of the Norwegian population when it comes to severe injuries such as brain traumas, heart attacks.
The heliport is located in the Southern of Norway where a basic low level routing structure exists for use by the Norwegian Air Ambulance to connect hospital heliports throughout the region.
NLA operations are currently conducted in IFR/IMC conditions and already use PinS approach procedures with LNAV minima for approach course 279° and 070°. The airspace is class G underlying OSLO TMA that starts at 2500 FT MSL (see figure below).
It is an area of relatively dense GA-traffic from time to time. Oslo city area has its own traffic advisory frequency: VHF122.000.

<u>SOLUTION SCENARIO</u>

The solution scenario sees the insertion of new designed PinS approach procedure in the operational environment surrounding and including Ullevål heliport. The new flight procedure has been evaluated in the operational context to assess the improvement in the approach operations.

The flights performed for the PinS RNP APCH approach procedure are reported in tables Table 15.

6.6.2.3 Deviation from the planned activities

No relevant deviations from planned activities.

6.6.3 Exercise Results

6.6.3.1 Summary of Exercise Results

6.6.3.1.1 Results per KPA

6.6.3.1.1.1 Safety

For the evaluation of this KPA, the following Key Performance Indicators (KPIs) have been selected:

- Flight crew subjective feedback;
- Flight crew workload;
- Flight crew situational awareness;
- Flight track adherence.

Flight crew subjective feedback

Pilots provided their view about the impact of the new procedures on Safety, comparing them with the procedures they are currently using (LNAV procedures). The high level results are provided in the following graph, while more detailed information is provided in the conclusion of this exercise and in Appendix G..

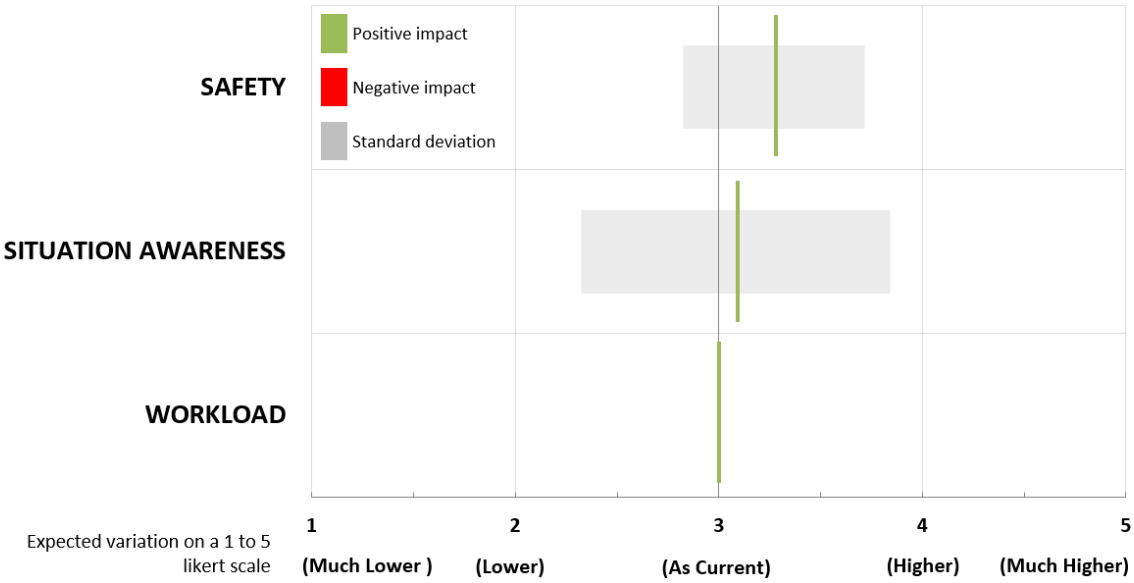


Figure 78: Questionnaires results for EXE-02.09-D-006 (Approach Ullevål).
Flight Trials Pilots' expected impact of the new procedures on Safety, Situation Awareness and Workload, compared with the current ones (answers' average).

The average result of safety, gathered from pilots' comments to the questionnaire is 3,27/5; basically, pilots foresee slight improvements of the new procedure in terms of Safety, Situation Awareness.

It must be noted that some of the questionnaires are answered by pilots that only flew the procedure to LNAV minima and without vertical guidance. The effect of the vertical guidance was hence not considered and also the lower minima provided was neither evaluated.

Significant safety improvements have been reached through the adoption of the 3D final segment up to a lower landing minima (LPV minima – see Figure 14), using the service augmentation provided by EGNOS system and the related ILS-like vertical guidance for a more precise final approach.

According to the pilots, the new procedures could have a positive impact on the operations. In this scenario as for Lørenskog, pilots considered the new procedures for the approaches safer and, moreover, they added that the procedures will allow a more precise and closer approach to the landing site. This is especially relevant under bad visibility circumstances, less during good weather.

However some hazardous circumstances have been considered and reported. They are related to the "plate layout", in particular to the amount of information provided and the different colours used in the design of the system. According to pilots, these factors can lead to potential unsafe situations, in case of misunderstanding regarding the information on the plate, as well as the limited view of the destination site. A new version of the IAC approach procedure has been produced including the modifications highlighted, thus improving the feedback on safety aspects.

Flight crew workload

The average value of the workload is 3/5 (see Figure 78), meaning that the introduction of the new procedure does not impact the workload according to pilots.

Flight crew situational awareness

The average value collected for this KPI is 3,08/5 (see Figure 78), meaning that no impact is foreseen by pilots on the situation awareness.

Flight track adherence

The adherence to the flight track has been quantitative evaluated in terms of Cross-track Flight Technical Error estimated by on board computer. In the following figures the FTE statistics are reported in terms of the 95th percentile.

The evaluation for each flight has been performed from different starting and ending waypoints, as shown in the following table, and described in detail in [12]:

Flight trial number	Registration number	Data	Range of data processed
1	#Run 1	08/06/2015	UH630 - UH601
2	#Run 2	08/06/2015	UH610 - UH601
3	#Run 3	08/06/2015	UH620 - UH602
4	#Run 4	08/06/2015	UH600 - UH602
5	#Run 5	08/06/2015	UH630 - UH602
6	#Run 6	08/06/2015	UH610 - UH602
7	#Run 7	08/06/2015	UH630 - UH602
8	#Run 8	08/06/2015	UH620 - UH602
9	#Run 9	09/06/2015	UH630 - UH602
10	#Run 10	09/06/2015	UH610 - UH602
11	#Run 11	09/06/2015	UH630 - UH602

Table 28: EXE-02.09-D-006 – Range of processed data

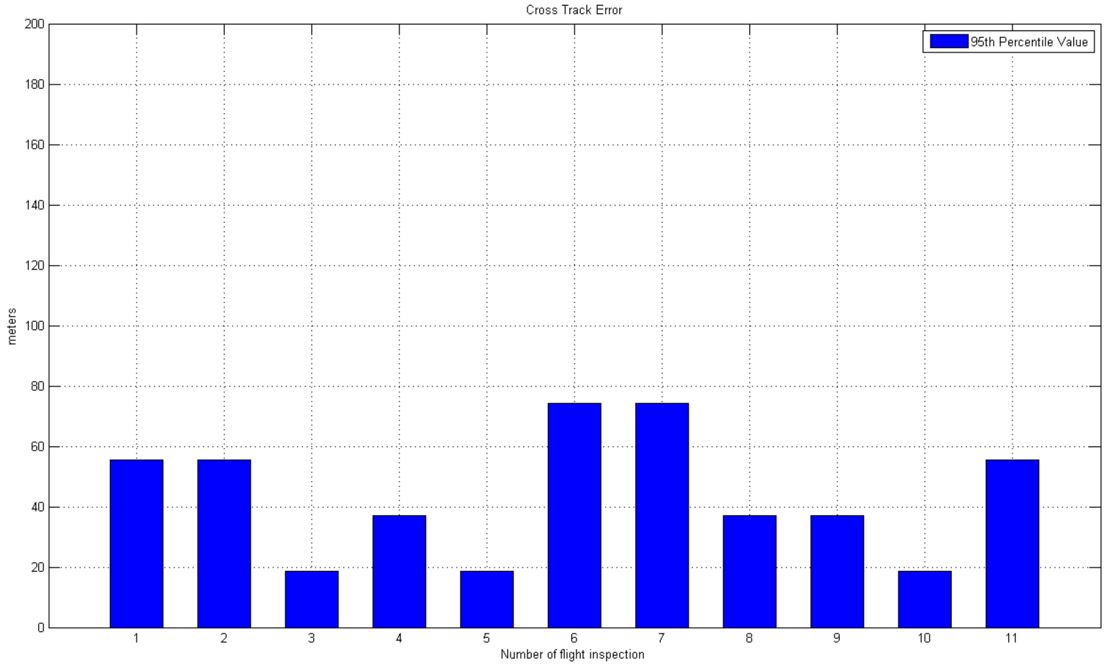


Figure 79: EXE-02.09-D-006 – Statistical evaluation of FTE cross track performed along Ullevål approach procedure

Detailed results related to helicopter navigation performances along each approach trial are reported in [12].

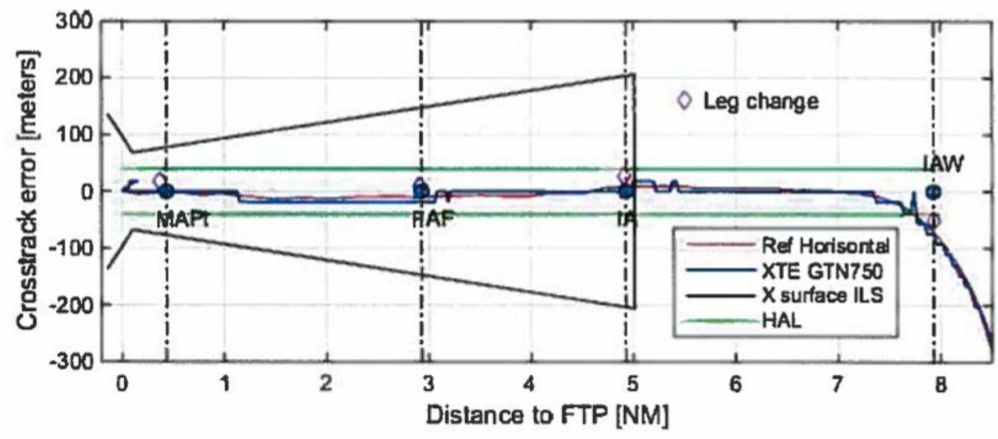


Figure 80: EXE-02.09-D-006 – Flight Track # 3 (Approach flight trial n. 3) and cross track FTE - Ullevål approach procedure

According to PBN Manual (see section 5.3.3.1) to satisfy the accuracy requirement of an RNP APCH, the 95 per cent FTE should not exceed 0.5 NM on the initial and intermediate segments. The 95 per cent FTE should not exceed 0.25 NM on the FAS of an RNP APCH.
Considering the data collected during the flight trials, statistical evaluation of cross track error shows that cross track error 95 per cent is always less than 0.25 NM (the most critical constraint in the final segment).

6.6.3.1.1.2 Accessibility

For the evaluation of site accessibility using the new approach procedures, the flight crew subjective feedback has been selected:

Pilots provided their view about the impact of the new procedure on accessibility, comparing them with the procedures they are currently using (LNAV procedures).

The average value collected for this KPA is 18% (see Figure 70); accessibility is expected to increase respect to the existing procedures, meaning that more take offs are expected to be performed thanks to the new procedure. For this exercise, as for the approach at Lørenskog, they consider the possibility to arrive closer at the heliport as one of the benefits, together with a reduction of the time of the flight. In addition the landing will be easier to perform, with respect to the current one.

More detailed information is provided in the conclusion of this exercise and in the Appendix G.

6.6.3.1.1.3 Environmental Sustainability

For the Emissions per flight and noise footprint KPIs consideration, see the same considerations reported for the ENLX approach.

6.6.3.1.1.4 Efficiency

For the evaluation of the efficiency, the following indicators have been chosen:

- Mileage;
- Time to land;
- Fuel consumption;
- Flight Crew Subjective feedback.

<u>Mileage</u>

For this KPI, see the same considerations reported for the ENLX approach.

<u>Time to land</u>

For this KPI, see the same considerations reported for the ENLX approach.

<u>Fuel consumption</u>

For this KPI, see the same considerations reported for the ENLX approach.

<u>Flight Crew Subjective feedback</u>

The average value gathered from pilots' answers is 16% (see Figure 70) demonstrating that a positive impact is foreseen with the new procedures.

The efficiency for this exercise was considered acceptable and among the benefits that the procedure can bring to the today's operations is the opportunity to perform direct approaches from directions where it is not possible to perform them with the current procedures. Moreover, as for the approach at Lørenskog, the new procedures will also allow to save time and thus, to perform more successful operations.

Three different transitions (i.e. STARs) have been designed and flown in order to connect each initial segment of the approach flight procedure to the low-level route infrastructure. The trials demonstrated an efficient and smooth transition from the en-route phase of flight to the approach procedure. The improvement provided by the STARs contributed to the overall efficiency result reported in Figure 70.

6.6.3.1.1.5 HP (Operating methods)

The KPI used to measure the impact of the new procedures on the Operating methods is the Flight Crew Subjective feedback.

The average value collected from the questionnaires analysis is 2,82/5.

Pilots stated that the procedures will have an impact on the operating methods as they require more effort in the phase of preparation to the landing with respect to the current operations; this has been considered, however, feasible.

6.6.3.1.1.6 HP (Pilots' task performance)

For the evaluation of the impact on Pilots' task performance impact, the following indicators (KPI) have been selected:

- Flight crew subjective feedback;
- Flight crew workload;
- Flight crew situation awareness;
- Error propensity.

Flight crew subjective feedback

For this exercise, as for the previous ones, pilots' task performance could be impacted by the new procedures leading to hazardous situations. In particular, pilots' comments focused on the interaction with the system where the following issues have been identified:

- the high amount and the different colours of the information provided;
- a different way of writing the procedures (with respect to the way in which they are currently written);
- a wrong programming of the system.

All these factors, in pilots' view, can downgrade their performance during the approach phase. These considerations raised during the flight campaign. After that a new version of the IAC approach procedure has been produced including the modifications highlighted, thus improving the feedback on pilots' task performance.

Flight crew workload

In regard to the workload the average value (3/5 see Figure 78), demonstrates that according to pilots the introduction of the new procedure globally does not impact on pilots' task performance in comparison with the current operations.

Flight crew situation awareness

In regard to the situation awareness the average value (3,08/5 see Figure 78), demonstrates that according to pilots the introduction of the new procedure does not impact on pilots' situation awareness in comparison with the current operations

Error propensity

See Flight crew subjective feedback.

6.6.3.1.1.7 HP (Performance of the technical system)

For the evaluation of the impact on the performance of the technical system the following indicators (KPI) have been selected:

- Flight crew subjective feedback;
- Flight Technical Error (FTE) cross track.

Flight crew subjective feedback

In case a system failure would occur, pilots affirmed that they would be able to manage the situation putting in place some mitigation means that they reported in the questionnaire, as the use of contingency procedures, the activation of warnings in case of loss of signals and the regular training of pilots in order to be able to fly the new procedures.

Flight Technical Error (FTE) cross track.

See Figure 79.

6.6.3.1.2 Results impacting regulation and standardisation initiatives

Not relevant results for regulation and standardization are provided.

6.6.3.1.3 Unexpected Behaviours/Results

Neither unexpected behaviour nor results has been identified.

6.6.3.1.4 Quality of Demonstration Results

See 6.4.3.1.4.

6.6.3.1.5 Significance of Demonstration Results

See 6.4.3.1.5.

6.6.4 Conclusions and recommendations

6.6.4.1 Conclusions

The results of this exercise show an improvement of the new procedure in terms of safety has been experimented.

According to the pilots, the new procedures could have a positive impact on the operations. In this scenario as for Lørenskog, pilots considered the new procedures for the approaches safer and, moreover, they added that the procedures will allow a more precise and closer approach to the landing site. This is especially relevant under bad visibility circumstances, less during good weather.

Significant safety improvements have been reached through the adoption of the 3D final segment up to a lower landing minima (LPV minima – see Figure 14), using the service augmentation provided by EGNOS system and the related ILS-like vertical guidance for a more precise final approach.

An increase in terms of accessibility is expected respect to the existing procedures, meaning that more take offs are expected to be performed thanks to the new procedure. For this exercise, as for the approach at Lørenskog, pilots consider the possibility to arrive closer at the heliport as one of the benefits, together with a reduction of the time of the flight. In addition the landing will be easier to perform, with respect to the current one.

The procedure itself does not introduce a more environmental friendly operation, but the fact that the pilot can chose a direct routing in clouds instead of flying around the terrain when weather is below VFR minimum, can bring a benefit from an environmental point of view. Furthermore, a steeper approach is more silent than a normal VFR approach.

Compared to VFR flights (considering that there were not any LNAV approach procedures from the considered approach direction), PinS approach procedure is less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless this new procedure is an additional solution to permit life-saving flights in IMC.

6.6.4.2 Recommendations

No relevant recommendations have been identify after the conduction of this exercise in addition to the ones reported in 6.4.4.2.

6.7 Demonstration Exercise EXE-02.09-D-007 Report

6.7.1 Exercise Scope

The exercise EXE-02.09-D-007 covers the following concept:

- PinS RNP APCH to LPV minimum at Chur hospital with GPA > 6.3°;
- Adoption of RNP 0.3 navigation specification in the initial, intermediate and missed approach segment.

The exercise EXE-02.09-D-007 consists in the execution of the new PinS RNP APCH to LPV minimum at Chur hospital, designed by IDS in the frame of PROuD.

This exercise was not foreseen in the demonstration plan, but as a PinS RNP APCH approach to LPV minimum was designed and performed during the flight campaign to execute the heliport to hospital connection between Samedan and Chur (see EXE-02.09-D-003 in the demonstration plan), it was decided to include this exercise separately.

The flight performance of this new procedure has been analysed following the same methods as the other exercises, which were initially planned in the project.

In order to explain the operational concept behind this exercise, it is worth mentioning that rotorcraft PinS RNP APCH approaches with LPV minima make use of EGNOS augmentation to the GPS constellation. Vertical guidance provided by SBAS (EGNOS) allows a precise height control throughout the final descent and the reduction of the risk of collision with terrain (CFIT), particularly at night and/or in challenging environment.

The current ICAO design criteria limit the GPA to maximum 6.3°. However, steep approach procedures, with GPA>6.3°, allows to fulfil the required obstacle clearance in the final approach segment, especially in challenging environment, through the adoption of sloped obstacle assessment surfaces similar to those used for ILS approaches.

Moreover, the adoption of the RNP 0.3 navigation specification in the missed approach segment further reduces the landing minimum, in comparison with standard missed approaches (RNP 1).

In regard to the level of the exercise, it corresponds to the E-OCVM level V4, as the exercise consisted of live trials in an operational environment.

6.7.2 Conduct of Demonstration Exercise EXE-02.09-D-007

6.7.2.1 Exercise Preparation

In relation to the preparation of the exercise EXE-02.09-D-007, several activities have been performed according to the ICAO regulations and criteria. The following list summarises these activities that were previously mentioned in the D01 PROuD Demonstration Plan:

- <u>Input data and operational requirements collection:</u>
  - No ad-hoc survey has been used. Aeronautical Data and Metadata acquisition and import into the design environment: DTM/DSM, airport/heliport data, obstacle data, ATS environment,, other data/information;
  - Definition of the operational requirements for the design of the new RNP APCH procedure.
- <u>PinS RNP APCH procedure design:</u>
  - Obstacle and terrain surfaces modelling and assessment for landing site suitability verification to support IFR PinS approach procedures;
  - Design of PinS RNP APCH procedures with LPV minima.

- Flight procedure ground validation and avionic database preparation:
    - Verification of accuracy of the data used for flight procedure design;
    - Verification of the correct application of ICAO PANS OPS criteria for flight procedure design;
    - Full flight simulations using the Rega AW109 full flight simulator for flight procedure flyability assessment;
    - Navigation DB preparation and upload on the FMS.

- On-board platform adaptation:
    - Avionic upgrade for ADS-B out capability;
    - Data acquisition and recording platform miniQaR and JAVAD already installed in the AW109 Helicopter.

- Coordination between involved stakeholders (Hospital) units:

  In parallel to the activities listed above, a proper coordination between all the involved stakeholders was set up in order to guarantee the necessary coordination.

- Procedure preparation:
    - Preparation and fulfilment of an in-house Rega SAFE (safety analyses in front of engagement);
    - Preparation of timely briefing for all participants for the flight validation trial (hospital management, local residents, regulator, flight crew) and flight validation execution plan;
    - Reservation and preparation of the installation of the dedicated flight inspection kit in the helicopter;

- Pilot training:
    - Training of pilots with Rega full flight simulator.

6.7.2.2 Exercise execution

The execution of the exercise has been structured in pre-flight activities, the demonstration flights performance and post-flight activities.

Below the exercise's steps are listed as they have been executed:

- Pre-flight activities:

  Preparation of timely briefing for all participants for the flight trial (hospital management, local residents, regulator, flight crew) invitation and flight trial execution plan.

- Flight trials execution:

  A total number of 11 flight trials (additional 2 flights in the FFS) were executed with the new PinS RNP APCH procedure to LPV minimum.

  During the execution of the exercise, data has been collected both on board the Rega helicopters and on ground where the GPS/EGNOS signal quality and the approach path, through a landing monitor, have been monitored.

  Qualitative techniques of data collection have been also used during the trials and they included over-the-shoulder non-intrusive observations of pilots and system behaviour during the trials, together with the think aloud methodologies

- Post-flight activities:

  Immediately after the flight, a debriefing has been held between involved stakeholders,(hospital management, , local residents, regulator, flight crew).

  At the end of the exercise the following activities have been executed:

    - Extraction of flight data records from helicopter on board equipment;

- Processing of navigation data acquired on board and elaboration of data acquired on ground;
- Performance assessment and anomaly investigation execution.

The information gathered during the exercise served as a description of the system performance when using the PBN IFR procedures. Quantitative and qualitative measures contributed to the final assessment of the flight trials.
Regarding the navigation performance assessment it is worth mention that Rega Flight inspection console, used during the flight trials allows the recording of all the necessary navigation parameters for the post processing activities.

REFERENCE SCENARIO

The reference scenario for this exercise is today's operational scenario in Chur heliport.
At Chur (ICAO code LSHC) heliport only VFR operations are currently allowed for both fixed wing and rotary wing aircraft.
No IFR approach procedure is available.

SOLUTION SCENARIO

The implementation of a PinS RNP APCH to LPV minimum combined with initial, intermediate and missed approach segments based on the RNP 0.3 navigation specification has been identified by Rega as both a necessary and an effective solution to overcome current existing limitations in terms of safety and hospital capacity/accessibility. This will be allowed by the EGNOS guidance capability along the final segment of the approach procedure.
PROuD flight trials at Chur hospital will be conducted in VFR/VMC conditions during the flight trials.

A helicopter flight inspection was performed by Rega along Chur approach procedure. The flight inspection performed for approach procedure is reported in Table 14.

6.7.2.3 Deviation from the planned activities

Additional exercise: this exercise was not foreseen in the Demonstration Plan but as a PinS RNP APCH approach to LPV minimum was designed and performed during the Flight Campaign to execute the heliport to hospital connection between Samedan and Chur (see EXE-02.09-D-003 in the Demonstration Plan), it was decided to include this exercise separately.

A total number of 11 flight trials (additional 2 flights in the FFS) were executed with the new PinS RNP APCH procedure to LPV minimum at Chur hospital.

6.7.3 Exercise Results

6.7.3.1 Summary of Exercise Results

6.7.3.1.1 Results per KPA

The following sections summarise the results collected during the flight trials for this exercise at Chur hospital. In regard to this exercise a number of KPAs have been selected and measured using several key performance indicators, whose value can give an idea of the impact that the implementation of the new procedures can produce for each KPAs.

6.7.3.1.1.1 Safety

For the evaluation of the safety impact of new approach procedures the following Key Performance Indicators (KPIs) have been selected:

- Flight crew subjective feedback;
- Flight crew workload,
- Flight crew situational awareness;

- Flight track adherence.

Pilots provided their view about the impact of the new procedures on Safety, comparing them with the procedures they are currently using (VFR procedures). The high level results are provided in the following graph together with the ones related to situation awareness and workload, while more detailed information is provided in Appendix G.

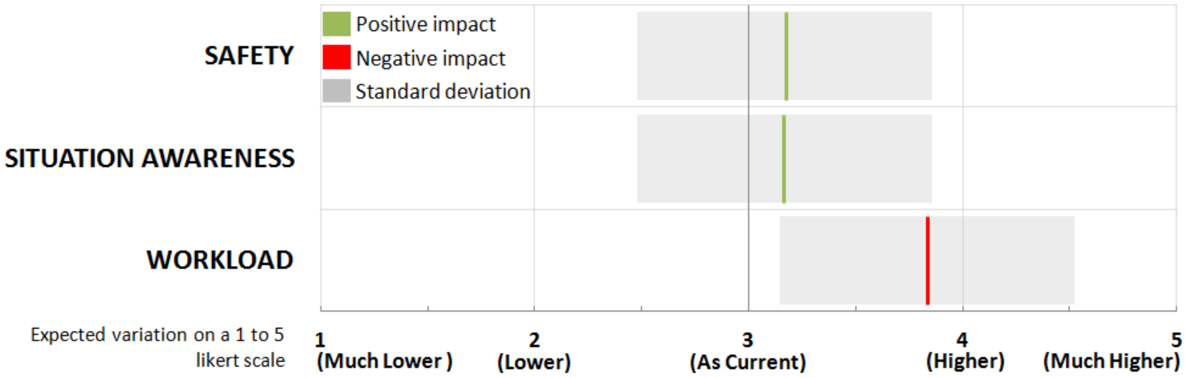


Figure 81: Questionnaires results for EXE-02.09-D-007 (Approach Chur).
Flight Trials Pilots' expected impact of the new procedures on Safety, Situation Awareness and Workload, compared with the current ones (answers' average).

Flight crew subjective feedback

With regard to this exercise, according to the pilots, these new procedures will improve the safety of the operations mainly in bad weather conditions and during night operations.

They do not see any improvement in case of good weather because they would fly the VFR procedures.

In addition, pilots identified possible circumstances in which the new procedures could produce safety issues. According to them, potential hazards are system errors or failure on board as well as hazards related to GNSS unavailability (no other conventional equipment is available; e.g. VOR).

A mitigation for the identified hazards could be to take an early decision according to the weather conditions, at 10'000 ft before descending below OEI Service Ceiling. A contingency procedure after this decision in the occurrence of an OEI Condition could be to continue the approach until ground contact in any case.

Flight crew workload

An increment of workload respect to current operations has been experienced, as the average value gathered from pilots’ answers (3,83/5) demonstrates.

Flight crew situational awareness

The average value collected for this KPI is 3,17/5, meaning that no impact is foreseen on situation awareness.

Flight track adherence

Statistics related to GPS errors and integrity limits have been calculated starting from acquired helicopter data between FAF and MAPt for Chur approach procedure in order to evaluate the performance of PinS RNP APCH in the final segment.

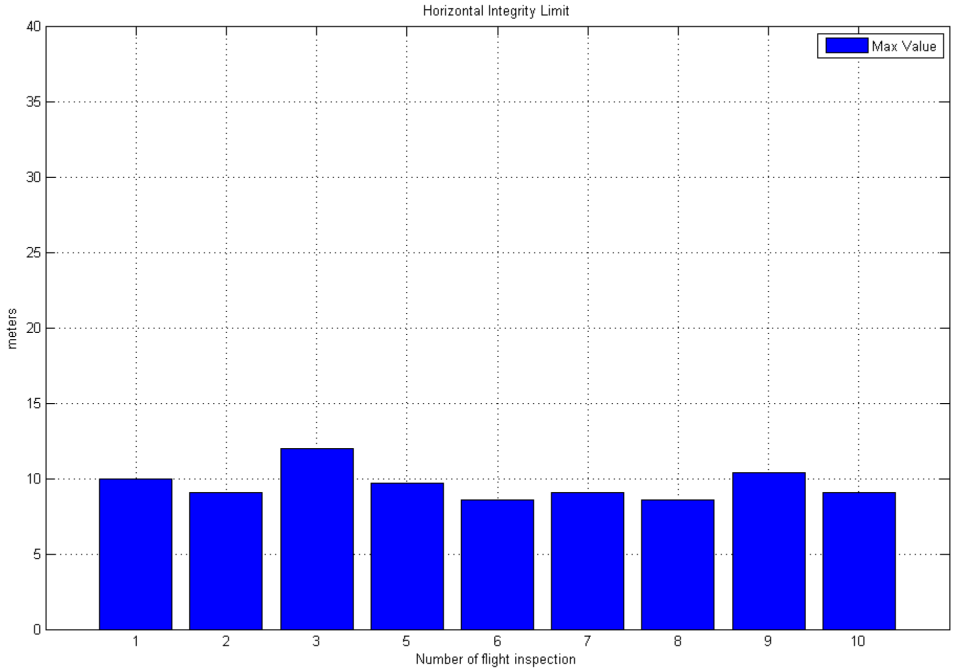


Figure 82: Horizontal Integrity Limit (max value) for each flight trial

The maximum recorded Horizontal Integrity Limits were below the SBAS APV-I/ Horizontal Alert Limit (40 m) on all flights.

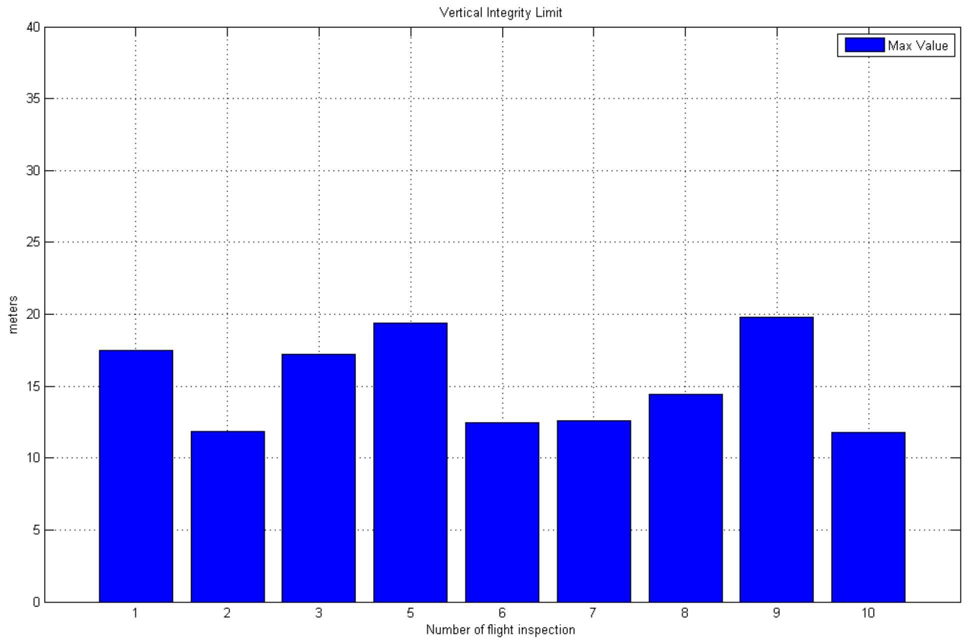


Figure 83: Vertical Integrity Limit (max value) for each flight trial

The maximum recorded Vertical Integrity Limits were below the SBAS APV-I Vertical Alert Limit (50m) on all flights.

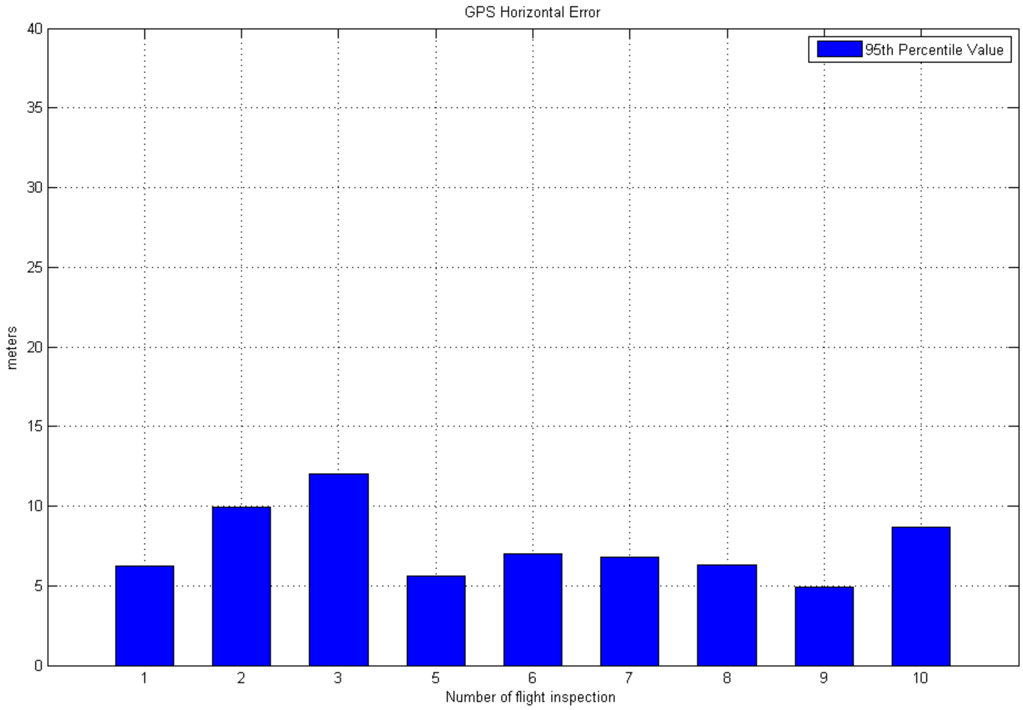


Figure 84: GPS/EGNOS horizontal error (95th percentile value) for each flight trial

The GPS/EGNOS horizontal error 95% is lower than the SBAS APV-I accuracy horizontal 95% requirement (16 m).

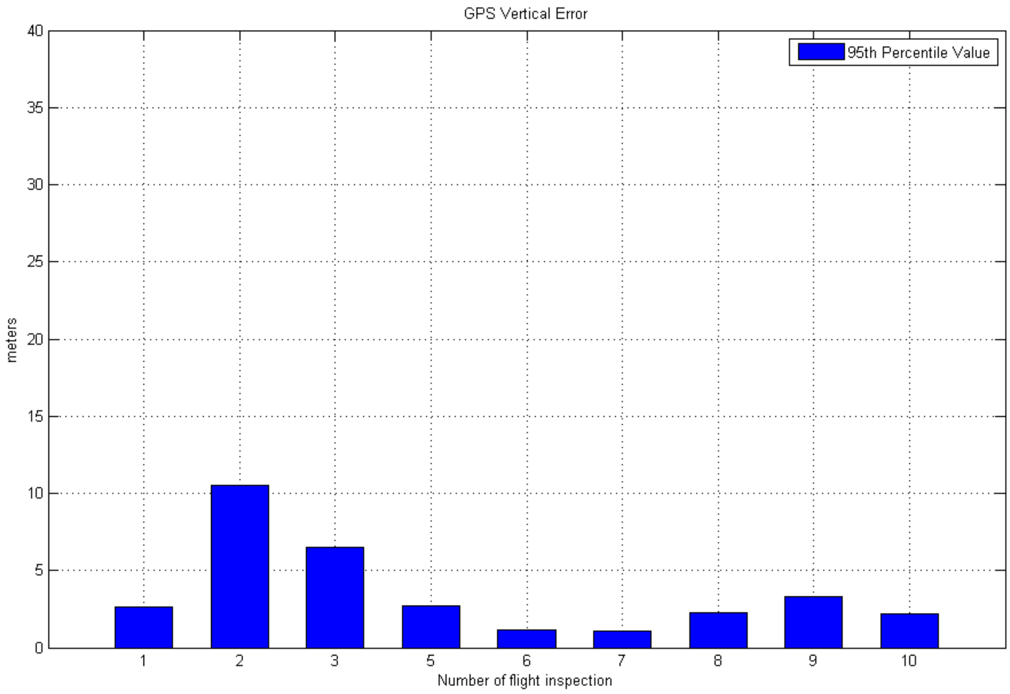


Figure 85: GPS/EGNOS vertical error (95th percentile value) for each flight trial

The GPS/EGNOS vertical error 95% is lower than the SBAS APV-I accuracy vertical 95% requirement (20m).

Statistics on Total System Error has been elaborated taking into account the data acquired when the helicopter joined the flight track until the FAF, therefore according to the flown trajectory, the data that have been processed are reported in the last column of the following table:

Flight inspection number[7]	Registration number	Data processed
1	#04	CHU01 – UR003 (FAF)
2	#06	CHU01 – UR003 (FAF)
3	#08	CHU01 – UR003 (FAF)
5	#09	UR001 – UR003 (FAF)
6	#11	UR001 – UR003 (FAF)
7	#21	UR001 – UR003 (FAF)
8	#04	UR002 – UR003 (FAF)
9	#13	UR001 – UR003 (FAF)
10	#23	UR002 – UR003 (FAF)

Table 29: EXE-02.09-D-007 - Range of processed data

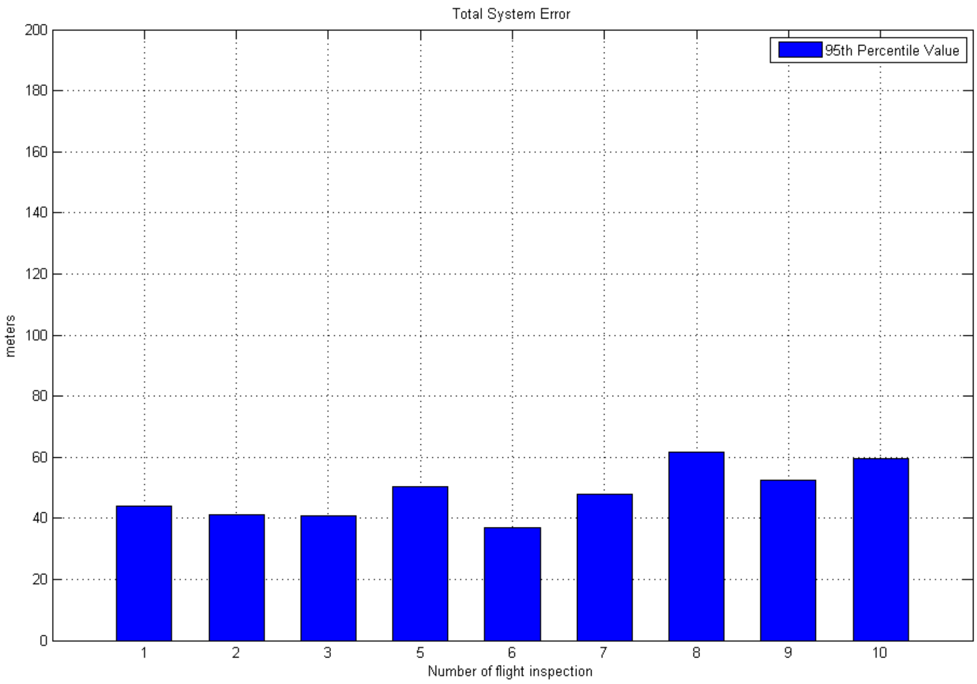


Figure 86: TSE cross track error (95th percentile value) in initial and intermediate segments

[7] Number is aligned with the one reported in Table 14

6.7.3.1.1.2 Accessibility

For the evaluation of site accessibility using the new approach procedures, the following indicators have been selected:

- Flight crew subjective feedback;

Flight crew subjective feedback

The average value of the pilots' feedback, +23%, demonstrates that a positive impact is expected by pilots. They affirmed that the new procedures will permit to fly through a cloud layer, in case of bad weather conditions, as for example fog patches and inversion meteorological situation.

This area is affected particularly by adverse geographical and weather conditions, in fact one of the important limiting factor is ice.

6.7.3.1.1.3 Environmental Sustainability

The flight track for the PinS RNP APCH procedure is longer and the approach speed is slower compared to VFR approach. The environmental impact is not reduced but the accessibility to and from the airport will increase in bad weather.

6.7.3.1.1.4 Efficiency

For the evaluation of the efficiency, the flight crew subjective feedback indicator has been selected.

The average result coming out from pilots' answers is -20%

Even if the low percentage of the flight crew subjective feedback measure value could make one think that the efficiency will decrease with the new procedures, pilots' comments highlighted that this rate is only related to the duration of the flight.

According to the current regulation, actually pilots cannot operate in VFR with adverse weather conditions, because the possibilities to reach the landing site are very low and the pilots with the patients would risk their lives during the route to the hospital. The introduction of the new procedures could produce a benefit for both the pilots and the patients, because, despite the higher duration of the flight, it will be possible at least to operate, with the resulting increase of the number of operations performed and, thus, of the efficiency in respect to the current ones.

6.7.3.1.1.5 HP (Operating methods)

The impact of the new procedures on this KPA has been measured using the flight crew subjective feedback as KPI.

The average value collected is 2,83/5, that demonstrates the changes in the operating methods lead by the new procedures are considered acceptable by the pilots.

Passing from VFR to IFR modality will have an impact on the current operating methods, because there will be a change in the current flight paths and procedures. However, pilots stated that an acceptable level of feasibility have been achieved with the new procedures, adding that an even higher level of consistency and acceptability could be reached with little changes of some technical aspects.

In order to cope with the operating methods changes, one solution identified was to have regular pilots training on the new procedures, to get them familiar with the procedure as soon as possible.

6.7.3.1.1.6 HP (Pilots' task performance)

For the evaluation of the impact on Pilots' task performance impact, the following indicators (KPI) have been selected:

- Flight crew subjective feedback;
- Flight crew workload;

- Flight crew situation awareness;
- Error propensity.

Flight crew subjective feedback

Pilots provided their view about the impact of the new procedures on Human Performance, with a focus on Pilots' task performance. Pilots provided their opinion regarding how much the changes introduced by the adoption of the new procedures are expected to impact their performance.

Flight crew workload

In regard to the workload the average value (3,83/5), demonstrates that according to pilots the introduction of the new procedures will have a negative impact on pilots' task performance.

Flight crew situation awareness

In regard to the situation awareness the average value (3,17/5), demonstrates that according to pilots the introduction of the new procedures will have basically no impact on this KPI.

Error propensity

In regard to the error propensity, pilots identified possible hazards in the interaction between the pilot and the system. The factors that can lead to incidents can be a high level of workload, together with little training and errors in programming the system.

However these safety issues are not considered highly hazardous, in fact according to pilots the procedures, the design of the procedures limits the probability that those kinds of risks can occur during operations performed with the RNP APCH approach.

6.7.3.1.1.7 HP (Performance of the technical system)

For the evaluation of the performance of the technical system impact of new approach procedures the following indicators (KPI) have been selected:

- Flight crew subjective feedback
- Protection levels
- GPS/EGNOS positioning errors 95%
- Total System Error (TSE) cross track 95%

Flight crew subjective feedback

Pilots provided their view about the impact of the new procedures on Human Performance in case the technical system degrades (e.g. loss of GNSS signal). Detailed information is provided in Appendix G.

In regard to the system degradation, pilots identified some examples of potential hazards.

Among them, there is the autopilot failure that was considered possible to handle but it would require a very demanding effort by the pilots. In addition the system degradation due to satellite position/coverage could be potentially disastrous and pilot would not be able to handle the situation.

The possible solution to those issues is redundancy of the system installed allowing pilots to get outside of the cloud with the remaining system. In addition, another mitigation to handle potential failures is represented by flying manually and training for the pilots of the new procedures in interaction with the systems.

In general, pilots stated that this new procedures are highly welcomed and need to be further improved in coordination with the helicopter manufacturer, in order to give pilots the possibility to fly with helicopters that can support them more efficiently in potential critical situation, in which the system degradation could not be easily handled by them.

Protection levels

See Figure 82 and Figure 83.

GPS/EGNOS positioning errors 95%

See Figure 84 and Figure 85.

Total System Error (TSE) cross track 95%

See Figure 86.

6.7.3.1.2 Results impacting regulation and standardisation initiatives

Not relevant results for regulation and standardization are provided.

6.7.3.1.3 Unexpected Behaviours/Results

Neither unexpected behaviour nor results has been identified.

6.7.3.1.4 Quality of Demonstration Results

See 6.1.3.1.5.

6.7.3.1.5 Significance of Demonstration Results

See 6.1.3.1.6.

6.7.4 Conclusions and recommendations

6.7.4.1 Conclusions

The results confirmed a slight positive impact in terms of several indicators used for the assessment.
A slight increase of safety is noted, compared to the VFR/VMC condition in day operations. During night time, the improvement in terms of safety is higher.
The average value of the pilots' feedback demonstrates that the new procedure permits to fly through a cloud or fog layer, when there are bad weather conditions thus improving site accessibility. However the improvement is very limited due to the high value of the LPV minima reached because of the challenging environment
The flight track for the PinS RNP APCH to LPV minimum procedure is longer compared to VFR approach; the environmental impact is not reduced but the accessibility to the airport will increase in bad weather and HEMS service availability.
Compared to VFR flights PinS RNP APCH to LPV minimum procedures are less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless, the additional efforts of PinS RNP APCH to LPV minimum procedures in costs and environmental burden pay off from both a humanitarian as well as from an economic point of view.

6.7.4.2 Recommendations

As recommendations, the following topics need to be investigated:

- Pilot training
- MTBF (Mean Time Between Failures)
- Risk-based approach
- Target level of safety of actual situation compared with new procedure.

Regular pilots training on the new procedures was identified as a solution for the safety issue identified during the exercise. The training will help pilots to get them familiar with the procedure as soon as possible.

6.8 Demonstration Exercise EXE-02.09-D-008 Report

6.8.1 Exercise Scope

The exercise EXE-02.09-D-009 consists in the execution of the new PinS departure from Chur hospital, designed by IDS in the framework of PROuD.

This exercise was not foreseen in the demonstration plan but as a PinS departure was designed and performed during the flight campaign to execute the hospital to hospital connection between Samedan and Chur (see EXE-02.09-D-003 in the demonstration plan), it was decided to include this exercise separately.

This demonstration exercise covers the concept of PinS departure at Chur hospital supported by EGNOS (not required as per the ICAO PBN Manual.) and the adoption of RNP 0.3 navigation specification.

The exercise level corresponds to the E-OCVM level V4, since the exercise encompasses live trials in operational environment.

The adoption of RNP 0.3 navigation specification in the departure phase and the design of PinS departure increase site availability in terms of IFR departures allowance, in particular during poor visibility with a reduced departure minimum cloud ceiling and minimum visibility. Moreover increased safety level of helicopter departures operations is expected in comparison with current VFR/VMC operations in terms of pilot improved situational awareness and workload reduction.

6.8.2 Conduct of Demonstration Exercise EXE-02.09-D-008

6.8.2.1 Exercise Preparation

In relation to the preparation of the exercise EXE-02.09-D-008, several activities have been performed according to the ICAO regulations and criteria. The following list summarises these activities that were previously mentioned in the D01 PROuD Demonstration Plan:

- Input data and operational requirements collection
  - No ad-hoc survey will be performed. Aeronautical data and metadata acquisition and import into the design environment: DTM/DSM, airport/heliport/hospital landing site data, obstacle data, ATS environment, other data/information
  - Definition of the operational requirements for the design of the new PinS departure procedure
- Landing site assessment and PinS departure procedure design
  - Obstacle and terrain surfaces modelling and assessment for landing site suitability verification to support IFR PinS departure procedures
  - Design of one PinS departure procedure
- Flight procedure ground validation and avionic database preparation
  - Verification of accuracy of the data used for flight procedure design
  - Verification of the correct application of ICAO PANS OPS criteria for flight procedure design
  - Full flight simulations using the Rega AW109 full flight simulator for flight procedure fly ability assessment
  - Navigation DB preparation and upload on the FMS
- On board platform adaptation:
  - Data acquisition and recording platform miniQaR and JAVAD already installed in the AW109 Helicopter.

- Coordination between hospital and operator:

  A proper coordination between all the involved stakeholders will be set up, mainly information of the hospital management and surrounding residents.

- Procedure preparation:

  - Preparation and fulfilment of an in-house Rega SAFE (safety analyses in front of engagement);
  - Preparation of timely briefing for all participants for the flight validation trial (regulator, flight crew, hospital management) invitation and flight validation execution plan;
  - Reservation and preparation of the installation of the dedicated flight inspection kit in the helicopter.

- Pilot training:

  - Training of pilots with Rega full flight simulator.

6.8.2.2 Exercise execution

The execution of the exercise has been structured in pre-flight activities, the demonstration flights performance and post-flight activities.

Below the exercise's steps are listed as they have been executed:

- Pre-flight activities:

  Preparation of timely briefing for all participants for the flight trial (hospital management, local residents, regulator, flight crew) and flight trial execution plan.

- Flight trials execution:

  A number of 8 departure flight trials have been executed;

  During the execution of the exercise, data have been collected on board Rega helicopters;

  Qualitative techniques of data collection have been also used during the trials and they included over-the-shoulder non-intrusive observations of pilots and system behaviour during the trials, together with the think aloud methodologies.

- Post Flight activities:

  Immediately after the flight, a debriefing has been held between involved stakeholders (airport authority Samedan, local ATC, local residents, regulator, flight crew).

  At the end of the exercise the following activities have been executed:

  - Extraction of flight data records from helicopter on board equipment;
  - Processing of navigation data acquired on board and elaboration of data acquired on ground;
  - Performance assessment and anomaly investigation execution.

The information gathered during the exercise served as a description of the system performance when using the PBN IFR procedures. Quantitative and qualitative measures contributed to the final assessment of the flight trials.
Regarding the navigation performance assessment it is worth mention that Rega flight inspection console, used during the flight trials, allows the recording of all the necessary performance parameters for the post processing activities.

REFERENCE SCENARIO

The reference scenario for this exercise is today's operational scenario in Chur hospital.
At Chur (ICAO code LSHC) hospital only VFR operations are currently allowed for rotary wing aircraft. No IFR departure procedure is available.

SOLUTION SCENARIO

The implementation of a PinS departure based on the RNP 0.3 navigation specification has been identified by Rega as both a necessary and an effective solution to overcome current existing limitations in terms of safety and airport capacity/accessibility.
PROuD flight trials at Chur hospital will be conducted in VFR/VMC conditions during the flight trials.
The flight inspection performed for departure procedure are reported in Table 14

6.8.2.3 Deviation from the planned activities

Additional exercise: this exercise was not foreseen in the Demonstration Plan but as PinS departure procedure was designed and performed during the Flight Campaign to execute the heliport to hospital connection between Samedan and Chur (see EXE-02.09-D-003 in the Demonstration Plan), it was decided to include this exercise separately.

A total of 8 flight trials were performed to evaluate the benefits of introduction of a PinS departure procedure from Chur hospital.

6.8.3 Exercise Results

6.8.3.1 Summary of Exercise Results

6.8.3.1.1 Results per KPA

The following sections summarise the results collected during the flight trials for this exercise at Chur hospital.
In regard to this exercise a number of KPAs have been selected and measured using several key performance indicators, whose value can give an idea of the impact that the implementation of the new procedures can produce for each KPAs in the current operations.

6.8.3.1.1.1 Safety

For the evaluation of the safety the following Key Performance Indicators (KPIs) have been selected:

- Flight crew subjective feedback on Safety;
- Flight crew workload;
- Flight crew situational awareness;
- Flight track adherence

Flight crew subjective feedback

Pilots provided their view about the impact of the new procedures on Safety, comparing them with the procedures they are currently using (VFR procedures). The high level results are provided in the following graph, while more detailed information is provided in Appendix G.

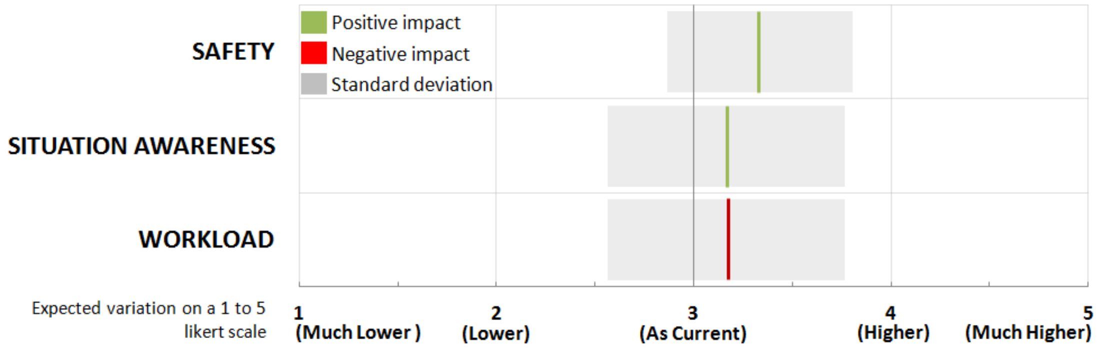


Figure 87: Questionnaires results for EXE-02.09-D-008 (Departure Chur).
Flight Trials Pilots' expected impact of the new procedures on Safety, Situation Awareness and Workload, compared with the current ones (answers' average).

The value for safety is 3,33/5, meaning that a slight improvement is expected by pilots for the selected indicators.

Flight crew workload

The average value of the workload is 3,17/5 (see Figure 87) and pilots considered the workload level acceptable and were satisfied about how the procedures worked. They highlighted that if weather is at the VFR Minima, the procedures will help them to follow standard procedures coupled to the autopilot.

Flight crew situational awareness

Concerning situation awareness, the average value collected for this KPI is 3,17/5 (see Figure 87), and according to pilots the implementation of IFR procedures will require much awareness that current VFR operations for the Chur area where it is actually not allowed to fly IFR. According to the pilots the slight increment of the SA with respect to current operations is due to the self-navigation and self-altitude navigation. However, a possible solution to increment the situation awareness can be the introduction of specific training for the pilots.

Flight track adherence

In the following figure the statistics of TSE are reported. In this case the TSE values are much higher than all the other Swiss performance results. This is due to the fact that the processing activities for the quantification of FTE and TSE error components have not been performed using the updated flight inspection RF leg functionalities as done for all the other acquired data within the Swiss flight campaign.

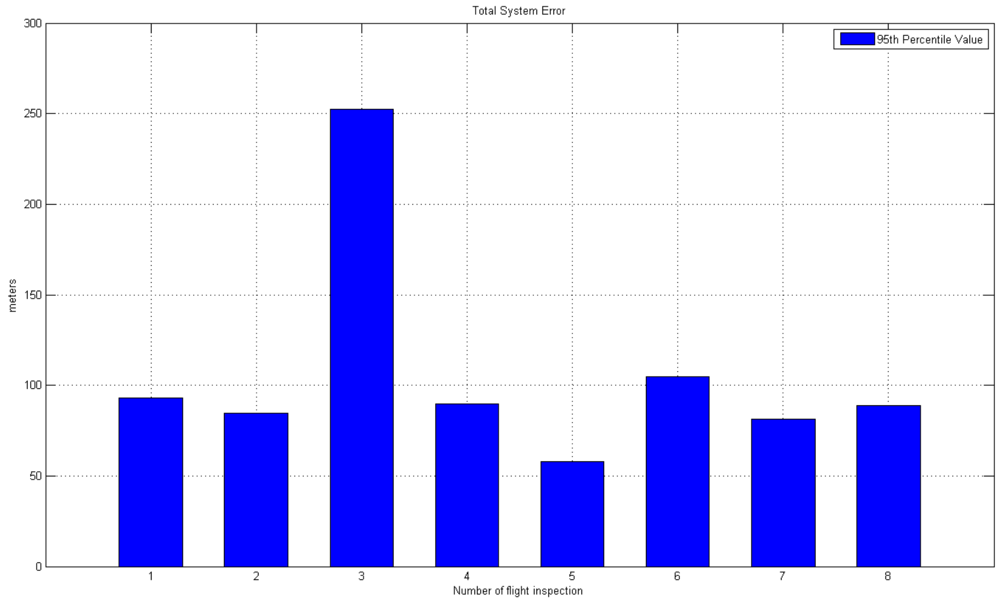


Figure 88: TSE cross track error (95th percentile value) for each flight trial from UR201 to UR204

The higher value of the 95th percentile TSE cross track error related to the departure flight n.3 is due to manual pilot intervention along the procedure (see [7] for details).

6.8.3.1.1.2 Availability

For the evaluation of the site availability using the new approach procedures, the following indicator has been selected:

- Flight crew subjective feedback

Flight Crew Subjective feedback

The average value collected by the subjective feedback of the pilots shows an increment of the availability of the departing side about 23% (see Figure 25).

When there are critical weather phenomena (like ice, ceiling and/or fog), HEMS operations in VFR are not allowed and this implicates that several search and rescue missions are cancelled. Thanks to the implementation of the new IFR procedures, pilots will be able to fly during adverse weather conditions, as ceiling, mantle of fog, low visibility, all situations that actually limit their operability.

6.8.3.1.1.3 Environmental Sustainability

The flight track for the PinS departure is longer compared to VFR departure. The environmental impact is not necessarily reduced but the airport availability will increase in bad weather.

6.8.3.1.1.4 Efficiency

For the evaluation of the efficiency, the flight crew subjective feedback indicator has been selected.

The measure value that pilots gave to the efficiency of the new procedures is -20% (see 4.1.3.4 and Appendix G). The reason behind those answers is that for this exercise, as for the previous ones, the only issues identified that motivates the negative value is the increment of the duration of the departure procedure, with respect to the current last of the flight performed in VFR.

Despite the increase of flight time, the new PinS departure could allow pilots to fly IFR in bad weather conditions, giving the pilots the possibility to offer a better Search and Rescue service, increasing the number of saved lives.

6.8.3.1.1.5 HP (Operating methods)

The impact of the new procedures on the operating methods has been measured using the flight crew subjective feedback as KPI.

The average value collected from the answers to the questionnaires is 2,83/5; this value demonstrates that the changes related to this KPA are considered feasible by the pilots.

For this exercise the same explanation was given by pilots as for the previous one, that means that also in this case the passage from VFR to IFR modality will have an impact on the current operating methods but an acceptable level of feasibility has been achieved with the new procedures. Pilots added that an even higher level of consistency and acceptability could be reached with little changes of some technical aspects.

To support pilots in the use of new procedures it has been highlighted the need to have regular training on the new procedures, to get pilots familiar with the procedure as soon as possible.

6.8.3.1.1.6 HP (Pilots' task performance)

For the evaluation of the impact on Pilots' task performance impact, the following indicators (KPI) have been selected:

- Flight crew subjective feedback;
- Flight crew workload;
- Flight crew situation awareness;
- Error propensity.

<u>Flight crew subjective feedback</u>

The values that pilots gave to the error propensity, workload and situation awareness are the same as for the approach exercise at Chur hospital. The same hazards were identified.

<u>Flight crew workload</u>

See 6.1.3.1.1.6.

<u>Flight crew situation awareness</u>

See 6.1.3.1.1.6.

<u>Error propensity</u>

See 6.1.3.1.1.6.

6.8.3.1.1.7 HP (Performance of the technical system)

The following KPIs have been selected to evaluate the performance of the technical system :

- Flight crew subjective feedback;
- Navigation System Error (NSE);
- Total System Error (TSE) cross track.

<u>Flight crew subjective feedback</u>

In regard to the system degradation, pilots identified the same potential system failures as for the exercise of the RNP APCH at Chur hospital. These hazards are a possible autopilot failure that was considered easily to handle but it would require a very demanding effort by the pilots. In addition, another failure identified is any system degradation due to satellite position/coverage.

The possible solution reported by pilots is redundancy of the system installed that could allow pilot to react in time to get outside of the cloud with the remaining system. Another mitigation that will allow them to handle potential failures is represented by flying manually and by the training for the pilots of the new procedures in interaction with the systems.

Navigation System Error (NSE)

In the following picture the statistics for the absolute NSE error component.

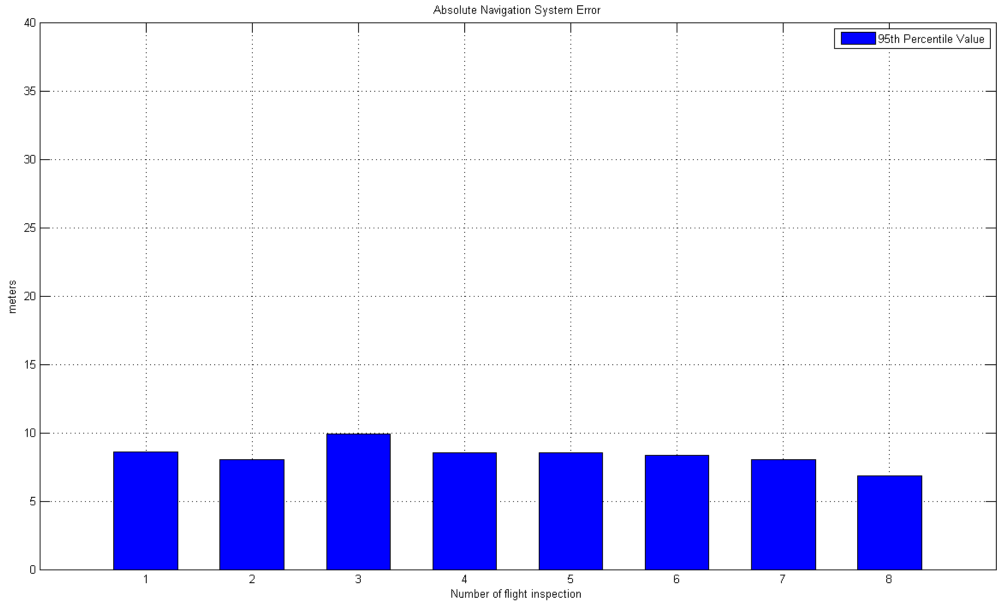


Figure 89: Absolute NSE (95th percentile value) for each flight trial from UR201 to UR205

Total System Error (TSE) cross track

See Figure 88.

6.8.3.1.2 Results impacting regulation and standardisation initiatives

Not relevant results for regulation and standardization are provided.

6.8.3.1.3 Unexpected Behaviours/Results

Neither unexpected behaviour nor results has been identified.

6.8.3.1.4 Quality of Demonstration Results

See 6.1.3.1.5.

6.8.3.1.5 Significance of Demonstration Results

See 6.1.3.1.6.

6.8.4 Conclusions and recommendations

6.8.4.1 Conclusions

In regard to this last exercise, the results demonstrate that despite the slight changes in the operating methods that have been foreseen by pilots, together with a slight decrement of the efficiency, the new procedure is considered a benefit for their current and future operations.

Mitigations means have been identified to handle potential hazardous situations that the new procedures could lead to.

An improvement of the new procedure in terms of safety has been experimented.

The average value of the pilots' feedback demonstrates that the new procedure will extend the site availability for departure operations also in bad weather conditions.

The flight track for the PinS departure is longer than VFR one; the environmental impact is not reduced, but the availability of the airport will increase in bad weather and HEMS service availability is improved.

Compared to VFR flights PinS departure procedure is less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless, the additional efforts of RNP AR APCH procedures in costs and environmental burden pay off from both a humanitarian as well as from an economic point of view.

6.8.4.2 Recommendations

As recommendations, the following topics need to be investigated:

- Pilot training
- MTBF (Mean Time Between Failures)
- Risk-based approach
- Target level of safety of actual situation compared with new procedure.

Regular pilots training on the new procedures was identified as a solution for the safety issue identified during the exercise. The training will help pilots to get them familiar with the procedure as soon as possible.

7 Summary of the Communication Activities

The PROuD Consortium has carried out communication and dissemination activities during the entire duration of the project.

The objective was to ensure timely and effective dissemination of the outcomes of the project to SESAR JU, the SESAR community, the EASA and Regulators community, as well as the interested general public and the Industrial and Scientific communities.

The communication and dissemination actions have been performed fully in line with SESAR JU recommendations and available guidelines. In particular any report, brochure or other documentation connected with the activities performed, mentions the SESAR JU co-financing as well as the "Powered by SESAR" logo, in order to:

- show the commitment and participation in the SESAR Programme and the belonging of PROuD Project to the frame of SESAR Joint Undertaking initiatives;
- give the important message to the European public that SESAR actively plays a fundamental and proactive role in supporting operational implementation of advanced rotorcraft satellite based procedures.

The project used also, when possible, the dissemination activities undertaken by SESAR JU to create a wider project impact.

7.1 Objectives and target audience

The objective of the PROuD communication activities were the following one:

- **Raising awareness:** create and increase awareness, both internally and externally to the project (conceptual use);
- **Generating understanding:** transfer specific messages to the target audience (instrumental use);
- **Engage:** promote interaction and participation among the target audience, showing the relevance of the project to their own practices and collecting feedback and comments (instrumental use);
- **Ensure impact:** Getting key messages to key decision makers so that project's developed methods, tools and good practices have an impact on policies or practices (strategic use).

These objectives have been communicated employing different kind of media used (e.g. website, brochure, press release) according to the type of message to be sent and to the various stakeholders to get through.

7.1.1 Objectives related to SESAR communication

PROuD consortium also took into consideration the broader SESAR high level communication objectives for the 2015 – 2020 timeframe:

1. To create awareness and outreach about SESAR and its demonstration projects;
2. To showcase the extensive benefits that SESAR solutions can bring to real day-to-day Air Traffic Management (ATM) operations;
3. To accelerate the operational acceptance and subsequent deployment of SESAR solutions.
4. Enhance the SESAR partnership spirit through internal communications activities.

7.1.2 Target audience

The following categories of stakeholders have been considered as target audience for the communication activities:

- **Interested general public;**
- **General EU and National decision markers:**
  - National Aviation Authorities (e.g. CAA, FOCA, DGAC, ENAC);
  - Air Navigation Service Providers (ANSP);
  - Regulation Authorities (e.g. EASA);
  - National and international bodies (e.g. ICAO, FAA);
- **Specialists ATM/Aviation related community:**
  - **Users and associations:**
    - Rotorcraft operators;
    - Rotorcraft associations;
    - Airport authorities;
  - **Scientific and industrial communities.**
- **SESAR JU and its members:**
  - SESAR related LSDs Project Managers;
  - SESAR OFA Coordinators of projects contributing to:
    - OFA 02.01.01 Optimised 2D/3D Routes;
    - ENB 01.01.04 Navigation;
  - Relevant SESAR Projects in WP4, WP5 and WP10;
  - Transversal Projects, relevant for human performances and safety assessment, e.g. WP16 L3.
- **Consortium:**
  - Consortium Members (IDS, SKYGUIDE, REGA, NORSK LUFTAMBULANSE, DEEP BLUE) personnel;
  - EHA – European Helicopter Association;
  - EHAC – European HEMS & Air Ambulance Committee.

For each stakeholder different communication objectives and communication means have been identified as reported in the D01 – Demonstration Plan. An overview is reported in the following table.

Stakeholder	Internal/ External	Objectives	Communication means
Consortium	Internal	Generating understanding Engage	Project website Meetings
Users and associations	Internal and external	Raising awareness Engage	Project website Conferences and meetings Brochure Press release

Stakeholder	Internal/ External	Objectives	Communication means
Decision makers	Internal and external	Generating understanding Engage Ensure impact	Project website Conferences and meetings
Interested general public	External	Raising awareness	Project website Brochure Press release
Scientific and industrial communities	External	Generating understanding Engage	Project website Conferences and meetings Scientific journals
SJU	External	Raising awareness Generating understanding	Project website Conferences and meetings Workshop

Table 30: List of stakeholders categories and related communication activities

7.2 Communication activities

The dissemination process followed by PROuD led to the development and creation of different kinds of communication activities, which are reported in the following paragraphs.

7.2.1 Products

The Communication products that have been produced in order to cover all communication channels are listed below:

- Press;
- Online and media channels;
- Events.

The communication materials produced is reported as following:

- Project logo (see Appendix D.7.3);
- Web site to promote the trial & demonstration activities and link the SJU website (the selected domain is: http://www.proud-project.eu/), see D.3;
- Selected social network accounts (twitter: https://twitter.com/PROuD_Project , Linkedin: http://it.linkedin.com/pub/proud-project/b2/147/a10), see Appendix D.4;
- **Press Kit** with information about the PROuD project and SESAR, PROuD templates for presentations, photos/images, the **project brochure** and a **leaflet** for the World ATM Congress, presenting PROuD objectives and activities, and a **poster** (see Press kit in D.7).

7.2.2 Scientific dissemination

Papers and articles for scientific journals/conferences in relevant disciplines have not been produced yet. They would be produced when final results are accepted and consolidated.

7.2.3 Events

PROuD representatives participated in relevant public events, such as conferences, air shows and meetings.

Hereafter a table with all the communication activities PROuD representatives participated in during the two-years of project:

Activity	When	Responsible	Where	Milestone associated	Ref.
Kick Off Meeting	06 Oct 2014	IDS	-	Yes	
F2F Meeting with SESAR JU	04 Nov 2014	IDS	Brussels	Yes	
Kick Off Meeting press release	20 Nov 2014	Deep Blue	-	-	D.1
Logo and branding	28 Nov 2014	Deep Blue	-	-	D.2
Official PROuD press kit	28 Nov 2014	Deep Blue	-	-	D.7
Brochure	30 Dec 2014	Deep Blue	-	-	D.7.4
Article on PROuD launch and objectives to relevant websites/magazines	Jan 2015	Deep Blue	-	-	
Website	30 Jan 2015	Deep Blue	-	Yes	
Critical Review Meeting #1	02 Mar 2015	IDS	Brussels	Yes	
EHAC Symposium 2015	28-29 Apr 2015	IDS	Brno	-	
Press release about Norwegian demo flights announcement – website publication	03 June 2015	Deep Blue	-	-	
Norwegian demo flights report - project website and twitter publication	9-12 June 2015	Deep Blue	-	-	
Norwegian TV news about Norwegian flight campaigns – project website	9-12 June 2015	NLA	-	-	
SESARJU News on project demonstration flights	12 June 2015	SJU	-	-	
Swiss demo flights announcement - project website and twitter publication	17-24 July 2015	Deep Blue	-	-	
Swiss demo flights news on: • Radio • Online • Print • TV	17-24 July 2015	REGA	-	-	
Helitech International 2015	6-8 Oct 2015	-	London	-	
Project poster presentation at SESAR Innovation Days (SIDs)	1-2 Dec 2015	Deep Blue	-	-	
WORLD ATM CONGRESS 2016	8-10 Mar 2016	IDS Deep Blue	Madrid	-	
PROuD Leaflet at World ATM Congress 2016	8-10 Mar 2016	IDS Deep Blue	Madrid		

Activity	When	Responsible	Where	Milestone associated	Ref.
PROuD Final Communication Event	30 Sep 2016	Deep Blue	Rome	Yes	
Article on PROuD results to relevant websites/magazines	Oct 2016	Deep Blue	-	-	
Article/paper on Project results to one relevant conference	Oct 2016	Deep Blue	-	Yes	
Press release about project conclusion and results	Oct 2016	Deep Blue	-	-	
Helitech International 2016	11-13 Oct 2016	-	Amsterdam	-	

Table 31: PROuD communication activities overview

8 Next Steps

In Switzerland, the PROuD flight procedures will be modified and improved based on the findings of the trial campaigns. For some procedures, a further technical and flight operational analysis will be required prior to an actual implementation. The PROuD procedures are also expected to play an important role in Rega's pursuit of operational approvals for RNP 0.3 and RNP AR APCH procedures.

The Norwegian CAA has already approved the approach procedures with LNAV and LPV minima for operational use by Norsk Luftambulanse. The PinS departure procedure was also validated and approved. NLA has received a temporary approval based on the PinS departure criteria together with some other company approval based on the ICAO Doc 8168 Volume II.

8.1 Conclusions

Several types of procedures (PinS RNP APCH to LPV minima, helicopter RNP AR APCH procedures, PinS departure procedures, Low Level IFR Route) and phases of flight have been assessed within the PROuD project, aiming at demonstrating the real operational and safety benefits for HEMS operators.

For both Swiss and Norwegian scenarios most of the key performance areas (safety, site accessibility/availability, HEMS service availability, predictability, human performance in terms of operating methods, pilots' task performance, performance of the technical system) have been positively impacted by the introduction of the new PBN operations.

In general, a medium/slight increase of safety is noted, compared to the VFR/VMC condition in day operations. Significant safety improvements are expected in marginal weather situations and during night operations.
The average value of the pilots' feedback and meteorological data analysis (for Norwegian Lørenskog heliport only) demonstrates that the new procedures will permit to fly through a cloud or fog layer, when there are bad weather conditions thus improving site accessibility, (reducing diversions and missed approaches) and site availability for departure operations also in bad weather conditions.

No improvements in comparison with current operations have been identified mainly in terms of environmental sustainability, while benefits in efficiency have been identified in marginal VMC conditions. Compared to VFR flights, new procedures are less efficient in terms of flight time, limited to VMC conditions, with regard to the aviation view. Nevertheless these new procedures are often the only solution to permit life-saving flights in IMC as they ensure the access to hospitals and airports/heliports in emergencies /catastrophic situations. In the light of higher costs as a result of a significantly worse medical result due to a significant delay in the patient´s definitive treatment, the additional efforts of new procedures in costs and environmental burden pay off from both a humanitarian as well as from an economic point of view.

The following section gives a summary of the conclusions raised by the synthesis of the different demonstration exercises analysis, particularly on the restrictions of current design procedures and operations:

- LPV procedures are simple, effective and easy to fly. However difficulties and restrictions in both design and use of EGNOS signal restricts operators to use them operationally in Norway and Denmark.
- PinS departure procedures with RNP0.3 are useful for safer operation and also to accommodate IFR departures in terrain that was not previously possible. In combination with RF-legs it is even better.
- PinS procedures are frequently located outside airports and hence there is a need for operators to monitor the obstacle situation closely. Some countries are very restrictive when constructors or others raise new or temporary high obstacles. Therefore, the operators must have a system to monitor, report and change the procedures accordingly. Design criteria are deemed too conservative when it comes to LPV to PinS minima. Especially two concerns are penalizing and may favour the implementation of LNAV or LP minima over LPV. These are:
    - Add on to OCA due to transition from instrument flying to visual manoeuvring. It should ensure that the descent is stopped at the PinS when entering the visual

segment. However, this add-on is already under discussion at the IFPP Helicopter WG and is envisaged to be removed for *Proceed VFR* and, if there is no descent point established, *Proceed Visually/Direct-VS* procedures.

  - The LPV PinS are located outside airports and the Y-surface of the LPV OAS is often penetrated and restrictive to the minimums. The Y-surface is an ILS heritage where the hazard to loosing track guidance in the missed approach was taken into consideration. On an LPV missed approach where track guidance is available for most of the systems in use there should be an opening for disregarding the Y-surface. The review of the relevant avionic standards and the potential update of the LPV design criteria is already on the agenda of the IFPP.

- Use of EGNOS-based LPV procedures are useful and contribute to safety with the vertical guidance. The design however is conservative and changes should be made to make them more effective in challenging terrain such as the RNP AR procedures are. Now there is no chance the EGNOS procedure will survive when manufacturers come up with a position sensor that can support a loss of GPS signal.

- Interpretation of the conditions for visual segment in a PinS procedure in ICAO Doc 8168 Volume II part 4 is somehow restrictive and at night, this makes the procedures less useful.

- EASA CAT.OP.MPA.305 states requirements for weather reporting before commencing an approach procedure. There is a gap in regulation that describes the specification and operability of such equipment or procedure.

Today, the RNP AR design criteria as stipulated in the current first edition of ICAO Doc 9905 RNP AR Manual only cover aircraft categories A to E, i.e. fixed wing aircraft. The Helicopter Working Group of the ICAO IFP Panel is already proposing a Corrigendum which will add the general statement that rotorcraft may be used to fly category A RNP AR procedures, if the helicopter and crew are accordingly certified and meet the AR requirements. However, in particular the procedure design activities in the Samedan scenario have shown that this may not always be sufficient. In order to enable the provision of IFR procedures with operationally beneficial approach minima or climb performance requirements in even the most demanding terrain environments, the option to design the following types of procedures would be of interest:

- Adoption of CAT H specific procedure design parameters such as speeds, climb/descent gradients and height loss to Doc 9905 RNP AR Manual.

- Extension of the scope of the RNP AR navigation specification to encompass the departure phase of flight and the development of the respective procedure design criteria.

- Extension of the Point-in-Space concept to encompass "PinS RNP AR" approach and departure procedures and the development of the respective procedure design criteria.

The outcomes of PROuD project can provide an input to the projects/solutions that will focus on rotorcraft advanced operations in the context of SESAR 2020 and/or in future R&D activities.

8.2 Recommendations

This section gives a summary of the recommendations for future activities:

- The PANS-OPS stipulated minimum distance required for positioning the IDF on a PinS departure with a direct visual segment is 0.8 NM, which corresponds to the along track tolerance (ATT) of the navigation specifications RNAV 1 and RNP 1. The minimum length requirement for a departure based on RNP 0.3 is currently under discussion at the IFPP Helicopter WG. Full IFR departure procedures from heliports are not expected to be possible in the near future due to lack of interest by the industry and issues related to the ICAO Annex 14 Volume II Obstacle Limitation Surfaces.

- According to PBN Manual 9613 Volume II Part C Ch. 5, LPV procedures require customized training. This includes both extensive theoretical knowledge and practical skills. A training program must be included into the operation. ICAO, EUROCONTROL and national service provider AVINOR offers this as online courses. However they are not specific to helicopter operations and PinS procedures. The operator must add some special training to comply with specially the visual segment calculations and obstacle situation and also the procedure and design regarding PinS departure procedures.

- Flight training is also required and since no operator of type specific simulators support LPV procedures this must be done in the real helicopter and hence it is an expensive training with exception AW109SP full flight simulator.
- Today's PANS-OPS design criteria already allow the application of RNP 0.3 in all phases of flight, however, more guidance is required for the designers to support the correct application of the criteria at the joining of different flight segments. This is already under discussion at the IFPP Helicopter WG.
- LPV and LNAV minima must be published in parallel since a lot of helicopters will not have the LPV capability for years. This is the normal practice but for an inexperienced operator ordering a RNP APCH procedure, this is emphasized because the designer needs to make two different calculations for the two.
- Existing IFR and VFR regulations have to be reviewed and amended where necessary to avoid contradictions with any safety-enhancing IFR procedures. Most prominent is a so-called “approach ban” caused by VFR weather minima which are not applicable or useful for satellite-based IFR procedures. Nevertheless, such regulation would e.g. prohibit helicopters from approaching landing sites of hospitals in remote areas. To solve this, clear, pragmatic and safe instructions are necessary:
    - Criteria for Approach and Departure IFR transitions
    - Under which weather conditions pilots may begin instrument procedure (approach and departures), especially locations without weather reporting
    - Use of synthetic vision systems to compensate deficiencies for human eyes due to weather phenomena.
    - Definitions of the MDA or DA/DH.
- In addition certification specifications (CS) for RNP0.3 and even RNP0.1 have to be set up to enable IFR PBN operation under the recommended minimum of RNP0.3 on helicopters de facto certified for RNP0.3 (or even RNP0.1).
- Since ATC is not everywhere at any time available, criteria have to be defined and procedures established under which conditions precisely defined low flight network systems or parts of such systems may be used for specialised operations, like HEMS, with without regular ATC support.
- EASA/ ICAO should reconsider the “Proceed VFR”- conditions and requirements stated in part 4 of the doc 8168 Volume II. If a procedure does not meet the requirements for proceed visually the suggestion is to increase visibility and ceiling values (e.g. instead of “proceed VFR”). Moreover it should be considered the possibility of a “night-time Minima”, which should be the actual minima with an add-on of a fixed value (e.g. + 1000 meters/+100ft). This is to make operators still being able to use the procedures at night without jeopardizing safety and still keep up operations.
- EASA CAT.OP.MPA.300 and CAT.OP.MPA.305 state the requirements for weather reporting before commencing an approach procedure. There should be some statement of the required equipment and quality of such reports. Many of the RNP PinS APCH procedures are to destinations without established weather observations. Therefore it is suggested to include specifications about helicopter air ambulance operations at airports and locations with an instrument approach procedure and at which a weather report is not available.

9 References

9.1 Applicable Documents

The documents mentioned in the template are examples that can be removed

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

[2] SESAR LSD.02.09 PROuD, D01 – PROuD Demonstration Plan 00.02.00, 24/03/2015

[3] FCS, SAMEDAN LSZS_COPTER RNAV 011_GNSS_Helicopter_Flight Inspection_150722_S_Reprocessed_V6

[4] FCS, Flight Inspection Report Helicopter Procedure - SAMEDAN LSZS RNAV (RNP) RWY 03 HELICOPTER CAT H, Date of Flight: 21.04.2016

[5] FCS, Flight Inspection Report Helicopter Procedure, SAMEDAN LSZS RNAV (RNP) RWY 21 HELICOPTER CAT H, Date of Flight: 21.04.2016

[6] FCS, Flight Inspection Report Helicopter Procedure - COPTER RNAV (GNSS) Low Flight Network (LFN) Chur – Samedan, Date of Flight: 20. - 22.07.2015

[7] FCS, Flight Inspection Report Helicopter Procedure - COPTER RNAV (GNSS) Kantonsspital Chur (LSKC), Date of Flight: 20. - 22.07.2015

[8] REGA, Instrument Flight Procedure Validation Report - COPTER RNAV (RNP) RWY 03 to RNP 0,1 minimums at Samedan Aerodrome LSZS – Switzerland, 22.04.2016

[9] REGA, Instrument Flight Procedure Validation Report - COPTER RNAV (RNP) RWY 21 to RNP 0,1 minimums at Samedan Aerodrome LSZS – Switzerland, 22.04.2016

[10] ACAMS Airport Tower Solution, VALIDATION REPORT, PROCEDURE: LØRENSKOG PINS LPV HELOCOPTER, June 2015

[11] ACAMS Airport Tower Solution, VALIDATION REPORT, PROCEDURE: LØRENSKOG PINS DEP HELOCOPTER, June 2015

[12] ACAMS Airport Tower Solution, VALIDATION REPORT, PROCEDURE: ULLEVÅL PINS LPV HELOCOPTER, June 2015

[13] Norwegian CAA, “NORK LUFTAMBULANSE AS – Godkjenning av LPV instrument prosedyrer” – approval letter for PROuD LPV procedures, 02/07/2015

[14] UNI EN ISO 9001:2008 – Quality Management System Requirements

9.2 Reference Documents

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

[1] ATM Master Plan
https://www.atmmasterplan.eu

[2] Operational Focus Area, Programme Guidance, Edition 03.00.00, May 2012

[3] OFA 02 01 01 Optimised 2D 3D Routes Description, 00.01.00, August 2014

[4] SJU Communication Guidelines for Demonstration Projects, Edition 00.02.00

[5] ICAO Doc. 9613, Performance-based Navigation (PBN) Manual, Fourth Edition – 2013

[6] ICAO Doc 8168, OPS/611, Volume I, Amendment No. 6, Fifth Edition – 2006

[7] ICAO Doc 8168, OPS/611, Volume II, Sixth Edition – 2014

[8] RTCA DO-236C, Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation, 2013

[9] RTCA DO-229C, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment, 2001

[10] AMC 20-26 Airworthiness Approval and Operational Criteria for RNP Authorisation Required (RNP AR) Operations, 23/12/2009

[11] AMC 20-28 Airworthiness Approval and Operational Criteria related to Area Navigation for Global Navigation Satellite System approach operation to Localiser Performance with Vertical guidance minima using Satellite Based Augmentation System, 24/09/2012

[12] ICAO Doc 9905, Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual, First Edition – 2009

[13] ICAO Doc 9906, Quality Assurance Manual for Flight Procedure Design, Volume 5 Validation of Instrument Flight Procedures, First Edition – 2012

[14] ICAO Doc 8071, Manual on Testing of Radio Navigation Aids, Volume II Testing of Satellite-based Radio Navigation Systems, Fifth Edition – 2007

[15] EUROCONTROL Air Navigation System Safety Assessment Methodology, https://www.eurocontrol.int/articles/safety-assessment-methodology-sam

[16] AW109SP Rotorcraft Flight Manual

[17] Rega Operation Manual

[18] ICAO Annex 4 Aeronautical Charts

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[21] ICAO Annex 15 – Aeronautical Information Services

[22] EUROCONTROL E-OCVM, Version 3.0, 2010

[23] COMMISSION REGULATION (EU) No 965/2012 of 5 October 2012

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[27] SESAR Air Transport Framework, The Performance Target, D2, 2006

[28] SESAR Definition Phase, The ATM Target Concept, D3, 2007

[29] Commission Regulation (EC) No 2096/2005 - Common Requirements for the Provision of Air Navigation Services (http://skybrary.aero/bookshelf/books/1475.pdf)

[30] Commission Regulation (EU) No 1035/2011 - Common Requirements for the Provision of Air Navigation Services (http://skybrary.aero/bookshelf/books/1721.pdf)

[31] EASA opinion 03-2014, Requirements for service providers and the oversight thereof (https://www.easa.europa.eu/system/files/dfu/EN%20to%20EASA%20Opinion%2003-2014.pdf)

[32] EUROCONTROL SAFETY REGULATORY REQUIREMENT (ESARR) 4: RISK ASSESSMENT AND MITIGATION IN ATM (http://www.skybrary.aero/bookshelf/books/512.pdf)

Appendix A KPA Results

An overview of KPAs results addressed in the PROuD exercises are reported in 5.3.1 and detailed KPAs results for each exercise are shown in the paragraph 6.X.3.1.1 (X=1 for EXE-02.09-D-001, X=2 for EXE-02.09-D-002, X=3 for EXE-02.09-D-003, X=4 for EXE-02.09-D-004, X=5 for EXE-02.09-D-005, X=6 for EXE-02.09-D-006, X=7 for EXE-02.09-D-007, X=8 for EXE-02.09-D-008).

Local Safety Assessment results performed in the PROuD project are reported in “Swiss Local Safety Assessment” appendix (Appendix E) and in “Norwegian Local Safety Assessment” appendix (Appendix F).

Appendix B Demonstration Scenarios

B.1 Swiss scenarios

In PROuD, three different scenarios have been considered for the Swiss flight campaign:

- **Scenario 01 (SCN-0209-001)**: Samedan airport (LSZS) area (15-20 NM surrounding the airport)
- **Scenario 02 (SCN-0209-002)**: Switzerland area for simulated IFR heliport-to-hospital connection between Samedan and Chur
- **Scenario 05 (SCN-0209-005):** Chur hospital (LSHC) area (15-20 NM surrounding the heliport)

The scenarios have been presented in the Demonstration plan, except for Scenario 06, added when the opportunity to design procedures also for Chur site arose. The following table briefly summarises the scenarios.

Identifier	SCN-0209-001
Scenario	This scenario refers to the Samedan airport and the surrounding area of 15-20 NM. The affected airspaces are Airspace E (2000 ft AGL – FL 100, visibility: 5 km, distance to clouds: Vertical 1‘000 ft, Horizontal 1‘500 M; FL100 to FL130 if MIL ON or FL150 if MIL OFF, visibility: 8 km) and Airspace G (GND – 2‘000 ft GND, visibility: 5 km clear of clouds and with surface in sight, flight visibilities reduced to not less than 1500m is permitted for flights operating at a speed of 140kts IAS or less to give adequate opportunity to observe other traffic or any obstacle in time to avoid air proxies and/or collisions. Helicopters are permitted to operate in less than 1500m, but not less than 800m, flight visibility, if manoeuvred at a speed that will give adequate opportunity to observe other traffic or any obstacles in time to avoid collisions. Flight visibilities lower than 800m are permitted for special cases, such as medical flights, search and rescue operations and fire-fighting. The VMC Conditions in Airspace G in Switzerland are agreed deviations from the EU Rules of the Air. Samedan airport has no light system and it is not approved for night operations, except for HEMS. The performed flight trials in this area focused on the execution of PinS “non-standard” departure and RNP AR approach procedures.

Identifier	SCN-0209-002
Scenario	This scenario refers to the heliport to heliport scenario between Samedan airport and Chur hospital. The low level route (RNP0.3) connection, which needs to be established between the two sites, was selected by Rega. The flight trials that were performed in this area focused on the execution of complete IFR connection including the execution of the PinS departure and approach procedures as well as Low Level IFR Route connections. The trials were executed under VFR/VMC condition only.

Identifier	SCN-0209-005
Scenario	This scenario refers to the Chur hospital area and the surrounding area of 15-20 NM. The affected airspaces are Airspace E (2000 ft AGL – FL 100, visibility: 5 km, distance to clouds: Vertical 1‘000 ft, Horizontal 1‘500 M; FL100 to FL130 if MIL ON or FL150 if MIL OFF, visibility: 8 km) and Airspace G (GND – 2‘000 ft GND, visibility: 5 km clear of clouds and with surface in sight, flight visibilities reduced to not less than 1500m is permitted for flights operating at a speed of 140kts IAS or less to give adequate opportunity to observe other traffic or any obstacle in time to avoid air proxies and/or collisions. Helicopters are permitted to operate in less than 1500m, but not less than 800m, flight visibility, if manoeuvred at a speed that will give adequate opportunity to observe other traffic or any obstacles in time to avoid collisions. Flight visibilities lower than 800m are permitted for special cases, such as medical flights, search and rescue operations and fire-fighting. The VMC Conditions in Airspace G in Switzerland are agreed deviations from the EU Rules of the Air. The flight trials that were performed in this area focused on the execution of PinS departure and approach procedures.

Table 32: Swiss scenarios

PROuD flight trials have been performed in VFR/VMC conditions during both the flight inspection and validation phase as well as during the demonstration phase as procedures are not expected to be published within the project lifetime. Moreover, according to existing Swiss Regulation, IFR operations are currently not allowed within Class G airspace.

B.1.1 Samedan airport (SCN-0209-001)

The reference scenario for this exercise is today’s operational scenario in Engadin/Samedan airport. To ease reading it will be named hereinafter in the document as “Samedan” only.

At Samedan (ICAO code LSZS) airport only VFR operations are currently allowed for both fixed wing and rotary wing aircraft.

No IFR approach procedure is available, IMC approaches are prohibited.

Samedan airport is situated in the Engadine valley and is surrounded by a mountainous region, wherein the flight procedures are very strongly affected by natural obstacles and aircraft performance is heavily impacted by high density altitudes. This is particularly true for VFR flights. This Swiss airport is the highest elevated airport in Europe (elevation 5.600ft AMSL) and it represents one of the Rega bases.

The reason behind the choice of this scenario is that the implementation of a PinS RNP APCH approach with LPV minima has been identified by Rega as both a necessary and an effective solution to overcome the currently existing limitations in terms of safety and airport capacity/accessibility.

Figure 90: Samedan airport overview: direction north-east (picture is provided by the Samedan Airport Authority)

Figure 91: Samedan airport overview: direction south-west (picture is provided by the Samedan Airport Authority)

The following characteristics are relevant for the reference scenario:

- Samedan has a FIZ (Flight Information Zone)
- Airport opening hours in summer: 0600Z to 1700Z.
- FIS (Flight Information Service) is available: 0600Z to 1700Z.
- Airport opening hours in winter: 0700Z to SS+30min
- FIS (Flight Information Service) is available: 0700Z to SS+30min
- NO NIGHT OPERATIONS (Except HEMS and HEMS training flights with PPR of the airport Manager)
- Runway 03/21

Samedan airport current operations:

- Hours of operations: open all year round, summer: 8am to 7pm, winter: 8am to dusk;
- Runway: length 1800 m, width 40m, height above sea level 1707m (5606 ft);
- Flights: total approx. 16.000 per year, of which approx. 40% piston engines, 38% helicopters, 15% jets and 7% turboprops;
- Largest aircrafts that can land at Samedan airport: Boing 737 BBJ, gulfstream G4/G5/G550, Airbus A319, Bombardier Global Express, DASH-8Q 400 (72 seats).

The airspace surrounding the airport is Class G and Class E.

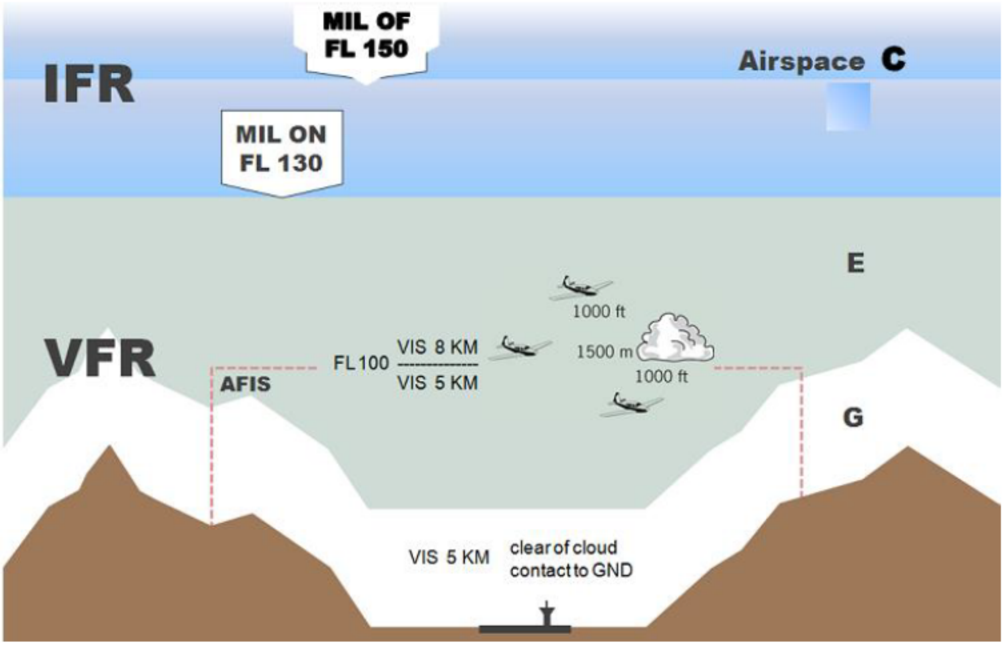

Figure 92: Swiss airspace classification (picture provided by the Samedan Airport Authority)

Weather minima

The weather minima for VFR operations are reported in the following table:

Weather minima for VFR traffic		
Airspace E FL 100 – FL 130/150 VIS: 8 km Distance to clouds: • Vertical 1.000 ft • Horizontal 1.500 m	**Airspace E 2000 ft AGL – FL 100** VIS: 5 km Distance to clouds: • Vertical 1.000 ft • Horizontal 1.500 m	**Airspace G GND – 2000 ft GND** • VIS: 5 km clear of clouds, visual contact to GND • VIS below 5 km (minimum 1.5 km), only if turning to reverse course is possible

Table 33: VFR traffic – weather minima

According to SERA.5001, helicopters may be permitted to operate in less than 1500m but not less than 800m flight visibility, if manoeuvred at a speed that will give adequate opportunity to observe other traffic or any obstacles in time to avoid collisions.

Flight visibilities lower than 800 m may be permitted for special cases, such as HEMS flights, search and rescue operations and state operation (e.g. police and fire-fighting flights).
Commission Regulation (EU) No. 965/2012 [23] (so-called EASA OPS) limits the flight weather conditions for HEMS in accordance with the following table.

SPA.HEMS.120 HEMS operating minima

(a) HEMS flights operated in performance class 1 and 2 shall comply with the weather minima in Table 1 for dispatch and en-route phase of the HEMS flight. In the event that during the en-route phase the weather conditions fall below the cloud base or visibility minima shown, helicopters certified for flights only under VMC shall abandon the flight or return to base. Helicopters equipped and certified for instrument meteorological conditions (IMC) operations may abandon the flight, return to base or convert in all respects to a flight conducted under instrument flight rules (IFR), provided the flight crew are suitably qualified.

Table 1: HEMS operating minima

2 PILOTS		1 PILOT	
DAY			
Ceiling	Visibility	Ceiling	Visibility
500 ft and above	As defined by the applicable airspace VFR minima	500 ft and above	As defined by the applicable airspace VFR minima
499 – 400 ft	1 000 m*	499 – 400 ft	2 000 m
399 – 300 ft	2 000 m	399 – 300 ft	3 000 m
NIGHT			
Cloud base	Visibility	Cloud base	Visibility
1 200 ft**	2 500 m	1 200 m**	3 000 m

* During the en-route phase visibility may be reduced to 800 m for short periods when in sight of land if the helicopter is manoeuvred at a speed that will give adequate opportunity to observe any obstacles in time to avoid a collision.

** During the en-route phase, cloud base may be reduced to 1 000 ft for short periods.

(b) The weather minima for the dispatch and en-route phase of a HEMS flight operated in performance class 3 shall be a cloud ceiling of 600 ft and a visibility of 1 500 m. Visibility may be reduced to 800 m for short periods when in sight of land if the helicopter is manoeuvred at a speed that will give adequate opportunity to observe any obstacle and avoid a collision.

Figure 93: EASA-OPS HEMS operating weather minima acc. to Commission Regulation (EU) No. 965/2012

Air Traffic Services

During the demonstration flight trials, the ATS were provided by the local FIS, according to the existing operational procedures.

FIS (Flight Information Service) is provided by local FISO within the FIZ (Flight Information Zone). FISO (Flight Information Service Officers) are not authorized to give ATC instructions or clearances, except for ground movements.

Solution scenario

The implementation of:

- RNP AR APCH in Samedan airport with RNP navigation accuracy requirement 0.1 NM along the initial, intermediate and final segments, and 0.3 NM respect 1 NM for the missed approach;
- PinS non-standard departure in Samedan.

B.1.2 Heliport to hospital (SCN-0209-002)

The reference scenario for this exercise is today's operational scenario between Samedan airport in the Engadine valley and the Chur hospital landing site in the Chur Rhein valley. These valleys are separated by mountain ridges exceeding 11'000ft AMSL. The distance between Samedan airport and Chur hospital is approximately 24 NM.
Today there are no IFR routes available for helicopters in that region.

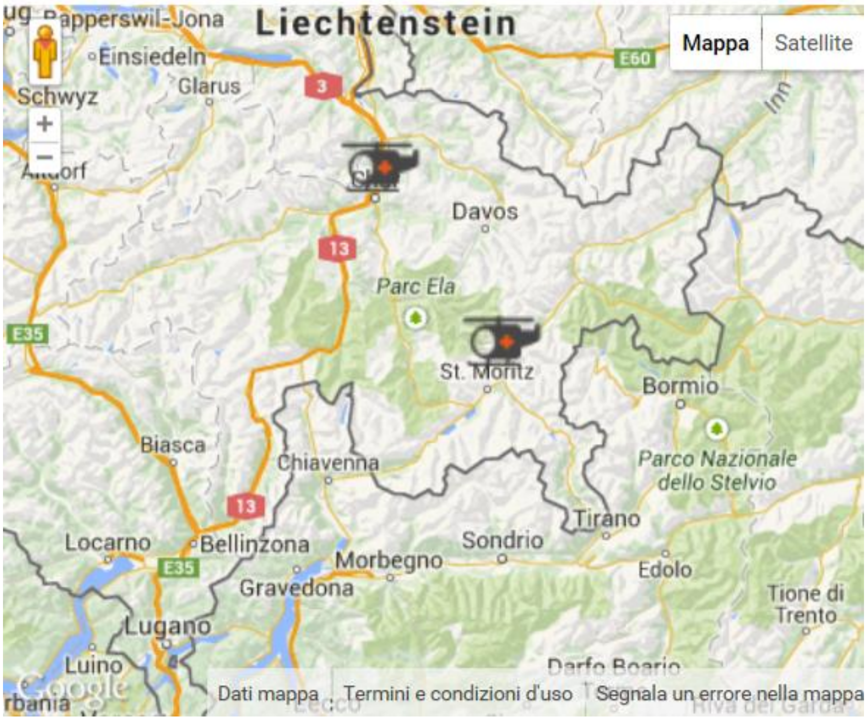

Figure 94: Samedan airport and Chur hospital sites overview (source: Google)

Figure 95: Samedan airport and Chur hospital sites satellite view (source: Google Earth)

Air Traffic Services

The en-route segments are all in Airspace E and the flights were performed in VFR/VMC conditions, therefore no ATS services were provided.

Solution scenario

Implementation of a connection between Samedan Airport and the Chur hospital landing site through a two way low level ATS route, linking the PinS approach and departure procedures to/from Samedan Airport and Chur hospital.

B.1.3 Chur hospital (SCN-0209-005)

This scenario has been added for approach and departure procedures performed to/from Chur hospital.
At the Chur hospital (new ICAO code LSHC; previous Rega ID LSKC) only rotary wing VFR operations are currently possible. Neither an IFR approach nor an IFR departure procedure is available.

The hospital is situated in the Chur Rhine valley and is surrounded by a mountainous region, wherein the flight procedures are very strongly affected by natural obstacles. In terms of number of HEMS movements, Chur hospital ranks amongst the top 3 hospitals in Switzerland.

The reason behind the choice of this scenario is that the implementation of a PinS RNP APCH approach with LPV minima has been identified by Rega as both a necessary and an effective solution to overcome the currently existing limitations in terms of safety and airport capacity/accessibility.

All Swiss hospital landing site are classified according to the Swiss Air Navigation order as off-airport landing sites/locations.

Figure 96: Chur Hospital (picture is provided by REGA)

Figure 97: Chur FATO (source: Bächtold & Moor AG)

Air Traffic Services

The landing Site Chur is located outside controlled airspace. Therefore no ATS or FIS was provided. During the procedures to and from the Chur hospital landing site the official air to air radio communication frequency for hospital air traffic in Switzerland at 123.375 MHZ was used.

Solution scenario

The implementation of a PinS RNP APCH to LPV minima and PinS departure procedures to/from Chur hospital.

B.2 Norwegian scenarios

In PROuD, two different scenarios have been considered for the Norwegian flight campaign:

- **Scenario 03 (SCN-0209-003)**: Lørenskog heliport (ENLX) area (15-20 NM surrounding the Heliport)
- **Scenario 04 (SCN-0209-004):** Ullevål heliport (ENUH) area (15-20 NM surrounding the Heliport)

The scenarios have been presented in the Demonstration plan and they are briefly summarised in the following tables.

Identifier	SCN-0209-003
Scenario	This scenario refers to the ENLX heliport and the surrounding area of 15-20 NM. The affected airspace is below OSLO TMA Airspace class C. The procedures are in class G airspace. The trials will be executed under VFR/VMC and IFR/IMC day/night conditions. The flight trials that will be performed in this area are focused on the execution of PinS LPV approach procedure and SID.

Identifier	SCN-0209-004
Scenario	This scenario refers to the ENUH heliport and the surrounding area of 15-20 NM. The affected airspace is below OSLO TMA Airspace class C. The procedures are in class G airspace. The trials will be executed under VFR/VMC and IFR/IMC day/night conditions. The flight trials that will be performed in this area are focused on the execution of the PinS LPV approach procedure.

Table 34: Norwegian scenarios

PROuD flight trials have been performed in VFR/VMC conditions during both the flight validation phase and the demonstration phase.

B.2.1 Lørenskog heliport (SCN-0209-003)

The reference scenario for this exercise is today's operation scenario at Lørenskog heliport. Lørenskog heliport (ICAO code ENLX) is the home base for two of the helicopters of NLA fleet. These serve approximately 35% of the Norwegian population when it comes to severe injuries like brain traumas, cardiac arrest, etc.
The heliport is located in the Southern of Norway where a low level routing structure exists for use by the Norwegian Air Ambulance to connect hospital heliports throughout the region.
NLA operations are currently conducted in IFR/IMC conditions and already use PinS approach procedures with LNAV minima for approach course 025°. The airspace is class G underlying OSLO TMA that starts at 2500 FT MSL (see figure below).
It is an area of relatively dense GA-traffic from time to time. Oslo city area has its own traffic advisory frequency: VHF122.000.

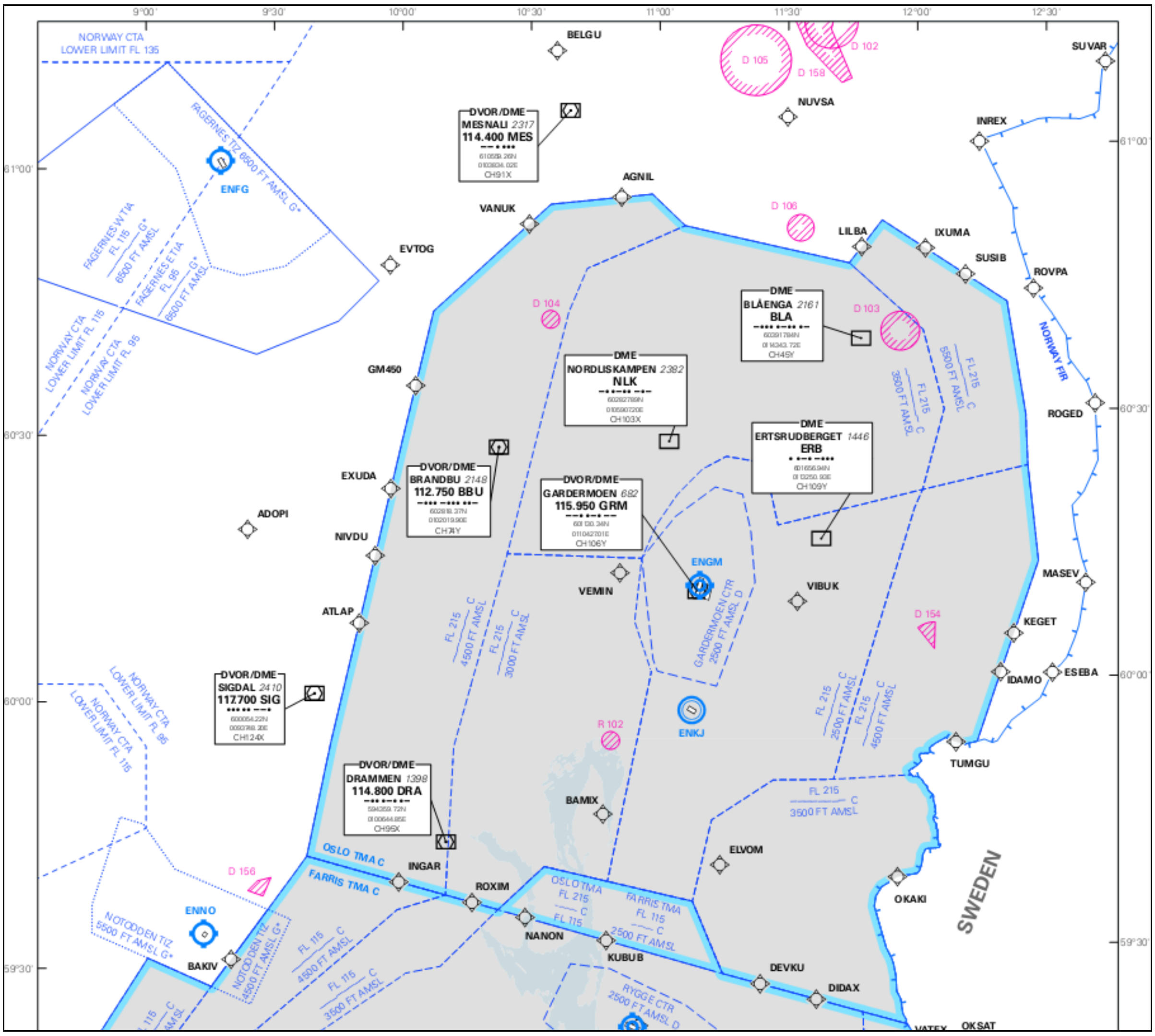

Figure 98: OSLO TMA – AIP Norway

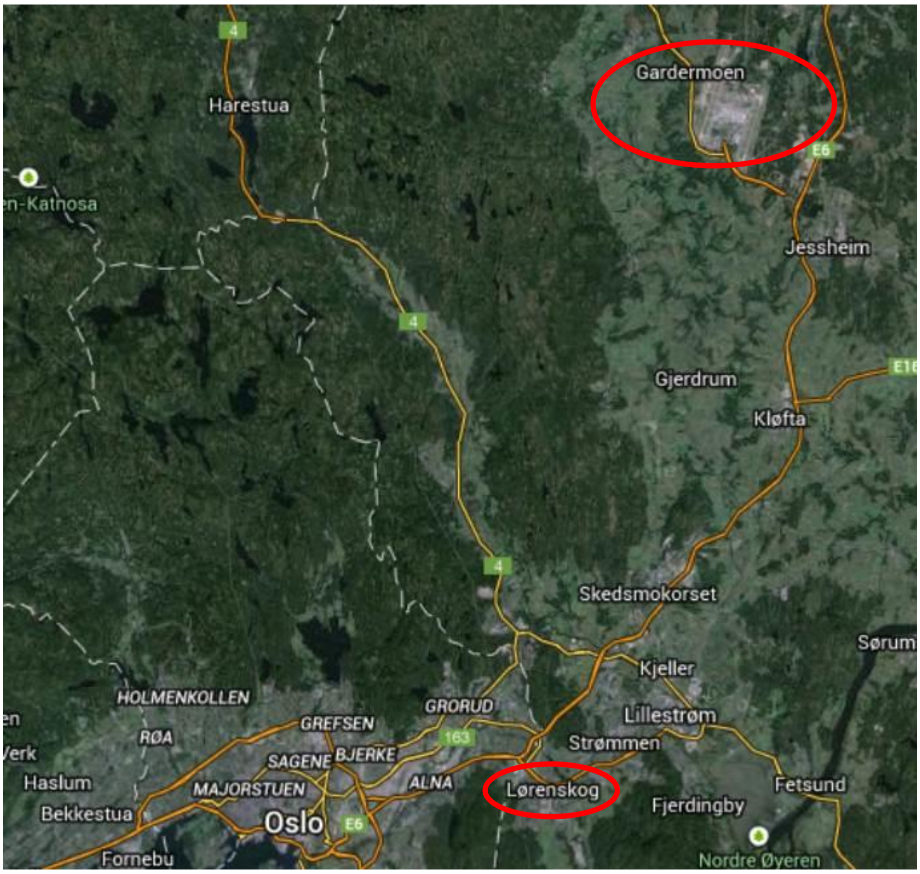

Figure 99: Lørenskog and Gardermoen positions (Google Maps)

Figure 100: Lørenskog and Ullevål positions (Google Maps)

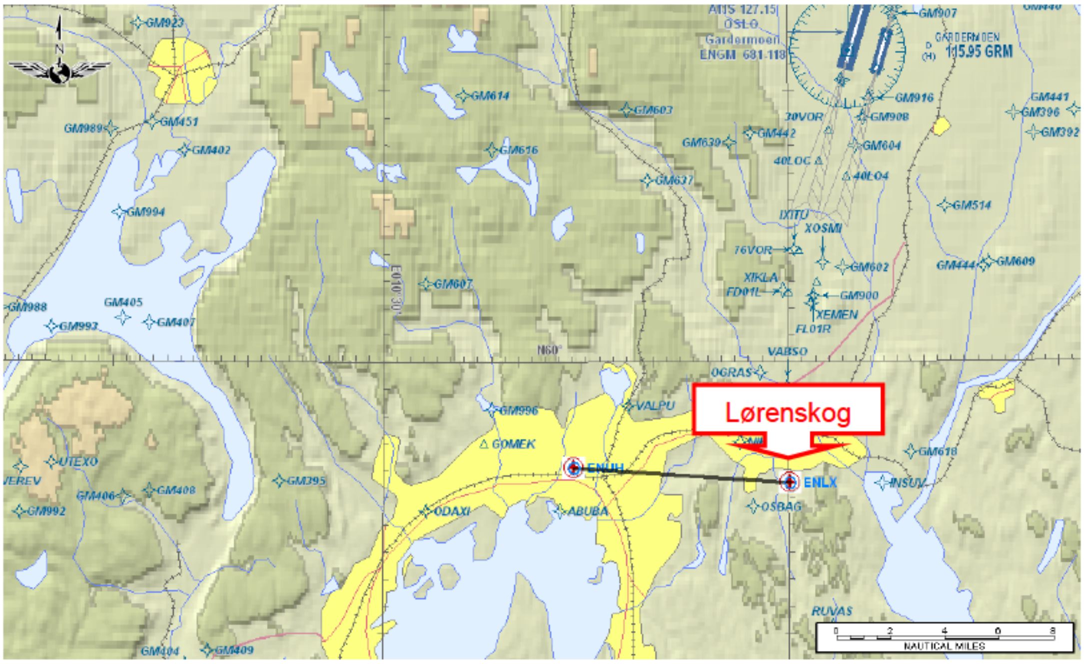

Figure 101: Lørenskog position

Figure 102: Lørenskog heliport (ENLX)

Weather minima

Oslo area has a continental artic type of climate. Summer is relatively warm (18-25°C) with typically showery conditions in the afternoons. Autumn is cool (8-16°C) occasionally with low ceilings and foggy. Without the fog present ceilings are generally 600-1000 FT AGL). Winter is cold (-10-0°C) mainly with temperatures below freezing and snow. Spring is cool and a mix of winter and autumn condition. Ceilings are generally better than in autumn.

Air Traffic Services

In class G airspace IFR and VFR flights are permitted and receive flight information service.
The requirements for the flights within class G of airspace are shown in the following table.

Type of flights	Separation service provided	Service provided	Speed limitation	Radio COMM requirements	Subject to an ATC clearance
IFR	Not provided	Flight Information Service	250KT IAS below FL 100	Not required Continuous two-ways*	Not required
VFR	Not provided	Flight Information Service	250KT IAS below FL 100	Not required Continuous two-ways*	Not required

Table 35: ATS service in class G airspace (Norway AIP)

* There is a requirement for continuous two-way radio communication when flying in those parts of class G airspace, which are established as TIZ/TIA, within HR of operation of the unit providing service. This is not the case for Oslo area.

Solution scenario
The implementation of:

RNP APCH PinS approach procedures with LPV minima, with approach standard gradient (GPA≤6.3°) at Lørenskog and Ullevål heliports for the arrival and approach segments;

PinS departure with the adoption of the 0.3 Navigation Specification at Lørenskog heliport.

B.2.2 Ullevål heliport (SCN-0209-004)

The reference scenario for this exercise is today's operation scenario at Ullevål heliport. Ullevål heliport (ICAO code ENUH) is the national trauma hospital for southern parts of Norway and is the delivery site for 5 EMS helicopters in addition to military rescue helicopters when it comes to severe injuries.
The heliport is located in the Southern of Norway where a low level routing structure exists for use by the Norwegian Air Ambulance to connect hospital heliports throughout the region.
NLA operations are currently conducted in IFR/IMC conditions and already use two PinS approach procedures with LNAV minima for approach course 279° and 070°. One is proceed visually and one is proceed VFR. The latter requires better weather during night time hours of operation. The airspace is class G underlying OSLO TMA that starts at 2500 FT MSL (see figure below).
It is an area of relatively dense GA-traffic from time to time. Oslo city area has its own traffic advisory frequency: VHF122.000.

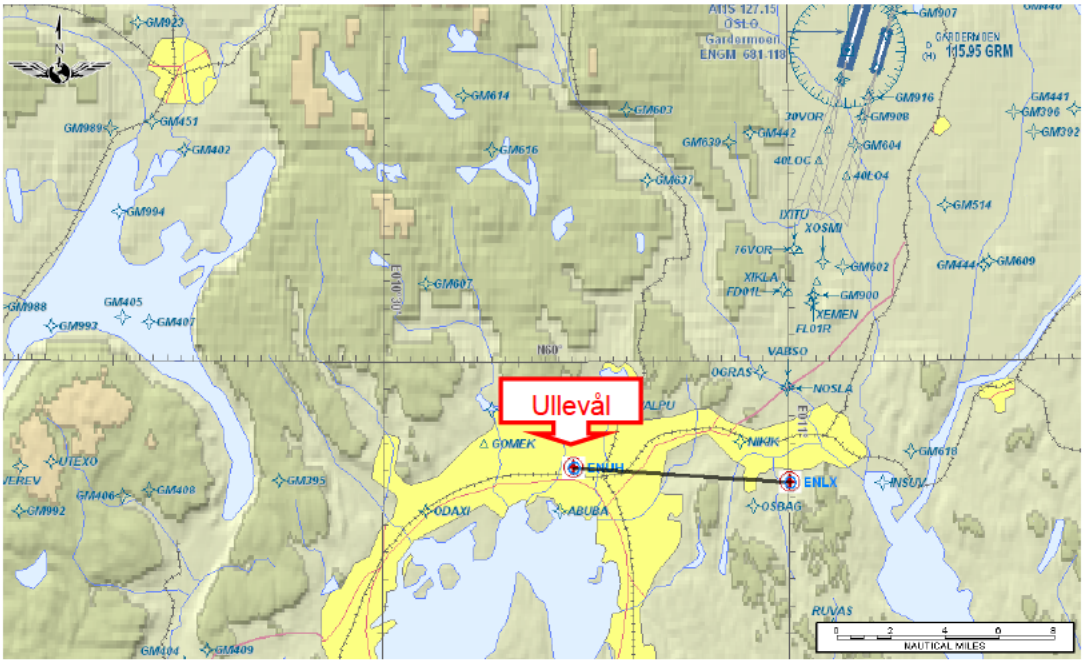

Figure 103: Ullevål position

Figure 104: Ullevål heliport (ENUH)

Weather minima

See weather minima description in the section B.2.1.

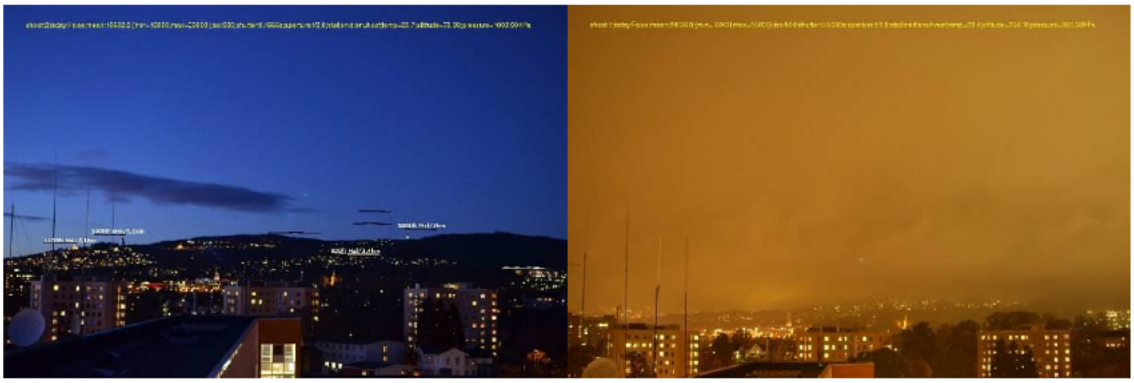

Figure 105: Example of weather conditions at ENUH PINS landing site

Air Traffic Services

Oslo area is supported by OSLO WEST approach for traffic information, frequency 120,450MHz. Additional inter-pilot frequency is established for traffic-information between all VFR and IFR traffic operating overhead Oslo city in class G airspace. Only EMS helicopters from NLA operate in IMC conditions to and from the area. Radar surveillance is considered good from ground level. There is a radar site located on a mountain top between Lørenskog an Ullevål, and ATC traffic information is good, but quality depends of controllers capacity to give timely and correct information of other traffic.
HEMS coordinator keeps track of all HEMS helicopters on a separate GPRS-data based tracking system. If two helicopters are inbound for the same IFR procedure they will normally advice the crew well in advance. Separation from other traffic is the pilots sole responsibility based and information available and procedures applied.

See also air air traffic services description in the section B.2.1.

Solution scenario

The implementation of:

RNP APCH PinS approach procedures with LPV minima, with approach standard gradient (GPA≤6.3°) at Ullevål heliports for the arrival and approach segments. A different direction (final approach track 350°) was chosen because of more challenging terrain in the missed approach and also not to interfere with the existing procedures and also to provide approach from a different and more direct routing for traffic approaching from the south.

Appendix C Demonstration Objectives

Identifier	OBJ-0209-001
Objective	Assess the safety of RNP-APCH PinS approach procedures with LPV minima on heliports.
Success Criterion	Increased safely level of helicopter approach operations is expected in comparison with VRF operations and approach operations without vertical guidance in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action

Table 36: Demonstration Objective OBJ-0209-001

Identifier	OBJ-0209-002
Objective	Assess the safety of RNP-APCH PinS approach procedures with LPV minima, with non-standard gradient (GPA>6.3°), on heliport, in critical environment.
Success Criterion	Increased safely level of helicopter approach operations is expected in comparison with VFR/VMC operations in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action.

Table 37: Demonstration Objective OBJ-0209-002

Identifier	OBJ-0209-003
Objective	Assess heliport accessibility using RNP-APCH PinS approach procedures with LPV minima.
Success Criterion	An increased heliport accessibility is expected in terms of increased landing possibility and reduction of number of diversions and missed approaches in comparison with VFR operations and approach operations without vertical guidance.

Table 38: Demonstration Objective OBJ-0209-003

Identifier	OBJ-0209-004
Objective	Assess heliport accessibility of RNP-APCH PinS approach procedures with LPV minima, in critical environment, by the adoption of non-standard gradient (GPA>6.3°).
Success Criterion	An increase in airport accessibility is expected in terms of increased landing possibility and reduction of number of diversions and missed approaches in comparison with VFR operations.

Table 39: Demonstration Objective OBJ-0209-004

Identifier	OBJ-0209-005
Objective	Assess the environmental sustainability for RNP-APCH PinS approach procedures with LPV minima, on heliports.
Success Criterion	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.

Table 40: Demonstration Objective OBJ-0209-005

Identifier	OBJ-0209-006
Objective	Assess the environmental sustainability for RNP-APCH PinS approach procedures with LPV minima on heliport, in critical environment, with approach non-standard gradient (GPA>6.3°).
Success Criterion	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.

Table 41: Demonstration Objective OBJ-0209-006

Identifier	OBJ-0209-007
Objective	Assess the impact on flight efficiency of RNP-APCH PinS procedures with LPV minima, on heliports.
Success Criterion	An optimization of efficiency of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR operations.

Table 42: Demonstration Objective OBJ-0209-007

Identifier	OBJ-0209-008
Objective	Assess the impact on flight efficiency of RNP-APCH PinS procedures with LPV minima on heliport, in challenging environment, by the adoption of non-standard gradient (GPA>6.3°).
Success Criterion	An optimization of efficiency of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR operations.

Table 43: Demonstration Objective OBJ-0209-008

Identifier	OBJ-0209-010
Objective	Assess VFR airport accessibility of RNP-APCH AR approach procedures in critical environment.
Success Criterion	An increase in airport accessibility is expected in terms of increased landing possibility and reduction of number of diversions and missed approaches in comparison with VFR approaches.

Table 44: Demonstration Objective OBJ-0209-010

Identifier	OBJ-0209-011
Objective	Assess the impact on safety of helicopter PinS departures and their integration with low level route structure.
Success Criterion	No negative impact on the safety level of helicopter departure operations is expected in comparison with VFR operations in terms of pilots' error propensity, workload, situational awareness and timeliness of actions.

Table 45: Demonstration Objective OBJ-0209-011

Identifier	OBJ-0209-012
Objective	Assess the site availability for helicopter PinS departures in critical environment and weather conditions.
Success Criterion	Increased site availability is expected in comparison with VFR operations in terms of IFR departures allowance during poor visibility with a reduced departure minimum cloud ceiling and minimum visibility.

Table 46: Demonstration Objective OBJ-0209-012

Identifier	OBJ-0209-013
Objective	Assess the environmental sustainability for PinS departure procedures.
Success Criterion	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.

Table 47: Demonstration Objective OBJ-0209-013

Identifier	OBJ-0209-014
Objective	Assess the flight efficiency of PinS departures and integration with low-level route structure.
Success Criterion	An optimization of efficiency of HEMS operations is expected in terms of fuel consumption, mileage in comparison with VFR operations

Table 48: Demonstration Objective OBJ-0209-014

Identifier	OBJ-0209-015
Objective	Assess HEMS operational efficiency and associated service availability enabled by IFR GNSS heliport to heliport connections based on low level IFR routes and on the adoption of new PBN navigation specifications and new ICAO PANS OPS design criteria.
Success Criterion	Increase of HEMS service availability and an optimization of flight efficiency of HEMS operations is expected in terms of reduction of flight preparation time, mileage, flight duration and fuel consumption in comparison with VFR operations.

Table 49: Demonstration Objective OBJ-0209-015

Identifier	OBJ-0209-016
Objective	Assess the impact on predictability for RNP heliport to heliport connection enabled by GNSS
Success Criterion	Increased predictability in terms of adherence of the flown path to planned flight.

Table 50: Demonstration Objective OBJ-0209-016

Identifier	OBJ-0209-017
Objective	Assess the impact of the new concept on the operating methods by identifying the changes imposed on the existing ones, feasibility of these changes and their compliance and consistency within the overall context (normal, abnormal and degraded conditions).
Success Criterion	Feasibility, consistency and acceptability of the changes of the current operating methods with the introduction of the new procedures, with respect to existing operating methods in relation to the overall environment, are expected to be within acceptable margins.

Table 51: Demonstration Objective OBJ-0209-017

Identifier	OBJ-0209-018
Objective	Assess the impact of the new concept on the pilots' task performance (error propensity, workload, situational awareness, timeliness of actions).
Success Criterion	Errors and untimely actions related to the new concept as well as the level of workload and situational awareness are expected to be within acceptable margins.

Table 52: Demonstration Objective OBJ-0209-018

Identifier	OBJ-0209-019
Objective	Assess the impact on pilot's performance in case of technical systems degradation, in terms of accuracy and timeliness of system information.
Success Criterion	Pilot's performance is expected to be within acceptable margins, even in case of degraded accuracy and timeliness of system information.

Table 53: Demonstration Objective OBJ-0209-019

Identifier	OBJ-0209-102
Objective	Assess the safety of RNP-APCH AR approach procedures on VFR airport, in critical environment.
Success Criterion	Increased safely level of helicopter approach operations is expected in comparison with current VFR/VMC operations in terms of error propensity (with a special focus on CFIT), workload, situational awareness and timeliness of action

Table 54: Demonstration Objective OBJ-0209-102

Identifier	OBJ-0209-106
Objective	Assess the environmental sustainability for RNP AR APCH procedures on VFR airport, in critical environment.
Success Criterion	Impact on environmental sustainability in terms of reduced noise footprint and emissions in comparison with VFR operations.

Table 55: Demonstration Objective OBJ-0209-106

Identifier	OBJ-0209-108
Objective	Assess the impact on flight efficiency of RNP-APCH AR procedures, on VFR airport, in challenging environment
Success Criterion	An optimization of efficiency of HEMS operations is expected in terms of reduction of mileage, time to land and fuel consumption in comparison with VFR operations.

Table 56: Demonstration Objective OBJ-0209-108

Identifier	OBJ-0209-116
Objective	Assess the safety of RNP heliport to heliport connection enabled by GNSS.
Success Criterion	Increased safely level of helicopter RNP heliport to heliport connections enabled by GNSS is expected in comparison with VFR/VMC operations in terms of workload, situational awareness and timeliness of action.

Table 57: Demonstration Objective OBJ-0209-116

Appendix D Communication Material

In this appendix all the material that has been produced along the entire project is reported.

- **Logo**: four versions of the logo have been created, according to the document format in which it has been used.
- **Website**: an ad-hoc website has been created at the following link http://www.proud-project.eu/
- **Twitter**: An account to reach more visibility among the Aviation community and reach a wider number of stakeholders. Here the link https://twitter.com/PROuD_Project
- **Press kit**: material contained in the press kit is reported in D.7
- **Photos**: here below some of the photos taken during the flight campaigns and events the project participated in.

D.1 PROUD Kick Off Press Release

The following press release (formatting of pictures will be revised for publishing purposes) is available for publishing on Partners' websites

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6th October, 2014 – The PBN Rotorcraft Operations under Demonstration (PROuD) Project Kick Off Meeting, held via teleconference with the participation of all PROuD partners and SESAR Joint Undertaking project manager, marks the "T0" point of the project's execution phase.

PROuD within SESAR

PROuD is one of the 15 Large Scale Demonstration projects that have been selected for co-financing by the SESAR JU (SJU), which coordinates the SESAR (Single European Sky ATM Research) programme.

The Project answers to the Lot 2 requirements of the SJU Call for Proposal for Large Scale Demonstration activities to be executed in the timeframe 2014-2016, dedicated to "Precision Arrival and Departure Procedures" bringing safety and economic improvements to small size airports and heliports already applying or implementing satellite rotorcraft operations.

PROuD will provide results that have the ambition of representing a reference for rotorcraft operators, paving the way for further operational campaigns and for the deployment in other European scenarios of the relevant SESAR demonstrated change. In relation to the ATM Master Plan, the demonstration foreseen in the project will cover the "Approach Procedures with vertical guidance" area.

The project is expected to give a very important contribution to the pre-operational implementation of precision arrival and departure helicopter procedures for small/medium size non-IFR airports/heliports and, hence, provide beneficial input to the relevant regulation for Europe.

Scope and objectives

The purpose of the project is to demonstrate how the introduction of satellite based procedures designed specifically for helicopters can improve operations in European scenarios, which can be particularly challenging for weather conditions, visibility limitations or geographical configuration.

In particular, PROuD aims at enhancing rotorcraft operations, principally for HEMS (Helicopter Emergency Medical Service) flights, including Search and Rescue missions.

Activities

The project will start with the design of dedicated PBN procedures for approach, arrival, departure and connection to low-level IFR routes and their validation through dedicated flights.

Two campaigns for a total of 80 flight tests will then be conducted, in Switzerland and Norway, with a view to demonstrat~~ing~~ improved safety, efficiency, availability, accessibility and weather resilience during the missions.

Routes and procedures flown in the PROuD live trials are on the path to become operational after the demonstration finishes.

PROuD Consortium

Each member of the consortium has a clear role in the project:

Ingegneria Dei Sistemi S.p.A (IDS) acts as Consortium coordinator. IDS is responsible for the Project Management. From the technical point of view, IDS will take care of the helicopter RNP procedures, exploiting its experience in flight procedure design. Indeed, IDS service department received in 2012 the endorsement in Flight Procedure Design Organization by ICAO.

Swiss Air-Rescue (Rega) entire AgustaWestland AW109SP helicopter fleet is capable and certified to perform LPV procedures. Rega is taking the role of the HEMS Operator. Rega takes care of the ground- and flight procedure validation, the avionics DB preparation in close collaboration with Jeppesen, and when necessary request the permit to fly with assistance of its own Part 21 DOA, plan and execute the flight campaign and support the flight data collection with the access to the dedicated helicopter flight inspection kit.

Norsk Luftambulanse (NLA) is a HEMS rotorcraft operator in Norway since 1978. Today they operate 9 helicopters on a state financed contract, as a part of the Norwegian health care system. NLA was the first European operator introducing PINS approaches as part of an IFR-philosophy. Approximately 10% of all missions are flown in IMC conditions. They just started operation of three HEMS bases in Denmark.

Skyguide, as the Swiss Air Navigation Services Provider, provides ANS expertise in the domains of PANS-OPS procedures design and validation, CNS engineering, ATM expertise. safety assessment of ATM aspects and air traffic control.

Deep Blue is an Italian research and consultancy company bringing in the project the long term experience on safety, performance analysis and dissemination proven also through the involvement in the SESAR Programme on these transversal areas. Deep Blue (DBL) is responsible for communication management and for the planning and execution of human performance and safety assessment. Moreover, DBL will lead the tasks assigned to data analysis and reporting.

Project duration

The PROuD Agreement has been signed 19th September 2014 and the project is expected to run until August 2016.

Between now and 2016, LSD projects will unite the skills and innovative capabilities of a wide range ATM stakeholders from across Europe in order to test SESAR solutions in a variety of real operational environments.

About SESAR

The SESAR programme is the technological and operational pillar of the Single European Sky (SES) initiative. The aim of SESAR is to overcome fragmentation of the ATM system and deliver advanced technological and operational solutions with a view to bringing Europe's ATM into the 21st century.

SESAR is managed by the SESAR JU which coordinates and concentrates all relevant research and development efforts on ATM with a view to harmonising industrial implementation. With almost 3,000 experts in Europe and beyond working together, SESAR is already bringing operational solutions to ATM systems; increasing operability, traffic predictability, flexibility, safety and cost efficiency, while reducing fuel consumption, CO2 emission. Research and innovation are ongoing and deployment by industry is on its way.

The SESAR JU was founded by the European Union, EUROCONTROL, and has 15 member companies: AENA, Airbus, Alenia Aermacchi, DFS, DSNA, ENAV, Frequentis, Honeywell, Indra, NATMIG, NATS (En Route) Limited, NORACON, SEAC, SELEX ES and Thales. A total of 70 companies are participating in SESAR, including members, associate partners, and their affiliates and sub-contractors.

D.1.1 KOM press release publication

The Kick Off Meeting press release has been published on partners' websites and it is available at the following links:

- Deep Blue:http://www.dblue.it/?news=sesar-proud-demonstration-project-kicks-off
- IDS:https://www.idscorporation.com/airnavigation/more-information/news/583-sesar-proud-demonstration-project-kicks-off
- NLA:http://www.norskluftambulanse.no/flere-og-bedre-gps-ruter-for-flyginger-til-og-fra-sykehus/

D.2 PROuD Logo

For what concern the creation of the Logo, a study has been carried out with the aim of communicating PROuD main elements in a simple and graphically appealing way.

A sans serif font has been chosen in order to be aligned with the institutional tone of a SESAR co-funded project.

An iconographic content has been added, evoking the context in which the trials will be performed (i.e. the profile of a mountain) and the technological elements involved: the EGNOS system (i.e. the waves normally associated to GPS signal representation), the PinS trajectories (i.e. the 3 trapezes) and the helicopters.

The colours have been chosen in order to refer to the context: grey to evoke snow and fog and orange to evoke technical mountain clothing and gear.

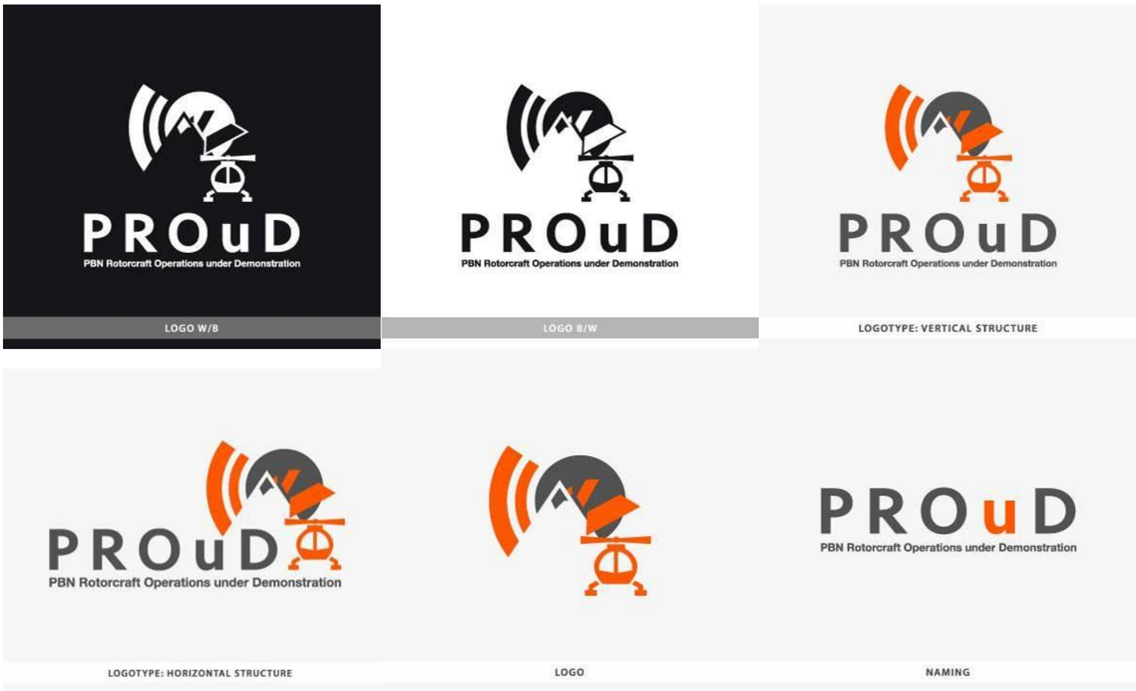

Figure 106: The PROuD logo in different formats

D.3 PROuD Website

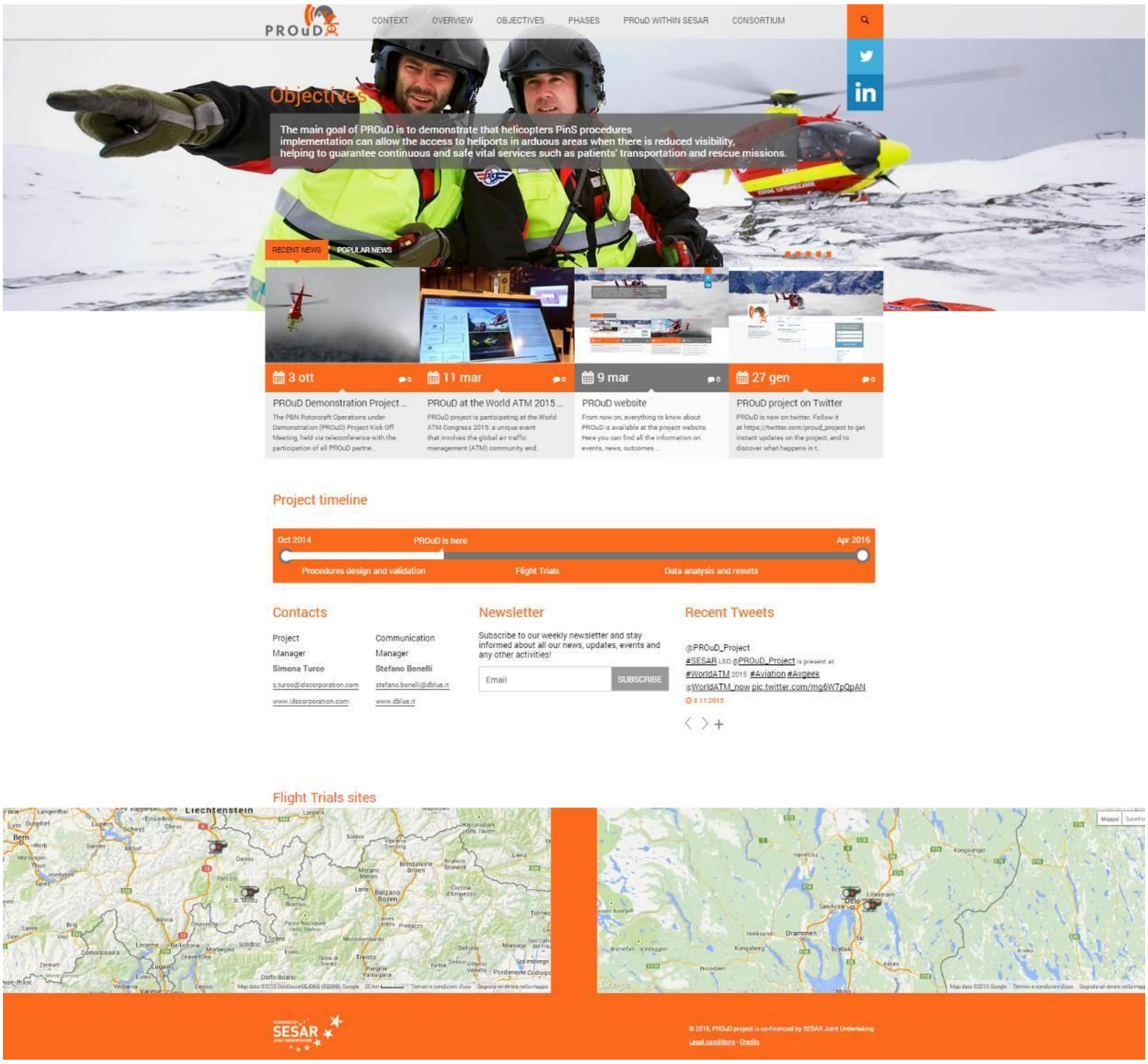

Figure 107: PROuD website home page

D.4 PROuD Social network accounts

With regard to the social network accounts, the twitter and LinkedIn web pages of the project have been created and the login credentials (username and password) have been provided to each partner, that can access and contribute to disseminate PROuD project.

Below it is shown the project page of both twitter and LinkedIn PROuD accounts page.

D.4.1 PROuD Twitter profile page

https://twitter.com/PROuD_Project

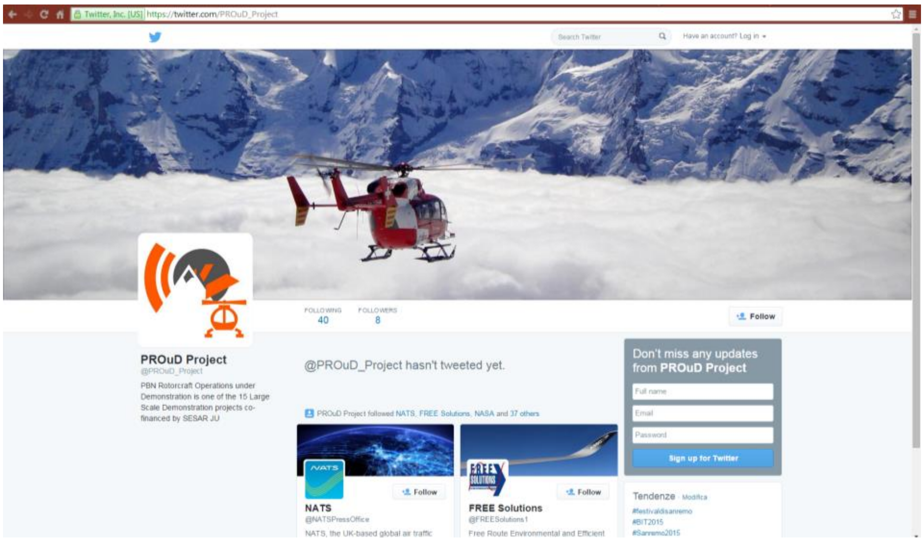

Figure 108: The PROuD Twitter Account

D.4.2 PROuD LinkedIn profile page

https://www.linkedin.com/profile/view?id=400467180&goback

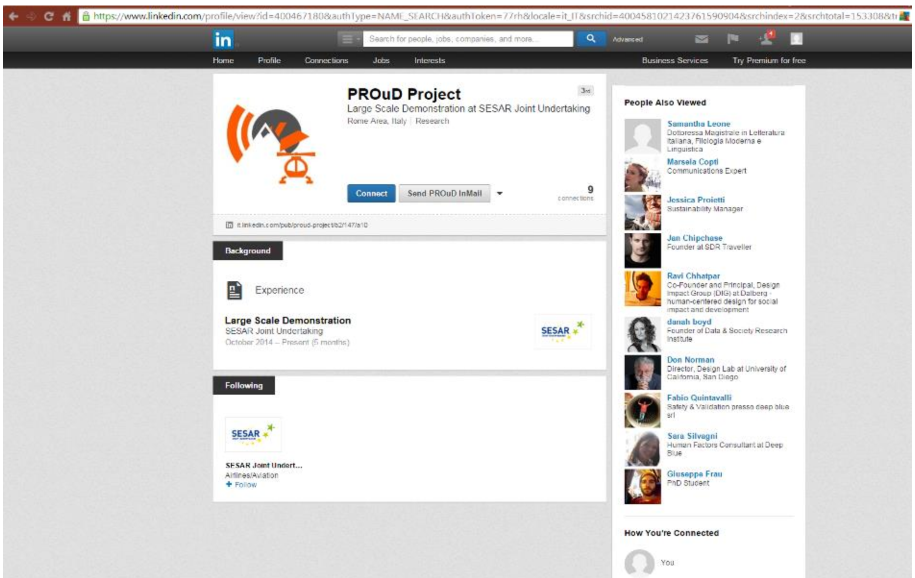

Figure 109: The PROuD LinkedIn Account

D.5 PROuD Brochure

PROuD within SESAR

PROuD project is one of the 15 **Large Scale Demonstration projects** that have been selected for co-financing by the Single European Sky ATM Research Joint Undertaking [SESAR JU], which coordinates the SESAR programme.

The Project answers to the SJU call for demonstration activities dedicated to "Precision Arrival and Departure Procedures" **bringing safety and economic improvements to small size airports and heliports** implementing satellite rotorcraft operations.

PROuD will provide results that have the ambition of representing **a reference for rotorcraft operators**, paving the way for further operational campaigns and for the deployment in other European scenarios of the relevant SESAR demonstrated change.

The PROuD Consortium is composed of **five partners**, each one bringing a unique knowledge or skill set to the Project.
The European HEMS & Air Ambulance Committee and **the European Helicopter Association** will contribute to PROuD, representing relevant airspace users.

Ingegneria Dei Sistemi S.p.A. [IDS]
[Consortium Coordinator] Industry

Swiss Air-Rescue Rega
HEMS Operator

Norsk Luftambulanse [NLA]
HEMS Operator

Skyguide
Swiss Air Navigation Services Provider

Deep Blue
Research and Development

PROuD
PBN Rotorcraft Operations under Demonstration

www.proud-project.eu

Project Manager: Simona Turco
s.turco@idscorporation.com
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www.sesarju.eu

PROuD project is co-financed by the SJU

PROuD project demonstrates helicopters Performance Based Navigation procedures, showing how their implementation can:

- provide instrument approach capabilities to locations where conventional navigation facilities are not available;
- enable safe and continued access to heliports in difficult to reach areas during reduced visibility conditions;
- guarantee the continuity of vital services such as patients' transport and mountain rescue, enhancing safety and saving costs for communities.

Powered by SESAR Joint Undertaking — Seeing is believing

Nowadays, many critical services, such as Helicopter Emergency Medical Service and Search and Rescue, are carried out in **very challenging environments**, requiring helicopters to often fly in adverse weather conditions and in unfavourable contexts [e.g. mountainous areas, urban environments].
In many cases, pilots are not supported by any navigation aid, as small airports and landing sites are not equipped with ground based facilities enabling instrument flight. Pilots mainly fly visually, thus **limiting the number of missions that can be completed successfully** when visibility is low.
PROuD project intends to demonstrate, in a live trial environment, how operations in European scenarios can be improved by the introduction of **new Point in Space [PinS] procedures using satellite-based GPS technology** designed specifically for helicopters.

OBJECTIVES

- Demonstrate how RNP PinS LPV approach and RNP PinS departure procedures **allow for the implementation of IFR operations** in small non-IFR airports/heliports located in challenging environments;
- Contribute to adopt **RNP 0.3 and RF leg capability for missed approach segments**;
- Evaluate the improvement in overall airspace usage of **gate to gate rotorcraft IFR flights**, connecting the PinS approach and departure segments with the relevant en-route low level flight segments;
- Contribute to the evolution and standardisation of ICAO PANS OPS amendments for flight procedure design criteria for LPV PinS approach procedures [**GPA > 8.3°**].

PROJECT PHASES

1 - PROCEDURES DESIGN and VALIDATION
PROuD will develop new instrument approach and departure procedures for specific sites: Samedan airport in Switzerland and Lorenskog and Ullevål helipads in Norway. Procedures safety and technical validation will be assured by local safety assessments, real time simulations and flight tests.

2 - FLIGHT TRIALS
A minimum of 80 trials will be performed by REGA and NLA helicopters, in order to get information about flight performances, EGNOS coverage reliability and human performance.

3 - DATA ANALYSIS and RESULTS
Based on data gathered, PROuD will assess the impact of the new procedures on:
✓ Flight safety ✓ Helipads accessibility and availability
✓ Environmental sustainability ✓ Crew performances
✓ Predictability of operations ✓ Flight efficency
The project will finally deliver conclusions on the **operational benefits and feasibility** of the deployment of PinS procedures for helicopters in the tested sites and across Europe.

The European Geostationary Navigation Overlay Service is a wide coverage augmentation system which provides horizontal position accuracy at the metre level.

Helicopters receive their position and the points in space they have to reach in order to follow PinS procedures by satellite-based transmitters.

Procedures are a series of predetermined maneuvers to be accomplished. PinS procedures are instrument procedures based on GPS guidance, augmented by Space-Based Augmentation System [EGNOS].

PROuD SYSTEM

D.6 PROuD Leaflet for World ATM Congress 2016

The SESAR PROuD Project was showcased on the IDS stand at the 2016 World ATM Congress in Madrid from 8th to 10th March 2016 using the following leaflet, available also in a website version.

The PROuD Consortium consists of:

IDS Ingegneria Dei Sistemi S.p.A.
Via Enrica Calabresi 24, 56121 Pisa (PI) Italy
Tel. +39 050 31241 Fax +39 050 3124201
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P.O. Box 796 - 1215 Geneva 15
Tel. +41 22 417 41 11
www.skyguide.ch

Deep Blue
Piazza Buenos Aires 20 - 00198 Roma
Tel. +39 06 85 55 208
www.dblue.it

Swiss Air-Rescue
Rega Centre
PO Box 1414 - 8058 Zurich Airport
Tel. +44 654 33 11
www.rega.ch

Norsk Luftambulanse
Holterveien 25, 1448 Drøbak
Tel. +47 64 90 44 45
www.norskluftambulanse.no

Endorsed by:

www.eha-heli.eu

www.ehac.eu

16_REV_1.6

PBN Rotorcraft Operations under Demonstration

SESAR LSD.02.09 PROuD

PBN Rotorcraft Operations under Demonstration
PBN procedures for HEMS operations in challenging environments

www.proud-project.eu
www.sesarju.eu

PBN Rotorcraft Operations under Demonstration

PROuD is one of the 15 Large Scale Demonstration projects that were selected for co-financing by the (SJU), which coordinates research and innovation activities of the SESAR (Single European Sky ATM Research) project.

The main goal of PROuD is to demonstrate improvements in rotorcraft operations, particularly for **HEMS** (Helicopter Emergency Medical Services) and **SAR** (Search and Rescue), through the implementation of Performance Based Navigation (PBN) procedures for approach, departure and IFR low-level routes.

The PROuD Consortium is composed of **IDS Ingegneria Dei Sistemi** (Project Leader), **REGA** (Swiss Air-Rescue), **Norsk Luftambulanse** (HEMS rotorcraft operator in Norway), **Skyguide** (Swiss ANSP) and **Deep Blue** (Italian research and consultancy company). **EHA** (European Helicopter Association) and **EHAC** (European HEMS & Air Ambulance Committee) endorsed the PROuD project's activities, providing guidance/feedback and a supporting interface with European regulators.

The PROuD project is in line with the high-level objectives and the operational improvements addressed by the SESAR OFA02.01.01 "Optimised 2D/3D Routes" where one of the contributing projects is P04.10 "GA and Rotorcraft Operations" (led by ENAV with the contribution of the Finmeccanica Helicopter Division and Airbus Helicopters).

Benefits

- Guarantee the continuity of vital services such as patient transport and mountain rescue, enhancing safety and saving costs for communities
- Improve the reliability and safety of helicopter operations, in particular at night and/or adverse weather conditions
- Increase operational efficiency and reduce costs
- Improve landing site accessibility

PROuD demonstrates, in a live trial environment, how the adoption of PBN flight procedures improves the safety and reliability of operations and landing site accessibility in challenging environments such as in adverse weather conditions or mountainous areas. It implies significant improvements in how the general population experience medical assistance by air.

The project is structured in three main phases (procedure design and validation, flight trials, data analysis and results). The first two phases have been successfully completed. The data analysis and results phase is currently underway.

Procedure design phase

The following PBN procedures were designed by IDS, which is responsible for procedure design activities within the project:

Norwegian scenarios

Lørenskog hospital:
- Helicopter PinS RNP APCH to LPV minima
- Helicopter PinS departure

Ullevål hospital:
- Helicopter PinS RNP APCH to LPV minima

Swiss scenarios

Samedan airport:
- Helicopter PinS non-standard departure
- Helicopter PinS RNP AR APCH

Chur hospital:
- Helicopter PinS RNP APCH to LPV minima
- Helicopter PinS departure

Helicopter low flight route Samedan - Chur

Before the flight trials were performed, safety workshops were carried out at the Norsk Luftambulanse headquarters in Oslo and at the REGA Centre in Zurich with the aim of demonstrating that the new procedures are safe and that they do not generate an increase in risk during the flight trials.

Flight trials phase

Norway - June 8th and 9th, 2015: The Norwegian Air Ambulance (Norsk Luftambulanse) and Airbus Helicopters performed test flights of the new instrument based departure and approach procedures with a latest generation Airbus Helicopters H135 helicopter, equipped with a Garmin GTN 750 navigation console for validation flights, at the Lørenskog base and Ullevål heliport in the Oslo area.

The flights were successfully executed and the procedures worked as expected to the great satisfaction of the entire team.

The flight procedures designed in the PROuD project were validated with the contribution of ACAMS Airport Tower Solution Flight Inspector.

The Norwegian CAA attended the flight trials and has recently approved the approach procedures with LNAV minima for operational use by Norsk Luftambulanse. The flight test campaign demonstrated improved accessibility for sites affected by low visibility and improved safety through EGNOS vertical guidance and reduced landing minima.

Switzerland - July 20th to 24th, 2015: Rega successfully tested a new instrument flight route (RNP 0.3) from Samedan airport to Chur hospital and new PBN approach and departure procedures, with an AgustaWestland AW109SP Da Vinci helicopter earmarked by Rega for the flight inspection task, equipped with an Aerodata AD-AFIS-220 flight inspection system and a Rockwell Collins TDR 94 ADS-B 1090 ES transponder. The flight procedures designed in the PROuD project were validated with the contribution of an FCS (Flight Calibration Services GmbH) Flight Inspector. The following IDS ground-based support equipment was installed at Samedan airport and used during the performance of flight trials:

- APM (Approach Path Monitoring) alert tool based on ADS-B data: an innovative ground safety net to support tower controllers & AFIS operators in small airports, to monitor approaching aircraft and provide an RNP tunnel-incident detection alarm in the case of tunnel infringement along the flight path.
- GNOME system: real time monitoring of GPS and EGNOS performance during flight validation trials as well as off-line performance assessment and GNSS environment characterization (e.g. EM horizon due to terrain masking, interference)

The initial feedback has been positive, and the pilots are confident that these new procedures could definitely improve the performance of Search & Rescue missions under adverse conditions. Other benefits are a reduction in the pilots' workload and the improvement of safety during flights, especially in bad weather conditions.

The PROuD project provides important output to support future evaluation by the Swiss Federal Office of Civil Aviation (FOCA) for the use of IFR procedures in class-G uncontrolled airspace, currently prohibited by Swiss regulation.

The project partners are currently analysing the qualitative and quantitative data, which will be provided in the PROuD final demonstration report planned for July 2016.

D.7 Press Kit

Among the communication activities, a press kit was created. The press kit contains the following elements.

D.7.1 About PROuD

The following section contains a brief presentation of the project, which was produced at the beginning of the project and it was included in the press kit as part of the communication activity.

Nowadays, many vital services, such as Helicopter Emergency Medical Service and Search and Rescue, are carried out in **very challenging environments**, requiring helicopters to often fly in adverse weather conditions and in unfavourable contexts (e.g. mountainous areas, urban environments).

In many cases, helicopters are not supported by any navigation aid, as small airports and landing sites are not equipped with ground based facilities enabling instrument flight. Pilots mainly fly visually**,** thus **limiting the number of missions that can be completed successfully** when visibility is low.

PROuD (PBN Rotorcraft Procedures under Demonstration) project intends to demonstrate, in a live trial environment, how the introduction of satellite based procedures designed specifically for helicopters can improve operations in European scenarios, challenging for weather conditions, visibility limitations or geographical configuration.

The project aims at enhancing rotorcraft operations, particularly for HEMS (Helicopter Emergency Medical Service) flights, through the implementation of GPS/EGNOS based procedures for departures and approaches for heliports and non IFR airports, heliport-to-hospital rotorcraft flights (connecting the PinS departure and approach segments with the relevant en-route low level flight segments) and the adoption of RNP 0.3 PBN Navigation specification in all phases of flight (except on final approach segment of operations).

Two campaigns for a total of 80 test flights are envisaged, in Switzerland and Norway, with a view to demonstrating improved safety, availability, accessibility and weather resilience. Routes and procedures flown in the PROuD live trials are considered as a starting point for future operational implementation, as soon as the local regulation allows it.

PROuD will provide results that have the ambition of representing a **reference for rotorcraft operators,** paving the way for further operational campaigns and for the deployment in other European scenarios of the relevant SESAR demonstrated change.

D.7.2 Links

Hereafter all the links related to PROuD project are listed.
- www.proud-project.eu
- https://twitter.com/PROuD_Project
- https://www.linkedin.com/profile/view?id=400467180&goback

D.7.3 Logo

The press kit contains the project logo in both web and printable format.

D.7.4 Brochure

The press kit contains the project brochure in both web and printable format.

D.7.5 Leaflet

The press kit contains the project leaflet in both web and printable format.

Appendix E Swiss Local Safety Assessment

E.1 Context for the Local Safety Assessment

The PROuD local safety assessment focused on the identification of potential hazards and associated risks that might affect the safety of the flight trials at the Swiss test sites.

The following activities were carried out:

- Functional Hazard Analysis (FHA) to identify and to describe hazards that are specific to the flight trial scenarios.
- Identification of Safety Requirements (SR) to control the risk associated with the identified hazards during the flight trials.

These activities were carried out during a local safety assessment workshop, where relevant stakeholders provided expert input.

E.1.1 Organisation of the Local Safety Assessment workshop

The local safety assessment workshop was held on May 13th, 2015 at Zurich airport, hosted by REGA.

In order to provide reasonable confidence in the output of the local safety assessment, an adequate representation of different roles and backgrounds of stakeholders was sought, including experts with operational, technical, human factors and safety engineering experience. The availability of a range of backgrounds ensured that during the local safety assessment different perspectives could be drawn upon.

The following stakeholders contributed to the FHA and the identification of SRs:

Name	Affiliation	Role
Ingo Mundt	Engadin Airport	Flight Information Service Officer
Oliver Anthon	Skyguide	System Safety Expert
Roland Wegmann	Skyguide	ATCO
Bastian Hess	Skyguide	Expert Lower Airspace Zurich
Mathias Nyffenegger	Skyguide	Instrument Flight Procedures Expert
Andrea Walser	REGA	Pilot / Flight Instructor
Markus Rieder	REGA	Flight Safety Officer
Valerio Paciucci	IDS	Flight Procedure Design Task Leader
Stefano Bonelli	DBL	Human Factors Expert
Mark Sujan	DBL	Safety Expert

E.1.2 Methodology

The local safety assessment was based on the EUROCONTROL Safety Assessment Methodology [15], which is compliant with Commission Regulation (EU) No 1035/2011 and EASA opinion 03-2014. The description and analysis of the hazards was undertaken in a qualitative manner. Stakeholders participating in the local safety analysis workshop provided consensus judgements about the acceptability of the risk associated with each identified hazard.

The identified hazards are based on the flight trial scenarios at the Swiss test sites. The scope of the local safety assessment was limited to situations that are specific to the flight trials, and that are not already covered by existing safety assessments. The hazards have been categorised to address people, equipment, procedures and environment.

The FHA was undertaken in accordance with the following iterative standard process:

1. Identification and description of the hazard
2. Description of possible consequences of the hazard
3. Description of defences in place
4. Recommendations for further defences to reduce the likelihood of occurrence or the severity of the consequences of the hazard
5. Assessment of acceptability of the risk associated with the hazard

Detailed information about the method used has been provided in D1 (v.2) [2].

E.1.3 Flight trial scenarios

The Swiss flight trials are scheduled to take place between Samedan Airport and Chur Hospital. The scenarios considered are departure from and approach to both test sites.

Detailed information on the flight trial scenarios is available in Deliverable D1 [2].

E.2 Safety Assessment Results

E.2.1 Assumptions

The following assumptions have been made during the FHA:

Assumption ID	Description
ASS-FHA-01	Flight trials will be conducted in summer time when icing conditions can be neglected.
ASS-FHA-02	Flight trials will be conducted in conditions with good visibility in which VFR can be applied.
ASS-FHA-03	Current VFR operations are acceptably safe.
ASS-FHA-04	Pilots participating in the flight trials are adequately trained, experienced and certified for IFR flights.
ASS-FHA-05	Flight trials will take place in Airspace E / G, where under VFR communication with ATC is not necessary.
ASS-FHA-06	The flight procedures have been validated and are suitable for the flight trial scenarios.
ASS-FHA-07	The existing SOP for uploading procedures onto the helicopter flight management system is acceptably safe.
ASS-FHA-08	Existing SOPs (including communication with ATC) are acceptably safe.

ASS-FHA-09	The flight trials will be carried out using existing REGA helicopters and avionics equipment.
ASS-FHA-10	Following missed approach, the new waypoint is already programmed in the flight management system, and does not need to be entered manually.
ASS-FHA-11	During the flight trials, there will be a second REGA member of staff in the cockpit (in addition to the REGA pilot flying).
ASS-FHA-12	A TAS is installed in the helicopter.

E.2.2 Hazard analysis

The identified hazards are described below using standard categories: people, equipment, procedures, and environment.

People

H-FHA-PE-01: Teamwork

Description	The crew during the flight trials will consist of a REGA pilot and a second REGA member of staff. There might be breakdowns in crew teamwork and communication.
Potential consequences	Increased coordination effort and reduced capacity to deal with unexpected emergencies.
Existing mitigation	All pilots have received crew resource management training, which reduces the likelihood of communication problems, and supports pilots in dealing with emergencies.
Recommended mitigation	Crew members shall perform detailed pre-flight briefings, to include clearly defined crew duties in case of emergencies requiring immediate action.
Acceptability	Acceptable

H-FHA-PE-02: Error in programming Flight Procedure into FMS

Description	Pilots make errors in programming procedures into the FMS
Potential consequences	Increased workload. Terrain separation might fall below acceptable levels.
Existing mitigation	Pilots shall follow the LNAV standard procedure for FMS programming.
Recommended mitigation	None
Acceptability	Acceptable

Equipment

No new equipment-related hazards were identified. The equipment that is being used is the standard REGA equipment. Waypoints will be pre-programmed, and there is no need to programme new waypoints en-route.

Procedures

H-FHA-PR-01: Flight Procedure Accuracy

Description	Aspects of the new flight procedure might be inappropriate or inaccurate for the specific flight trial scenario.
Potential consequences	Increased workload. Terrain separation might fall below acceptable levels.
Existing mitigation	Instrument Flight Procedures have been developed following a certified instrument flight procedure design process by IDS FPDO (Flight Procedure Design Organization). The certified FPDO design process complies with ICAO QAM Doc 9906 Vol 1. The FPDO designers are qualified in accordance with ICAO QAM Doc 9906 Vol 2. The supporting design tool (FPDAM) is validated in accordance with ICAO QAM DOC 9906 Vol 3.
Recommended mitigation	The flight procedure shall be tested in a full simulator prior to the flight trials. Flight procedure suitability shall be validated during initial validation phase. Pilots shall apply VFR in case of flight procedure inaccuracies.
Acceptability	Acceptable

Environment

H-FHA-EN-01: Temporary Obstacles

Description	On the day of the flight trial there might be new temporary obstacles that could not be considered beforehand.
Potential consequences	Separation falls below acceptable levels. The worst-case scenario could be collision with the obstacle.
Existing mitigation	Routine local information exchange on obstacles makes it unlikely that unrecognised obstacles would be encountered on the day of the flight trial. Flights will take place at least 300m above ground making encounter with obstacles unlikely. NOTAM consultation.
Recommended mitigation	The validation flights shall be performed in VMC, verifying the absence of unknown obstacles. Pilots shall apply VFR in case of encounter with obstacles.
Acceptability	Acceptable

H-FHA-EN-02: Adverse Weather Conditions

Description	On the day of the flight trial there might be clouds or other adverse weather conditions.
Potential consequences	Separation to obstacles or terrain falls below acceptable levels when approaching Decision Altitude.
Existing mitigation	Strict adherence to the described tracks and minimum altitudes. Flight trials will only take place if weather forecast predicts good visibility and supportive weather conditions (ASS-FHA-01 and ASS-FHA-02).
Recommended mitigation	Pilots shall avoid and fly around areas of poor visibility (as they do in current operations).
Acceptability	Acceptable

H-FHA-EN-03: Local Conflicting Traffic (not REGA)

Description	There might be other traffic within the area of the test flights.
Potential consequences	Increased workload. Separation falls below acceptable levels.
Existing mitigation	Standard procedure for visual lookout whenever flying under VMC. Second crewmember for airspace observation. Communication with ATC. Application of VFR. TAS resolution.
Recommended mitigation	The flight procedure shall consider sector altitude. In case of encountering local traffic in IMC, with the potential to cause loss of separation, pilots shall perform the described contingency procedure, proceed to safe altitude and apply existing collision avoidance mitigation. In VMC, visual manoeuvring for avoidance of local traffic must be performed.
Acceptability	Acceptable

H-FHA-EN-04: Local Conflicting Traffic (REGA)

Description	There might be other REGA traffic departing or approaching in the area covered by the flight trials.
Potential consequences	Increased workload. Separation falls below acceptable levels.
Existing mitigation	Standard procedure for visual lookout whenever flying under VMC. Second crewmember for airspace observation. REGA helicopters share common frequencies, and have flight coordinates given by a common dispatcher.

	TAS resolution.
Recommended mitigation	Other REGA pilots operational on the day of the flight trial shall be briefed about the timing and routes of the flight trials. In case of encountering local traffic in IMC with the potential to cause loss of separation, pilots shall perform the described contingency procedure, proceed to safe altitude and apply existing collision avoidance mitigation. In VMC, visual manoeuvring for avoidance of local traffic must be performed.
Acceptability	Acceptable

H-FHA-EN-05: Military Activity

Description	The missed approach flight path crosses an area designated as military training zone.
Potential consequences	Helicopter caught up in military activity. Possibility of “friendly fire”.
Existing mitigation	None.
Recommended mitigation	Flight trials shall not take place during periods of scheduled military activity in the area of the missed approach flight path.
Acceptability	Acceptable

E.2.3 Recommendations

Based on the above hazard analysis, it is recommended that the validity of the assumption be verified before the flight trials. This applies in particular to the weather conditions, because the application of VFR is a suggested mitigation for a number of hazards.

The safety requirements that have been identified during the hazard analysis are summarised below:

Safety Requirement	Description
SR-FHA-01	Crewmembers shall perform detailed pre-flight briefings, to include clearly defined crew duties in case of emergencies requiring immediate action.
SR-FHA-02	Flight procedure shall be tested in full simulator prior to flight trials.
SR-FHA-03	Flight procedure suitability shall be validated in VMC during initial validation phase.
SR-FHA-04	Pilots shall apply VFR in case of flight procedure inaccuracies.
SR-FHA-05	The validation flights shall be performed in VMC, verifying the absence of unknown obstacles.
SR-FHA-06	Pilots shall apply VFR in case of encounter with obstacles.

SR-FHA-07	Pilots shall avoid and fly around areas of poor visibility.
SR-FHA-08	The flight procedure shall consider sector altitude.
SR-FHA-09	In case of encountering local traffic in IMC, with the potential to cause loss of separation, pilots shall perform the described contingency procedure, proceed to safe altitude and apply existing collision avoidance mitigation.
SR-FHA-10	In VMC, visual manoeuvring for avoidance of local traffic must be performed.
SR-FHA-11	Other REGA pilots operational on the day of the flight trial shall be briefed about the timing and routes of the flight trials.
SR-FHA-12	Flight trials shall not take place during periods of scheduled military activity in the area of the missed approach flight path.

E.3 Conclusions

During the hazard analysis a number of assumptions have been made, and safety requirements have been identified, which are thought to be adequate and sufficient to control the risks associated with the identified hazards during the flight trials to acceptable levels.

A key defence is the application of VFR, which mitigates the risk associated with a number of different hazards. Therefore, it is crucial that the assumption that flight trials will be carried out under good visibility and supportive weather conditions holds.

Appendix F Norwegian Local Safety Assessment

F.1 Context for the Local Safety Assessment

The PROuD local safety assessment focused on the identification of potential hazards and associated risks that might affect the safety of the flight trials at the Norwegian test sites.

The following activities were carried out:

- Functional Hazard Analysis (FHA) to identify and to describe hazards that are specific to the flight trial scenarios.
- Identification of Safety Requirements (SR) to control the risk associated with the identified hazards during the flight trials.

These activities were carried out during a local safety assessment workshop, where relevant stakeholders provided expert input.

F.1.1 Organisation of the Local Safety Assessment workshop

The local safety assessment workshop was held on April 17th, 2015 at Lørenskog base, hosted by NLA.

In order to provide reasonable confidence in the output of the local safety assessment, an adequate representation of different roles and backgrounds of stakeholders was sought, including experts with operational, technical, human factors and safety engineering experience. The availability of a range of backgrounds ensured that during the local safety assessment different perspectives could be drawn upon.

The following stakeholders contributed to the FHA and the identification of SRs:

Name	Affiliation	Role
Lars Amdal	NLA	Pilot
Bjarte Ellingsen	NLA	Operational Safety Expert
Valerio Paciucci	IDS	Flight Procedure Design Task Leader
Stefano Bonelli	DBL	Human Factors Expert
Mark Sujan	DBL	Safety Expert

F.1.2 Methodology

The local safety assessment was based on the EUROCONTROL Safety Assessment Methodology [15], which is compliant with Commission Regulation (EU) No 1035/2011 and EASA opinion 03-2014. The description and analysis of the hazards was undertaken in a qualitative manner. Stakeholders participating in the local safety analysis workshop provided consensus judgements about the acceptability of the risk associated with each identified hazard.

The identified hazards are based on the flight trial scenarios at the Norwegian test sites. The scope of the local safety assessment was limited to situations that are specific to the flights trials, and that are not already covered by existing safety assessments. The hazards have been categorised to address people, equipment, procedures and environment.

The FHA was undertaken in accordance with the following iterative standard process:

6. Identification and description of the hazard
7. Description of possible consequences of the hazard
8. Description of defences in place
9. Recommendations for further defences to reduce the likelihood of occurrence or the severity of the consequences of the hazard
10. Assessment of acceptability of the risk associated with the hazard

Detailed information about the method used has been provided in D1 (v.2) [2].

F.1.3 Flight trial scenarios

The Norwegian flight trials are scheduled to take place at the Lørenskog and Ullevål bases. The scenarios considered are departure from Lørenskog Heliport, and approach to Lørenskog and Ullevål respectively.

Detailed information on the flight trial scenarios is available in Deliverable D1 [2].

F.2 Safety Assessment Results

F.2.1 Assumptions

The following assumptions have been made during the FHA:

Assumption ID	Description
ASS-FHA-01	Flight trials will be conducted in summer time when icing conditions can be neglected.
ASS-FHA-02	Flight trials will be conducted in conditions with good visibility in which VFR can be applied.
ASS-FHA-03	Current VFR operations are acceptably safe.
ASS-FHA-04	Pilots participating in the flight trials are adequately trained, experienced and certified for IFR flights.
ASS-FHA-05	The flight procedures have been ground validated and are suitable for the flight trial scenarios.
ASS-FHA-06	The existing SOP for uploading procedures onto the helicopter flight management system is acceptably safe.
ASS-FHA-07	Existing SOPs (including communication with ATC) are acceptably safe.
ASS-FHA-08	Pilots involved in the flight trials who are not familiar with NLA SOPs will receive adequate briefings.

F.2.2 Hazard analysis

The identified hazards are described below using standard categories: people, equipment, procedures, and environment.

People

H-FHA-PE-01: Teamwork

Description	The crew during the flight trials will consist of a company pilot and a test pilot from the helicopter manufacturer. There might be breakdowns in crew teamwork and communication due to the unfamiliarity of the pilots with each other, and of the test pilot with the local organisational culture.
Potential consequences	Increased coordination effort and reduced capacity to deal with unexpected emergencies.
Existing mitigation	All pilots have received crew resource management training, which reduces the likelihood of communication problems, and supports pilots in dealing with emergencies.
Recommended mitigation	Pilots shall perform detailed pre-flight briefings, to include clearly defined crew duties in case of emergencies requiring immediate action.
Acceptability	Acceptable

H-FHA-PE-02: Missed Approach Manual Entry

Description	Following the missed approach (part of the flight trials), the new approach needs to be entered manually into the flight management system. This might be done incorrectly.
Potential consequences	Increased workload, as the approach needs to be re-entered.
Existing mitigation	Existing SOP for re-computing new approach following missed approach. The procedure verification described in OM A is part of the programming procedure.
Recommended mitigation	None
Acceptability	Acceptable

H-FHA-PR-03: Error in programming Flight Procedure into FMS

Description	Pilots make errors in programming procedures into the FMS
Potential consequences	Increased workload. Terrain separation might fall below acceptable levels.
Existing mitigation	Pilots shall strictly adhere to the procedure verification and entry check given in the OM A 8.3.2 IFR SOP, for programming of instrument approaches.
Recommended mitigation	None
Acceptability	Acceptable

Equipment

H-FHA-EQ-01: Unfamiliar Avionics System

Description	The helicopter that will be used during the flight trials is equipped with an avionics system that is different from the one that is used in the existing NLA helicopters.
Potential consequences	Increased workload and potential mode confusion.
Existing mitigation	The helicopter manufacturer test pilot who will participate in the flight trials is experienced with this type of helicopter avionics system. The participating NLA pilot has completed theoretical differential training to qualify for the avionic system installed.
Recommended mitigation	The participating NLA pilots shall receive detailed briefings about the helicopter avionics system that will be used during the flight trials.
Acceptability	Acceptable

H-FHA-EQ-02: Unavailable GNSS

Description	The RNP flight procedures are based on GNSS. In extremely rare circumstances this accuracy might not be available.
Potential consequences	Increased workload. Terrain separation might fall below acceptable levels.
Existing mitigation	Pilots have the possibility of verifying GPS availability during the pre-flight phase. The avionic system has alerting and monitoring capability that provides, during the flight execution, integrity warning in case GPS is not usable for the defined navigation specification.
Recommended mitigation	Pilots shall apply VFR in case of GNSS unavailability.
Acceptability	Acceptable

Procedures

H-FHA-PR-01: Flight Procedure Accuracy

Description	Aspects of the new flight procedure might be inappropriate or inaccurate for the specific flight trial scenario.
Potential consequences	Increased workload. Terrain separation might fall below acceptable levels.
Existing mitigation	Instrument Flight Procedures have been developed following a certified instrument flight procedure design process by IDS FPDO (Flight Procedure Design Organization). The certified FPDO design process complies with ICAO QAM Doc 9906 Vol 1. The FPDO designers are qualified in accordance with ICAO QAM Doc 9906 Vol 2. The

	supporting design tool (FPDAM) is validated in accordance with ICAO QAM DOC 9906 Vol 3.
Recommended mitigation	Flight procedure suitability shall be validated in VMC during initial validation phase.
Acceptability	Acceptable

Environment

H-FHA-EN-01: Temporary Obstacles

Description	On the day of the flight trial there might be new temporary obstacles that could not be considered beforehand.
Potential consequences	Separation falls below acceptable levels. The worst-case scenario could be collision with the obstacle.
Existing mitigation	Routine local information exchange on obstacles makes it unlikely that unrecognised obstacles would be encountered on the day of the flight trial.
Recommended mitigation	The validation flights shall be performed in VMC, verifying the absence of unknown obstacles. Pilots shall apply VFR in case of encounter with obstacles.
Acceptability	Acceptable

H-FHA-EN-02: Adverse Weather Conditions

Description	On the day of the flight trial there might be patches of fog or other adverse weather conditions.
Potential consequences	Separation to obstacles or terrain falls below acceptable levels when approaching Decision Altitude.
Existing mitigation	Strict adherence to the described tracks and minimum altitudes. Flight trials will only take place if weather forecast predicts good visibility and supportive weather conditions (ASS-FHA-01 and ASS-FHA-02).
Recommended mitigation	Pilots shall avoid and fly around areas of poor visibility (as they do in current operations).
Acceptability	Acceptable

H-FHA-EN-03: Local Conflicting Traffic (not NLA)

Description	There might be other traffic within the area of the test flights.
Potential consequences	Increased workload. Separation falls below acceptable levels.

Existing mitigation	Standard procedure for visual lookout whenever flying under VMC. Communication with ATC. Application of VFR. TCAS resolution.
Recommended mitigation	The flight procedure shall consider sector altitude. In case of encountering local traffic in IMC, with the potential to cause loss of separation, pilots shall perform the described contingency procedure, proceed to safe altitude and apply existing collision avoidance mitigation. In VMC, visual manoeuvring for avoidance of local traffic must be performed.
Acceptability	Acceptable

H-FHA-EN-04: Local Conflicting Traffic (NLA)

Description	There might be other NLA helicopters departing or approaching in the area covered by the flight trials.
Potential consequences	Increased workload. Separation falls below acceptable levels.
Existing mitigation	Standard procedure for visual lookout whenever flying under VMC. There is limited NLA traffic. NLA helicopters share common frequencies, and have flight coordinates given by a common dispatcher. TCAS resolution.
Recommended mitigation	Other NLA pilots operational on the day of the flight trial shall be briefed about the timing and routes of the flight trials. In case of encountering local traffic in IMC with the potential to cause loss of separation, pilots shall perform the described contingency procedure, proceed to safe altitude and apply existing collision avoidance mitigation. In VMC, visual manoeuvring for avoidance of local traffic must be performed.
Acceptability	Acceptable

F.2.3 Recommendations

Based on the above hazard analysis, it is recommended that the validity of the assumption be verified before the flight trials. This applies in particular to the weather conditions, because the application of VFR is a suggested mitigation for a number of hazards.

The safety requirements that have been identified during the hazard analysis are summarised below:

Safety Requirement	Description
SR-FHA-01	Pilots shall perform detailed pre-flight briefings, to include clearly defined crew duties in case of emergencies requiring immediate action.
SR-FHA-02	The participating NLA pilots shall receive detailed briefings about the

	helicopter avionics system that will be used during the flight trials.
SR-FHA-03	Pilots shall apply VFR in case of GNSS unavailability.
SR-FHA-04	Flight procedure suitability shall be validated in VMC during initial validation phase.
SR-FHA-05	The validation flights shall be performed in VMC, verifying the absence of unknown obstacles.
SR-FHA-06	Pilots shall apply VFR in case of flight procedure inaccuracies.
SR-FHA-07	Pilots shall apply VFR in case of encounter with obstacles.
SR-FHA-08	Pilots shall avoid and fly around areas of poor visibility.
SR-FHA-09	The flight procedure shall consider sector altitude.
SR-FHA-10	In case of encountering local traffic in IMC, with the potential to cause loss of separation, pilots shall perform the described contingency procedure, proceed to safe altitude and apply existing collision avoidance mitigation.
SR-FHA-11	In VMC, visual manoeuvring for avoidance of local traffic must be performed.
SR-FHA-12	Other NLA pilots operational on the day of the flight trial shall be briefed about the timing and routes of the flight trials.

F.3 Conclusions

During the hazard analysis a number of assumptions have been made, and safety requirements have been identified, which are thought to be adequate and sufficient to control the risks associated with the identified hazards during the flight trials to acceptable levels.

A key defence is the application of VFR, which mitigates the risk associated with a number of different hazards. Therefore, it is crucial that the assumption that flight trials will be carried out under good visibility and supportive weather conditions holds.

Appendix G PROuD questionnaires

Swiss Campaign (Samedan, Chur and Low Level Network between Samedan and Chur)	
Questionnaire	Answers (7/7)
2nd Swiss Campaign (only Samedan approaches)	
Questionnaire	Answers (4/4)
Norwegian Campaign (Lørenskog, Ullevål)	
Questionnaire	Answers (14)
Denmark Campaign	
Questionnaire	Answers (3)

For both the first and second Swiss campaign, all the pilots participating to the flight trials filled the questionnaires.
For the Norwegian and Denmark campaigns, as the procedures were operational, many pilots received the request of filling the questionnaire; the total number is not available.

G.1 Swiss questionnaire

Screenshots of on-line questionnaire produced for Swiss campaign are reported hereafter, as example:

PROuD - Questionnaire about the impact of the new procedures on operations

Hello.

This brief questionnaire aims at collecting your feedback about your experience with the new procedures you have flown and get your expert opinion regarding their possible impact on operations. We would like to get as much as possible information on the benefits and the possible drawbacks of this kind of procedures, in order to generate a final report to be provided to SESAR.

Some notes:

- Please note that some questions refer to what you have experienced during the flights with the new procedures, while others ask to provide an expert guess or prevision of the impact the new procedures could have if put in operations

- When motivating your answers, please try to provide examples from the flights you have performed or from your professional experience.

- When answering the questions on the expected impact, please take in mind the different kind of missions and weather conditions you could experience in your operational life

- When we say "current operations", we refer to VFR

- Try to explain the technical terms and do not use acronyms

Thank you for your time and help

The PROuD Team

*Campo obbligatorio

Name *

Surname *

WORKLOAD - Please rate the workload you have experienced during the demonstration flights, comparing it with the one you experience during

current operations

NOTE: Rate 3 if the workload experieced was the same of your experience with the current procedures

Departure Samedan *

	1	2	3	4	5	
Much lower	○	○	○	○	○	Much higher

Departure Chur *

	1	2	3	4	5	
Much lower	○	○	○	○	○	Much higher

Gate to gate *

	1	2	3	4	5	
Much lower	○	○	○	○	○	Much higher

Approach Samedan *

	1	2	3	4	5	
Much lower	○	○	○	○	○	Much higher

Approach Chur *

	1	2	3	4	5	
Much lower	○	○	○	○	○	Much higher

Please motivate your previous answers

Situation Awareness

SITUATION AWARENESS - Please rate the situation awareness you have experienced during the demonstration flights, comparing it with the one you experience during current operations *

NOTE: Rate 3 if the situation awareness experieced was the same of your experience with the current procedures

	1	2	3	4	5	
Much lower	◯	◯	◯	◯	◯	Much higher

Please motivate your previous answer.

SAFETY - Please rate the expected impact of the new procedures on flight safety, comparing it with current operations

NOTE: Rate 3 if the perceived safety was the same of your experience with the current procedures

Departure Samedan *

	1	2	3	4	5	
Much lower	◯	◯	◯	◯	◯	Much higher

Departure Chur *

	1	2	3	4	5	
Much lower	◯	◯	◯	◯	◯	Much higher

Gate to gate *

	1	2	3	4	5	
Much lower	◯	◯	◯	◯	◯	Much higher

Approach Samedan *

	1	2	3	4	5	
Much lower	○	○	○	○	○	Much higher

Approach Chur *

	1	2	3	4	5	
Much lower	○	○	○	○	○	Much higher

Please motivate your previous answers.

Can you foresee any circumstances in which the new procedures can generate a safety issue (e.g. EGNOS coverage unavailability, systems errors, etc...)

Accessibility and Availability

ACCESSIBILITY - Please rate the expected impact of the new procedures on the possibility to land with respect to current operations *

NOTE: please refer to your operational experience and the weather conditions typical of your area of work

- ○ + 50%
- ○ + 40%
- ○ + 30%
- ○ + 20%
- ○ + 10%
- ○ 0
- ○ - 10%
- ○ - 20%
- ○ - 30%
- ○ - 40%

- - 50%

Please motivate your previous answer.

AVAILABILITY - Please rate the expected impact of the new procedures on the possibility to take off with respect to current operations *

NOTE: please refer to your operational experience and the weather conditions typical of your area of work

- + 50%
- + 40%
- + 30%
- + 20%
- + 10%
- 0
- - 10%
- - 20%
- - 30%
- - 40%
- - 50%

Please motivate your previous answer.

Flight performance

EFFICIENCY - Please rate the expected impact of the new procedures on flight time efficiency with respect to current operations *

NOTE: please refer to your operational experience and the weather conditions typical of your area of work

- + 50%
- + 40%
- + 30%
- + 20%

- + 10%
- 0
- - 10%
- - 20%
- - 30%
- - 40%
- - 50%

Please motivate your previous answer.

PREDICTABILITY - Please rate the expected impact of the new procedures on flight time predictability with respect to current operations *

NOTE: please refer to your operational experience and the weather conditions typical of your area of work

- + 50%
- + 40%
- + 30%
- + 20%
- + 10%
- 0
- - 10%
- - 20%
- - 30%
- - 40%
- - 50%

Please motivate your previous answer.

Human performance

OPERATING METHODS - Please rate how much do you agree with the following statement "The changes introduced by the adoption of the new procedures are expected to be

feasible, consistent and acceptable as with respect to current operating methods and to the overall operational environment" *

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

Please motivate your previous answer.

ERRORS: Can you foresee any circumstances in which the new procedures and the related activities (programming, activating, etc.) can lead you to make errors?

SYSTEM DEGRADATION: In case the system degrades, do you think you will be able to handle the situation without compromising safety?

Invia

Non inviare mai le password tramite Moduli Google.

Powered by

Questo modulo è stato creato all'interno di Deep Blue.

Segnala una violazione - Termini di servizio - Ulteriori termini

Appendix H Minima used for weather data analysis

DAY	Approach		
	NEW(LNAV, GPS)		
		Visibility	800 m
		Ceiling	544 ft
	NEW (LPV, EGNOS)		
		Visibility	800 m
		Ceiling	374 ft
NIGHT	Approach		
	NEW(LNAV, GPS)		
		Visibility	3000m
		Ceiling	1000ft
	NEW (LPV, EGNOS)		
		Visibility	800m
		Ceiling	374

Table 58: Minima for Lørenskog approach: LNAV vs LPV

DAY	Approach		
	CURRENT (VFR)		
		Visibility	800 m
		Ceiling	No ceiling (up to 2500ft)
	NEW (LPV, EGNOS)		
		Visibility	800 m
		Ceiling	374 ft
NIGHT	Approach		
	CURRENT (VFR)		
		Visibility	3000m
		Ceiling	No ceiling (up to 2500 ft)
	NEW		
		Visibility	800 m
		Ceiling	374 ft

Table 59: Minima for Lørenskog approach: VFR vs LPV

DAY	Departure		
	CURRENT (VFR)		
		Visibility	800 m
		Ceiling	200 ft
	NEW PinS		
		Visibility	800 m
		Ceiling	200ft
NIGHT	Departure		
	CURRENT (VFR)		
		Visibility	3000m
		Ceiling	1000ft
	NEW PinS		
		Visibility	1000 m
		Ceiling	200 ft

Table 60: Minima for Lørenskog Departure: VFR vs PinS

Appendix I Traceability between PROuD Objectives, Phases of Flight, KPA, Exercises and Scenarios

Objective	Phase of flight	KPA	Exercises	Scenario
OBJ-0209-001	Approach	Safety	EXE-02.09-D-004 EXE-02.09-D-006	SCN-0209-003 SCN-0209-004
OBJ-0209-002	Approach	Safety	EXE-02.09-D-007	SCN-0209-005
OBJ-0209-003	Approach	Accessibility	EXE-02.09-D-004 EXE-02.09-D-006	SCN-0209-003 SCN-0209-004
OBJ-0209-004	Approach	Accessibility	EXE-02.09-D-007	SCN-0209-005
OBJ-0209-005	Approach	Environmental Sustainability	EXE-02.09-D-004 EXE-02.09-D-006	SCN-0209-003 SCN-0209-004
OBJ-0209-006	Approach	Environmental Sustainability	EXE-02.09-D-007	SCN-0209-005
OBJ-0209-007	Approach	Efficiency	EXE-02.09-D-004 EXE-02.09-D-006	SCN-0209-003 SCN-0209-004
OBJ-0209-008	Approach	Efficiency	EXE-02.09-D-007	SCN-0209-005
OBJ-0209-010	Approach	Accessibility	EXE-02.09-D-001	SCN-0209-001
OBJ-0209-011	Departure	Safety	EXE-02.09-D-002 EXE-02.09-D-005 EXE-02.09-D-008	SCN-0209-001 SCN-0209-003 SCN-0209-005
OBJ-0209-012	Departure	Availability	EXE-02.09-D-002 EXE-02.09-D-005 EXE-02.09-D-008	SCN-0209-001 SCN-0209-003 SCN-0209-005
OBJ-0209-013	Departure	Environmental sustainability	EXE-02.09-D-002 EXE-02.09-D-005 EXE-02.09-D-008	SCN-0209-001 SCN-0209-003 SCN-0209-005
OBJ-0209-014	Departure	Efficiency	EXE-02.09-D-002 EXE-02.09-D-005 EXE-02.09-D-008	SCN-0209-001 SCN-0209-003 SCN-0209-005
OBJ-0209-015	Heliport-to-hospital	Efficiency and service availability	EXE-02.09-D-003	SCN-0209-002
OBJ-0209-016	Heliport-to-hospital	Predictability	EXE-02.09-D-003	SCN-0209-002
OBJ-0209-017	Approach/ Departure	HP (Operating methods)	EXE-02.09-D-001 EXE-02.09-D-002 EXE-02.09-D-003 EXE-02.09-D-004 EXE-02.09-D-005 EXE-02.09-D-006 EXE-02.09-D-007 EXE-02.09-D-008	SCN-0209-001 SCN-0209-003 SCN-0209-004 SCN-0209-005
OBJ-0209-018	All	HP (Pilots' task performance)	EXE-02.09-D-001 EXE-02.09-D-002 EXE-02.09-D-003 EXE-02.09-D-004 EXE-02.09-D-005 EXE-02.09-D-006 EXE-02.09-D-007 EXE-02.09-D-008	SCN-0209-001 SCN-0209-002 SCN-0209-003 SCN-0209-004 SCN-0209-005
OBJ-0209-019	Arrival-Approach	HP (Performance of the technical system)	EXE-02.09-D-001 EXE-02.09-D-004 EXE-02.09-D-006 SCN-0209-007	SCN-0209-001 SCN-0209-003 SCN-0209-004 SCN-0209-005
OBJ-0209-102	Approach	Safety	EXE-02.09-D-001	SCN-0209-001

OBJ-0209-106	Approach	Environmental Sustainability	EXE-02.09-D-001	SCN-0209-001
OBJ-0209-108	Approach	Efficiency	EXE-02.09-D-001	SCN-0209-001
OBJ-0209-116	Heliport-to-hospital	Safety	EXE-02.09-D-003	SCN-0209-002

Table 61: Traceability between PROuD Objectives (including demonstration objective status), Phases of Flight, KPA, Exercises and Scenarios

The legend related to the filling of "Objective" cell is the following:

- green → demonstration objective status is "OK"
- yellow → demonstration objective status is "Partially OK"
- red→ demonstration objective status is "NOK"

Appendix J Denmark Campaign

The following RNAV procedures have been flown in Denmark and pilots' feedback have been collected to evaluate the pilots' experience during the performance of the PinS RNP APCH procedures and the possible impact of these procedures in HEMS.

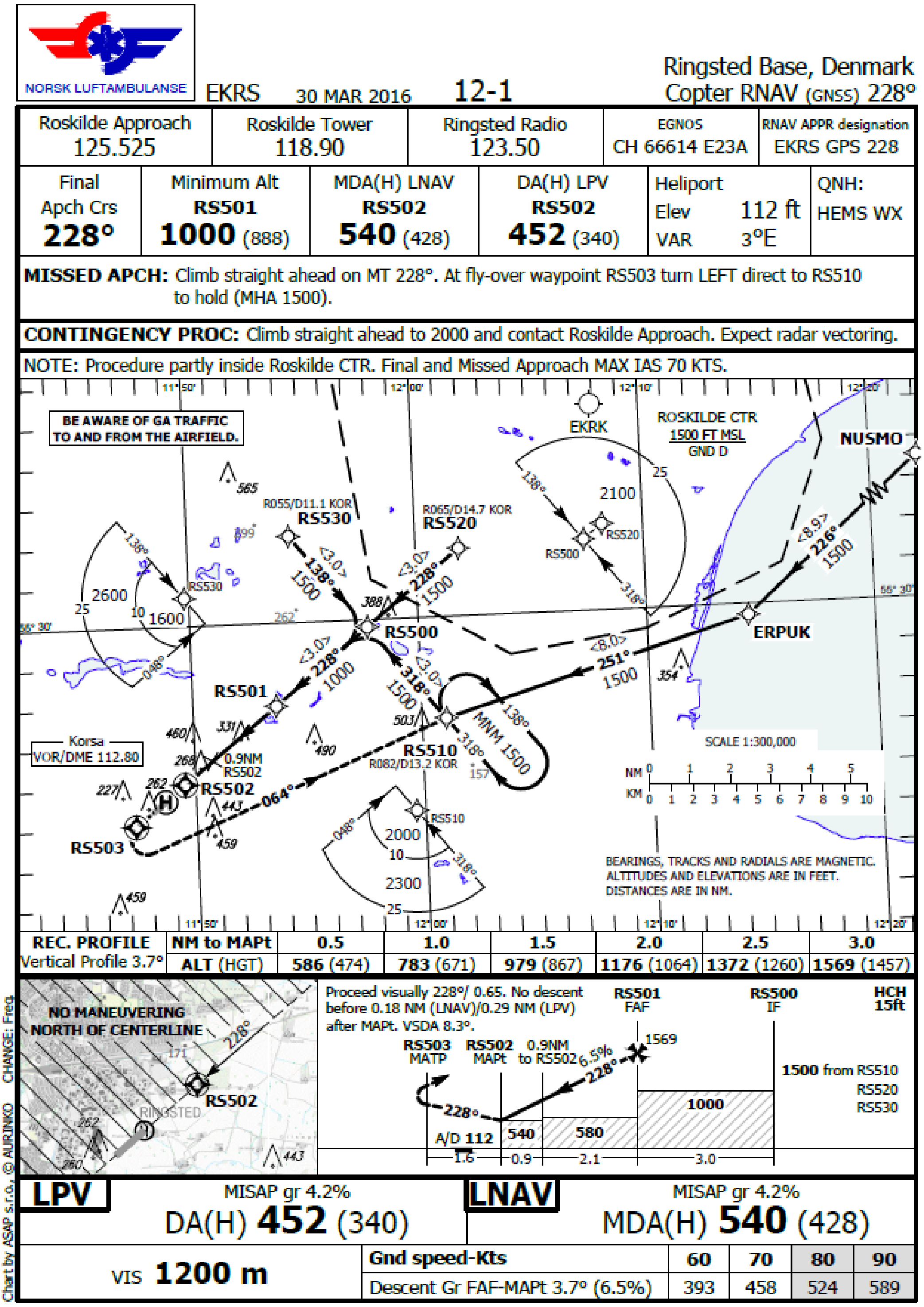

Figure 6: RNAV (GNSS) 228° - Ringsted Base, Denmark

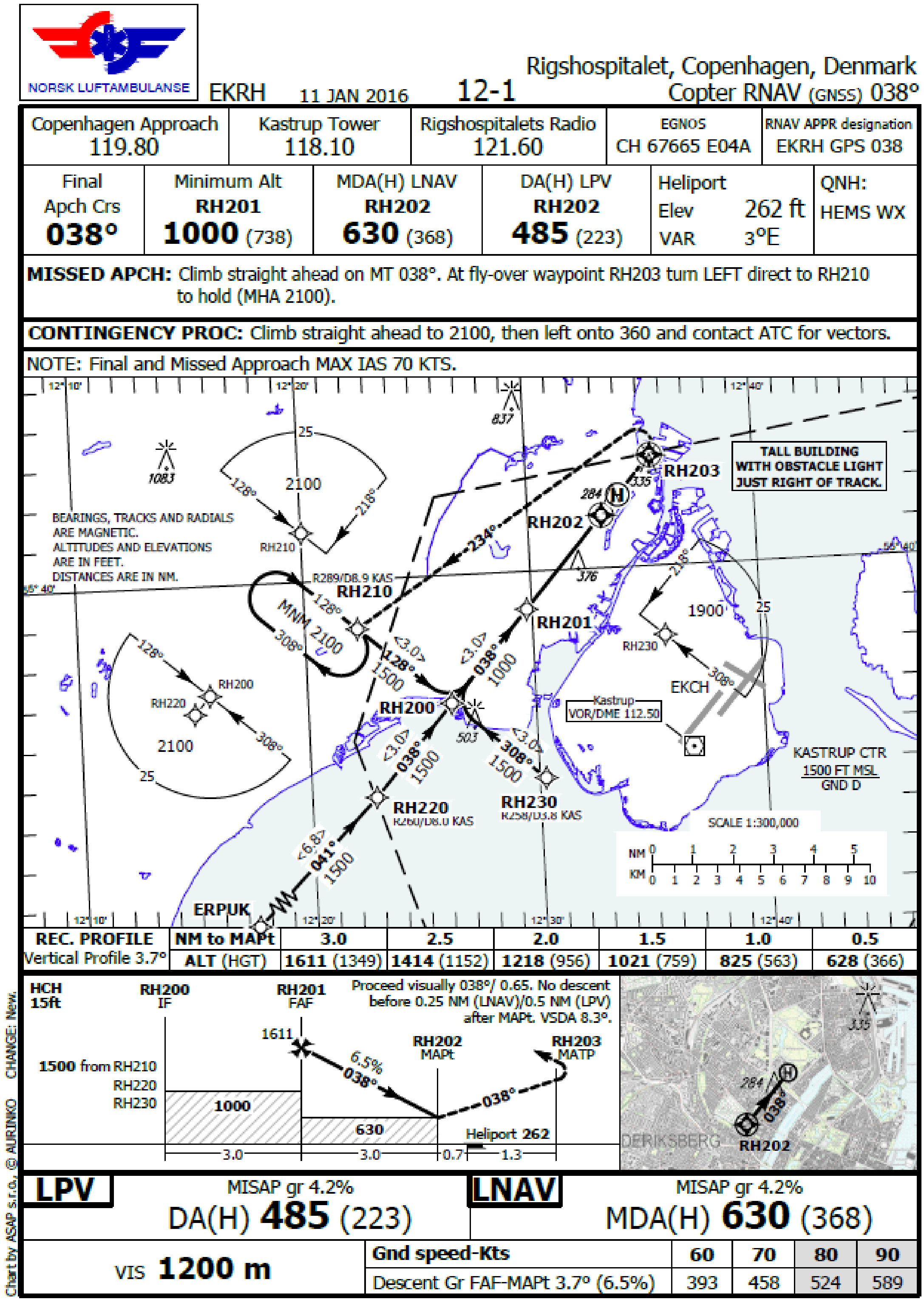

Figure 6: RNAV (GNSS) 038° - Righospitalet, Copenhagen, Denmark

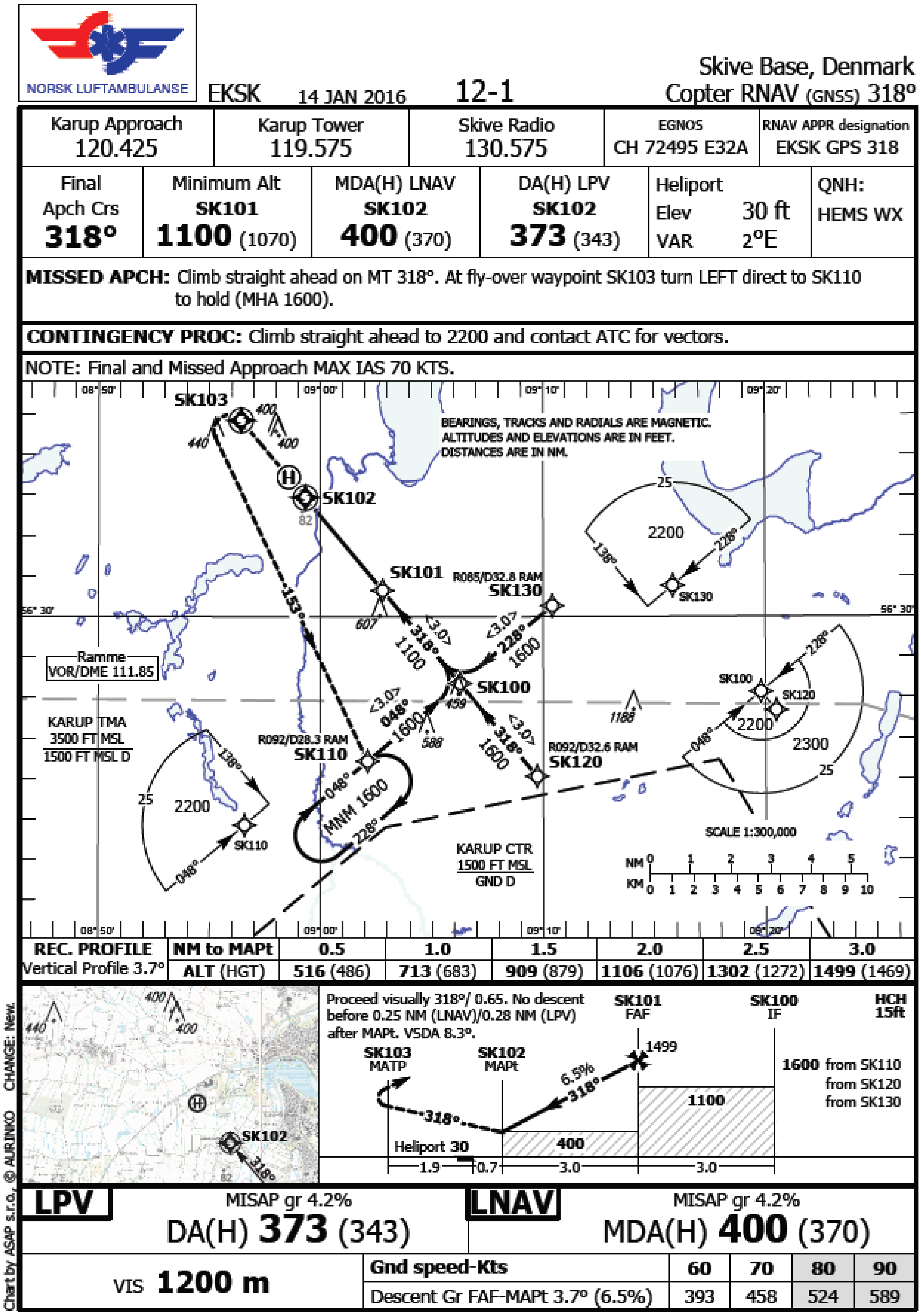

Figure 6: RNAV (GNSS) 318° - Skive Base, Denmark

J.1 Summary of post-flights questionnaire results

In the operational framework of the Norwegian campaign, PinS procedures have been performed also in Denmark at the following sites: Rigshospitalet, Ringsted, Skejby and Skive.

Danish CAA authorized PinS RNP approach procedures based on the design and flightvalidation of these procedures. They also accepted the weather reporting system as fulfilling the requirement to visibility reporting system ref 965/2012 (EASA OPS) CAT.OP.MPA.300 and CAT.OP.MPA.305(b).

The procedures flown in this second additional campaign are PinS RNP APCH with LPV minima but the procedures have been flown down to LNAV minima due to lack of an EGNOS working agreement with ESSP.

A summary of the results collected from the post-flight questionnaire is reported here below.

In regard to the level of **workload** experienced, on a scale from 1 to 5 (where 1= much lower and 5= much higher than the one experienced in current operations) the average value for the operations at Rigshospitalet is 3,5/5, a slightly higher value with respect to current operations, as stated by one of the pilots "*I have only flown the PinS approach at Rigshospitalet once, and my experience was that the airspace coordination and high traffic density gave higher workload. Hopefully (it) will be better with more experience*".

The average workload value for the flights at Ringsted is 2/5. Slightly lower if compared to the current operations.

Pilots affirmed also that with some procedures training, they would be able to get familiar with the new PinS, thus improving their performance and decreasing the level of workload.

In regard to the **situation awareness**, the answers demonstrated that this KPA does not decrease; some pilots did not experience any differences with respect to the current operations, while others reported a very high value. The final average one is 4/5.

With regard to the **safety**, pilots affirmed that it is higher than the current operations, in fact the average value for all the four sites where the procedures have been flown is 4,5/5.

The positive answers can be justified by the possibility to fly also when bad weather conditions do not allow to operate in VFR. As one of the pilots wrote "*We are now able to fly into the clouds and land on base/hospital in bad weather*."

Hazardous circumstances in which the new procedures can produce safety issues have been identified and summarised in the following points:

- VFR traffic below the clouds;
- Other IFR/IMC traffic in class G;
- Icing;
- Descending on wrong waypoint (for LNAV approaches);
- Loss of GPS signal.

The mitigation mean proposed by the pilots is to have a "backup plan" that can avoid dramatic consequences.

The **accessibility** and the **availability** values are around the +30-40%, meaning that the introduction of the new procedures would have a positive impact on the current operations; as stated by one of the pilots, in relation to the availability "*40% is a wild guess, but experience to the local area shows that we often have lower clouds than other places in Denmark. In respect to this I think we will now be able to take-off and rendezvous with the ambulance at a safe location*."

With regard to the **efficiency** and the **predictability**, no changes are foreseen with respect to the current operations, as the same average percentage (+17% for both the KPAs) demonstrates.

Concerning **human performance**, slight increment is in operating methods have been reported by the pilots; while regarding the potential errors that the procedures and the related activities can generate, pilots identified the following issues related to possible difficulties in the interaction with the system:

- Descending to wrong waypoint only with LNAV (vertical guidance is provided when using LPV);
- Forgetting the activation of the approach function on the GPS.

The mitigation mean suggested to avoid the above mentioned errors is to modify and improve the design of the system.

The results of the questionnaire, according to the pilots' experience, demonstrate a positive impact of the new procedures on the KPAs selected for the validation.

More detailed information can be found in Appendix G.

Appendix K Samedan Flight Inspection Reports

To limit the length of this Demonstration Report, a copy of Samedan flight inspection reports (produced by FCS – Flight Calibration Services) related to the first and the second Samedan campaigns are reported in a separate document named “LSD.02.09-D02-Demonstration Report (B1) - Appendix K”.

-END OF DOCUMENT-