INSuRE Demonstration Report

Document information	
Project Title	INSuRE
Project Number	RPAS.02
Project Manager	IDS
Deliverable Name	INSuRE Demonstration Report
Edition	00.01.01
Template version	01.00.00
Task contributors	
IDS; ANS CR; SD	

Abstract

This document is the Demonstration Report of INSuRE 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.
Conclusions of INSuRE simulation and flight campaigns are pointed out as well as recommendations for future RPAS activities.
This document also provides a summary of the communication activities performed during the project execution.

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Rational for rejection
None.

Document History

Edition	Date	Status	Author	Justification
00.00.01	18/12/2015	Draft	IDS	New Document
00.00.02	23/12/2015	Draft	IDS	Version with SD and IDS input from Flight Campaign for internal review
00.01.00	30/12/2015	Final	IDS	Final version for internal review and approval preliminary to handover to SESAR JU
00.01.01	21/03/2016	Final	IDS	Final version implementing SJU Assessment Report

				comments (see RPAS 02-D02_SJU_Assessment_report file for details)

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This deliverable consists of SJU foreground.

Table of Contents

List of tables

List of figures

Executive summary

The INSuRE Project started on 6th October 2013 and executed through the cooperation of three entities forming the INSuRE Consortium: Ingegneria Dei Sistemi S.p.A. (IDS), Air Navigation Services of the Czech Republic (ANS CR) and Sistemi Dinamici (SD).

The INSuRE purpose was to demonstrate the operational management of one rotary wing RPAS, piloted from a fixed station on ground, evaluating its interaction with other vehicles in a non-segregated airspace, the operational aspects in implementing nominal ATCO procedures, the safety aspects to be assessed to allow safe integration in controlled airspaces and the human factor aspects addressing both pilot and ATCOs workload and reactions.

In particular, the prime objectives of the INSuRE Demonstration were:

Objective 1. Demonstrate the safe integration of the RPAS in airport surface operations preliminary to take off and landing.

Objective 2. Demonstrate the integration of the RPAS in non-segregated Air Traffic Management through a Demonstration Campaign that can significantly test all aspects of integration from controlling procedures and verification of integrity of control link, to communication between RPAS pilot and ATCOs.

Objective 3. Demonstrate safe execution of RPAS flights using a collision detection capability compatible with existing operating procedures, identify alternative RPAS surveillance, communications and navigation solutions.

The demonstration overall activities included, in the INSuRE approach, both simulation and flight campaign within two different airspaces:

- CTR/TMA BRNO (Czech Republic) for the real time simulations;
- TARANTO Grottaglie Airport (ICAO: LIBG) for the flight trials.

The original approach foreseen in the INSuRE Demonstration Plan was to consider the BRNO scenario for both simulations and flight trials and implement incremental steps, in line with the SESAR validation and demonstration strategy. The execution of the steps described hereafter and detailed in this document allowed the overall fulfillment of the project goals, building on all the results of the different project phases.

The first step has been the definition of an INSuRE Demonstration Plan (project deliverable D01), identifying the exercises to fulfill the project objectives either through real time simulations or through life trials. Then, the project has detailed the operational concept and processes necessary to pave the way for the simulation activities and in parallel for the operational safety assessment.

The safety assessment activities covered all elements of the overall system ï people, procedures and equipment - together with the environment characteristics, as per the safety methodology adopted (EATMN Safety Assessment Methodology - SAM, developed by EUROCONTROL - and includes procedures being developed by ANS CR or collected as the best practices).

As first demonstration activity, the real time simulations were executed in January 2014 with the participation of two RPAS Pilots, three certified ATCOs, one manned aircraft pilot, the ATM experts evaluating the realism of the simulation and the system engineers supporting the configuration and set up of the platform. The simulations encompassed different traffic situations, nominal and non-nominal events. The simulation platform included: Tower and environment ATM simulator with the relevant Tower and Ground Controller Working Positions, two RPAS simulators, a cockpit simulator and surrounding traffic generator to complete the realism of more complex exercises situations.

During the process for the request and issuing of the Permit to Fly, the interaction with the Civil Aviation Authority of Czech Republic and with the Italian CAA (ENAC) has been strict and several meetings have been held to clarify the needed input and the foreseen process which, for the relevant class of RPAS (SD-150 HERO, a rotor-blades RPAS with MTOW of 150kg) has been rather new to the stakeholders and implied the definition of specific requirements for the RPAS pilots as well as for the characteristics of the operations to be approved for execution in flight. Due to logistic reasons and time and weather constraints, the project partners have agreed to perform the flight trials in Italy instead of in Czech Republic. In Italy, the selected temporary segregated area (through NOTAM issued by ENAV) for the flight trials has been LI R315 in Grottaglie (published in the Italian AIP and including part of the runway of Taranto Grottaglie airport). The characteristics of the selected area for the RPAS flight, being very similar to the one originally planned for Brno, allowed the achievement of the project objectives, including operational procedures for interaction with ENAV, ENAC and Airport authorities.

The resulting INSuRE recommendations are summarized hereafter and are proposed as points for consideration in the set-up of future RPAS demonstrations as well as operational activities:

- The use of ADS-B Out capability on board a of an ADS-B receiver on ground at the Pilot station is recommended as a first step in the implementation of a traffic awareness and detection capability, although only useful for issuing of warning and alerts on cooperative traffic and requiring pilot intervention for the avoidance manoeuver.
- Future work to define and standardize a D&A automatic capability for RPAS is considered the key for real integration of RPAS in ATM.
- A standard process for issuing of RPAS certification and PtF should be defined for Europe, in particular identifying the minimum set of requirements per RPAS class for the airborne and ground system as well as for the pilots in command.
- Integration of multiple RPAs (one pilot controlling 2 RPAs from the same ground control station): the 2 pilots who tested this configuration (in the simulation campaign) declared that they did not feel safe enough in handling 2 systems simultaneously and that their workload was too high in particular during take-off and landing phases. ATCOs also reported that RPAS pilot response to clearance was slower when controlling 2 RPAS from the same Unmanned Controlled Station (EXE-RPAS.02-004, OBJ-RPAS 02-210). This could indeed be related to the HMI as suggested later in the assessment of the specific exercise. The resulting suggestion from the project is anyhow that human factor integration concepts for a single pilot in charge of several RPAs deserve special attention and further studies and validation in complex traffic scenarios.
- The importance of a collaborative environment and of having clear roles and responsibilities in place for the operational handling of RPAS flight activities has been identified as key for the success of the INSuRE Flight campaign execution and is recommended to be defined for all RPAS operations to be run in controlled airspaces.
- The operational procedure for an RPAS taking-off from outside the runway or defined helipad and not following a preliminary taxiing phase using defined taxiways should be in place and applicable to ATCOs and RPAS Pilot in Command.
- An integrated multi-frequency voice segment in the UCS should be considered for future implementation since it can represent a good upgrade, reducing the need of using different appliances (e.g. communication through VHF, UHF radio and phone as backup) to keep all communication under control.

1 Introduction

1.1 Purpose of the document

This document provides the Demonstration Report for RPAS.02 – INSuRE Project. It describes the results of demonstration exercises defined in milestone Final Demonstration Plan [12] – Ed.00.01.00, 08/05/2015 (which reports updated information with respect to in the first official delivery Demonstration Plan [7] – Ed. 00.01.01, 28/02/2014) 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 are informed about the INSuRE project activities 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 INSuRE stakeholders, who had a role in the different phases of the project:
  - CAA of the Czech Republic;
  - Consortium Members (ANS CR, SD, IDS) personnel.

Other targeted readers:

- SESAR RPAS Demonstration - Project Managers;
- BRNO Airport Operator;
- Regulatory authorities (including EASA and other European CAAs);
- SESAR community as a whole.

1.3 Structure of the document

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

The INSuRE Demonstration Report document is organised as follows:

- Chapter 1- this introduction;
- Chapter 2 - context of the demonstration presenting at a high-level the exercises under the scope of the Demonstration Report;
- Chapter 3 - project management;
- Chapter 4 - execution of the demonstration exercises (preparation, execution and deviation from planned activities);
- Chapter 5 - exercises results of the demonstration activities referring to both simulation and flight campaign;
- Chapter 6 - details of each INSuRE exercise;
- Chapter 7 - summary of the Communication Activities performed during the INSuRE project execution;
- Chapter 8 - next steps for RPAS integration into non-segregated airspace;
- Chapter 9 - References.

1.4 Glossary of terms

The following are the definitions of the main concepts that are relevant for the Project and are used with the meaning presented below, throughout the INSuRE project description:

Term	Definition
ADS-B application	ADS-B application is designed to become the primary surveillance method for controlling aircraft worldwide. In the United States, ADS-B is an integral component of the NextGen national airspace strategy for upgrading or enhancing aviation infrastructure and operations. The ADS-B system can also provide traffic and government generated graphical weather information through TIS-B and FIS-B applications. ADS-B enhances safety by making an aircraft visible, real time, to ATC and to other appropriately equipped ADS-B aircraft with position and velocity data transmitted every second. ADS-B data can be recorded and downloaded for post-flight analysis. ADS-B also provides the data infrastructure for inexpensive flight tracking, planning, and dispatch.
Collision Avoidance	Function of the D&A procedure that allows performing the necessary actions to prevent an intruder from entering the RPAS Collision Volume. This function is activated when the function of Self-Separation fails.
Collision Avoidance Threshold	Boundary that establishes the necessity of the Collision Avoidance to avoid possible collisions within the Collision Volume.
Conflict	Any situation that involves two or more aircrafts or an aircraft and one or more obstacles in which the required separation may be compromised.
Detect and Avoid	The RPAS ability to maintain safe conditions and avoid collisions with other elements of the air traffic or obstacles D&A provides the functions of Self-Separation and Collision Avoidance to meet the requirements of the rules on the "See and Avoid".
RPAS intent	Information on planned future RPAS behaviour, which can be obtained from the RPAS systems (Ground Control Station). It is associated with the commanded trajectory and will enhance airborne functions. The RPAS intent data correspond either to RPAS trajectory data that directly relate to the future aircraft trajectory as programmed inside the Ground Control Station, or the aircraft control parameters as managed by the flight control system.
ATC Clearance	ATC Clearance Authorization for an aircraft to proceed under conditions specified by an air traffic control unit.
ATC Instruction	Directives issued by air traffic control for the purpose of requiring a pilot to take a specific action.
ATS Route Segment	A portion of an Air Traffic Service (ATS) route to be flown between two consecutive significant points.
Flight intent	The future RPAS trajectory expressed as a 4-D profile until destination (taking account of RPAS performance, weather, terrain, and ATM service constraints), calculated and “owned” by the RPAS ground and airborne systems, and agreed by the pilot.
Flight Operation Manager	The Flight Operation Manager appointed by the RPAS Operator is responsible for the Flight Campaign and coordinates the activities of the RPAS Pilots, Flight Test Engineers and RPAS system engineering team.

Term	Definition
Flight Test Engineer	The flight test engineer has overall responsibility for the planning of a specific flight test phase, which includes preparing the test plans in conjunction with other systems engineers, overseeing the build-up of the aircraft to the proper configuration, working with the flight test instrumentation engineer to ensure the sensors and recording systems are installed for required data parameters, and the maneuver-by-maneuver plan for each test flight.
Flight Test Card	The record describing the flight phases, procedures and maneuvers to be performed by the flight crew during a specific flight trial and to be overseen by the FTEs.
RUAS-HERO	Is the name of the remotely piloted aircraft used for the INSuRE demonstration campaign, a rotorcraft RPA produced by Sistemi Dinamici S.p.A. (INSuRE consortium partner representing the RPAS Manufacturer and Operator). Throughout the demonstration plan the remotely piloted air system provided by SD is, for readability and simplicity, referred to as HERO or with the generic acronym, RPAS.
Latency	Latency is a measure of time delay experienced in a system.
Managed Airspace	Airspace in which all traffic and its intent is known to the Air Traffic System.
Operational Flight Plan	The operational flight plan currently provided by the RPAS Operator is more detailed than the ATC flight plan and consists in the detailed list of the waypoints of the route, predefined or computed by Ground Control Station tool to build lateral transitions and vertical profiles, with their associated altitude, speed, time and fuel estimates.
Operational Scenarios	Within the context of an operational concept scenarios are a description of how a future system could work. 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 should be able to identify user requirements and potential business cases.
Pseudo Pilot	An operator that takes in control more than one aircraft in ATC simulator. He can issue the commands to determine aircraft trajectory.
Remotely-piloted aircraft system	A set of configurable elements consisting of a remotely-piloted aircraft, its associated remote pilot station(s), the required command and control links and any other system elements as may be required, at any point during flight operation.
RPAS pilot (Remote pilot)	The person who manipulates the flight controls of a remotely-piloted aircraft during flight time.
Rotorcraft Flight Manual	A Rotorcraft flight manual is a book containing the information required to operate the rotorcraft. A typical flight manual will contain the following: limitations, operating procedures, performance.
Segregated Airspace	Airspace of specified dimensions allocated for exclusive use to a specific user(s).
Self-Separation	Function of the D&A procedure that in compliance with the rules of air allows the RPAS to operate and to prevent a Collision Avoidance maneuver.

Term	Definition
Self-Separation Threshold	Beyond the Self-Separation boundary the function of Self-Separation states that an action is necessary to prevent an aircraft, representing a potential risk, to cross the threshold of the Collision Avoidance. The requested action is to maintain the Self-Separation and keep the RPAS in safety conditions
Trajectory (4D)	The 4D trajectory is a set of consecutive segments linking published waypoints and/or pseudo waypoints computed by air or ground tools to build the lateral transitions and the vertical profiles. Each point is defined by a longitude, latitude, a level and a time with associated constraints where and when required.
Unmanned Aircraft	An aircraft which is intended to operate with no pilot on board.
Unmanned Aircraft System	An aircraft and its associated elements which are operated with no pilot on board.

1.5 Acronyms and Terminology

Term	Definition
A/G	Air/Ground
ACI	Airports Council International
ADS-B	Automatic Dependant Surveillance – Broadcast
ADT	Air Data Terminal
AeroSIG	Aeronautical Special Interest Group
AGL	Above Ground Level
AIS	Aeronautical Information Service
ANS CR	Air Navigation Services of the Czech Republic
ANSP	Air Navigation Services Provider
APP	Approach Control
ARO	Air Traffic Services Reporting Office
ASM	Airspace Management
ATC	Air Traffic Control
ATCEUC	Air Traffic Controllers European Unions Coordination
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Service
ATSEP	Air Traffic Safety Electronic Personnel
AV	Aerial Vehicle
B-VLOS	Beyond Visual Line Of Sight
C&C	Command & Control
C&CDL	Command & Control Data Link
CAA	Civil Aviation Authority
CANSO	Civil Air Navigation Services Organisation
CTA	ConTrol Area
CTR	ConTRol zone
CWP	Controller Working Position
DOD	Detailed Operational Description
D&A	Detect and Avoid
EASA	European Aviation Safety Agency
EHS	EnHanced Surveillance

Term	Definition
ENAC	Ente Nazionale Aviazione Civile (The Italian Aviation Authority)
ENAV	Ente Nazionale di Assistenza al Volo (the Italian Air Navigation Services Provider)
E-OCVM	European Operational Concept Validation Methodology
ERF	European Rotorcraft Forum
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology
E-VLOS	Extended Visual Line Of Sight
FCC	Flight Control Computer
FCS	Flight Control System
FHA	Functional Hazard Assessment
FIS-B	Flight information services-broadcast
FL	Flight Level
FOM	Flight Operation Manager
FPDAM	Flight Procedures Design and Airspace Management
FTE	Flight Test Engineer
FTI	Flight Test Instrumentation
G/G	Ground/Ground
GAT	General Air Traffic
GCS	Ground Control Station
GDT	Ground Data Terminal
GNSS	Global Network Satellite System
GPS	Global Positioning System
HMI	Human Machine Interface
IAS	Indicated Airspeed
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IDET	International Exhibition of Defence and Security Technologies
IDS	Ingegneria Dei Sistemi S.p.A.
IFATCA	International Federation of Air Traffic Controllers' Associations
IFP	Instrument Flight Procedures
IFR	Instrument Flight Rules
INSuRE	RPAS Integration into non-segregated ATMs
KO	Kick-Off
KPA	Key Performance Area
KPI	Key Performance Indicator
LKTB	Brno-Turany airport
MC	Management Committee
MTOM	Maximum Take Off Mass
NA	Not Applicable
OFA	Operational Focus Areas
OTW	Out The Window
p/h	person/hours
p/m	person/months
PCM	Project Configuration Manager
PM	Project Manager
PMP	Project Management Plan
PoC	Point of Contact
PQM	Project Quality Manager
PSSA	Preliminary System Safety Assessment
PtF	Permit to Fly
PWP	Pilot Working Position
QA	Quality Assurance
R&D	Research and Development
RPA	Remotely Piloted Aircraft

Term	Definition
RPAS	Remotely Piloted Aircraft System
RTS	Real Time Simulation
RUAS	Rotorcraft Unmanned Aerial System
SAM	Safety Assessment Methodology
SD	Sistemi Dinamici S.p.A.
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency
SSA	System Safety Assessment
SSR	Surveillance Secondary Radar
TAS	True Airspeed
TIS-B	Traffic information services-broadcast
TMA	Terminal Control Area
TTL	Technical Team Leader
TWR	Aerodrome Control (ToWeR)
UA	Unmanned Aircraft
UAV	Unmanned Aerial Vehicle
UCS	User Control Station
UVS	Unmanned Vehicle Systems
VHF	Very High Frequency
VLOS	Visual Line Of Sight
VTOL	Vertical Take-Off and Landing
w.r.t.	with respect to
WBS	Work Breakdown Structure
WP	Work Package

2 Context of the Demonstrations

The INSuRE Project implemented a set of Demonstration activities addressing the integration of RPAS (Remotely Piloted Aircraft Systems) into non-segregated airspace.

The INSuRE purpose has been to demonstrate the operational management of one rotary wing RPAS, piloted from a fixed station on ground, evaluating its interaction with other vehicles in a non-segregated airspace, the operational aspects in implementing nominal ATCO procedures, the safety aspects to be assessed to allow safe integration in controlled airspaces, the human factor aspects addressing both pilot and ATCOs workload and reactions.
INSuRE is one of the nine SESAR Demonstration projects dedicated to RPAS integration in ATM in the context of the SESAR Programme first phase, covering research activities until 2016. The operational context related to RPAS is one of the key investigation areas these days, considering that several activities have been initiated at different levels, e.g. regulatory, research, safety, operational, certification and system enablers. At National and International level the interest and initiatives on RPAS have been growing also thanks to projects, such as the SESAR Demonstration ones.
The National regulations in place at present are evolving and looking also at the results of the research on-going programmes for improving the current requirements to be fulfilled by the relevant RPAS operators.
In an operational context evolving as we speak, the INSuRE flight trials have been possible, to remain within the project agreed life cycle and in respect of the good-visibility conditions required, in the temporary segregated area in Grottaglie (Italy, Apulia's region) with a PtF granted to the RPAS Operator by the Italian CAA.

2.1 Scope of the demonstration and complementarity with the SESAR Programme

The scope of the INSuRE project has been limited to specific aspects of the RPAS integration in ATM in accordance with SESAR concepts, in particular:

- Dedicated RPAS procedures design;
- Technical enablers evaluation (airborne and ground), such as ADS-B capability;
- Relevant scenario and operational concept definition;
- Complex Simulation scenarios;
- Safety Assessment;
- Flight demonstrations;
- Contingency situations;
- Human factor evaluation.

To cover the above points, the project carried on real time simulations and flight trials:

- Simulations: the objectives of the simulations were to evaluate whether current ATC operational procedures are applicable to RPAS in a representative controlled traffic environment, both in nominal and non-nominal cases and if the communication/interaction and perception of the workload and handling time for ATCO and Pilot would be considered acceptable for implementation in operations.

- Real Flights: the main objectives in the in-flight demonstrations were:
  - evaluate human factor impact in RPAS integration in standard ATM procedures;
  - test the acceptance by ATC of current RPAS procedures during some non-nominal situations such as communication loss or command and control loss;
  - demonstrate comparable response times between RPAS and conventional aircrafts.

The following exercises have been executed:

Demonstration Exercise ID and Title	**EXE-RPAS.02-001: INSuRE #1**
Leading organization	IDS
Demonstration exercise objectives	To demonstrate that designed flight procedures are compliant with RPAS flight envelope. To demonstrate the RPAS compliance with ATCO clearances. To demonstrate that RPAS reaction time is comparable to that of a manned aircraft. To evaluate the impact on ATCOs and RPAS pilot workload and situational awareness.
High-level description of the Concept of Operations	In this exercise the RPAS executes a mission on a segregated area. To reach this area the RPAS shall depart from a non-segregated area, follow a defined flight plan up to the last point in controlled airspace. Then the RPAS moves in the segregated area to perform its task and finally it returns to the starting airport entering again in the controlled airspace performing the approach procedure.
Applicable Operational Context	Nodes: • ATS Operation • Airport Operation • Airspace User Operation Phases of Flight: • Take off • Climb • Cruise • Arrival • Approach • Final Approach • Landing
Expected results per KPA	Predictability: Neutral Safety: Neutral Human Performance: Neutral
Number of flight trials	6 simulated flights
Related projects in the SESAR Programme	P 04.03 P 06.07.01 P 06.05.01 P 06.05.02 P 06.05.03 P 06.05.04
OFA addressed	OFA 03.01.08 System Interoperability with air and ground data sharing OFA 01.02.02 Enhanced situational awareness OFA 05.01.01 Airport Operations Management

Table 1: EXE-RPAS.02-001 (INSuRE #1)

Demonstration Exercise ID and Title	EXE-RPAS.02-002: INSuRE #2
Leading organization	IDS
Demonstration exercise objectives	To demonstrate safe integration of RPAS in departing and arrival airport traffic.
High-level description of the Concept of Operations	In this exercise the RPAS departs from the Brno airport following a specific GNSS trajectory, during its climb phase a manned light aircraft takes-off from the same airport but with a different climb path. After mission accomplishment, both RPAS and aircraft return to the airport. Air traffic controllers coordinate RPAS with the other aircraft during ground (taxiing, departure), climb, cruise and descent (approach/landing) phases.
Applicable Operational Context	Nodes: • ATS Operation • Airport Operation • Airspace User Operation Phases of Flight: • Take off • Climb • Cruise • Arrival • Approach • Final Approach • Landing
Expected results per KPA	Airport Capacity: Neutral Airspace Capacity: Neutral Predictability: Neutral Safety: Neutral Human Performances: Neutral
Number of flight trials	4 simulated flights
Related projects in the SESAR Programme	P 06.07.01 P 06.07.02 P 06.07.03 P 05.07.03 P 04.03 P 10.07.01 P 06.05.01 P 06.05.02
OFA addressed	OFA 01.02.02 Enhanced situational awareness OFA 03.03.02 Ground Based Separation Provision in the TMA OFA 03.01.08 System Interoperability with air and ground data sharing OFA 04.02.01 Integrated Surface Management OFA 05.01.01 Airport Operations Management

Table 2: EXE-RPAS.02-002 (INSuRE #2)

Demonstration Exercise ID and Title	EXE-RPAS.02-003: INSuRE #3
Leading organization	IDS
Demonstration exercise objectives	To demonstrate the collision detection capability: the collision detection system is able to detect a conflict situation and notify to the RPAS pilot a conflict alert. To demonstrate the collision information capability: the collision detection system provides the RPAS pilot, with enough information about the conflicting aircraft in order to permit the execution of an efficient manoeuvre to resolve the conflict. To demonstrate the Detect & Avoid timing capability: collision detection system is able to provide the RPAS pilot with all the information required with a sufficient advance in order to give to the RPAS pilot enough time to perform the proper manoeuvre.
High-level description of the Concept of Operations	In this exercise a detection and avoidance manoeuvre is performed in order to evaluate the RPAS behaviour when a conflict situation arises. In a segregated area the RPAS and a light aircraft, with an enlarged detection area, gets close, below safety parameters. This event triggers a conflict detection alert to RPAS pilot that performs the adequate action on the control station to resolve the conflict.
Applicable Operational Context	Nodes: • ATS Operation • Airport Operation • Airspace User Operation Phases of Flight: • Take off • Climb • Cruise • Arrival • Approach • Final Approach • Landing
Expected results per KPA	Safety: Neutral Predictability: Neutral Human Performances: Neutral
Number of flight trials	4 simulated flights
Related projects in the SESAR Programme	P 04.03 P 06.07.01
OFA addressed	OFA 03.01.08 System Interoperability with air and ground data sharing OFA 01.02.01 Airport Safety Nets OFA01.02.02 Enhanced situational awareness

Table 3: EXE-RPAS.02-003 (INSuRE #3)

Demonstration Exercise ID and Title	EXE-RPAS.02-004: INSuRE #4
Leading organization	IDS
Demonstration exercise objectives	To demonstrate safe integration of RPAS in airport ground traffic. To demonstrate the safe integration of multiple RPAS in nominal traffic situation. To evaluate the operational procedures and ATCO workload due to the introduction of two RPA in a nominal traffic scenario. To evaluate the impact on the pilot workload in managing two RPAS vehicles from the same ground station.
High-level description of the Concept of Operations	In this exercise a possible future situation is presented: more than one RPAS is inserted into normal aircraft flow of an airport/airspace to verify the impact of the throughput of the controlled area. This is the only simulated scenario, which does not have a corresponding flight trial executed during the lifetime of the INSuRE project. The scenario is simulated to preliminary validate the impact of RPAS traffic over conventional manned traffic: the introduction of more than one RPAS in the normal aircraft flow of an airport/airspace does not affect the airport/airspace capacity due to the fact that RPAS, from ATCOs point of view, can be assimilated to a new category of vehicles.
Applicable Operational Context	Nodes: • ATS Operation • Airport Operation • Airspace User Operation Phases of Flight: • Take off • Climb • Cruise • Arrival • Approach • Final Approach • Landing
Expected results per KPA	Airport Capacity: Neutral Airspace Capacity: Neutral Predictability: Neutral Safety: Neutral Human Performance: Neutral
Number of flight trials	5 simulated flights
Related projects in the SESAR Programme	P 04.03 P 06.07.01
OFA addressed	OFA 03.01.08 System Interoperability with air and ground data sharing

	OFA 01.02.02 Enhanced situational awareness

Table 4: EXE-RPAS.02-004 (INSuRE #4)

Demonstration Exercise ID and Title	**EXE-RPAS.02-005: INSuRE Ground Test**
Leading organization	SD
Demonstration exercise objectives	To demonstrate integrity of the RPAS command & control data link. To demonstrate efficient communication between RPAS pilots and ATCOs. To demonstrate integrity of the ADS-B system.
High-level description of the Concept of Operations	The exercise is intended to evaluate the RPAS integration in airport surface operation preliminary to take off and landing.
Applicable Operational Context	NA (this is a validation of the system preliminary to the first flight trial exercise)
Expected results per KPA	Safety: Neutral
Number of flight trials	N/A
Related projects in the SESAR Programme	P 04.03 P 06.07.01
OFA addressed	OFA 03.01.08 System Interoperability with air and ground data sharing OFA 01.02.02 Enhanced situational awareness

Table 5: EXE-RPAS.02-005 (INSuRE Ground Test)

Demonstration Exercise ID and Title	EXE-RPAS.02-006: INSuRE #6
Leading organization	SD
Demonstration exercise objectives	To demonstrate the RPAS capability to actually fly the designed path. To demonstrate seamless integration of RPAS in standard ATM procedures. To evaluate human factors impact in RPAS integration in standard ATM procedures.
High-level description of the Concept of Operations	This flight campaign is aimed to evaluate the capability of the RPAS to follow the designed flight path and procedures during a complete mission simulation: starting from the take-off from airport surface, perform the mission and approaching back to the airport for landing. The whole exercise is performed in a temporary segregated area.
Applicable Operational Context	Nodes: • ATS Operation • Airport Operation • Airspace User Operation Phases of Flight: • Take off • Climb • Cruise • Arrival • Approach • Final Approach • Landing
Expected results per KPA	Predictability: Neutral Safety: Neutral Human Performance: Neutral
Number of flight trials	2 flight trials
Related projects in the SESAR Programme	P 04.03 P 06.07.01 P 06.05.01 P 06.05.02 P 06.05.03 P 06.05.04
OFA addressed	OFA 03.01.08 System Interoperability with air and ground data sharing OFA 01.02.02 Enhanced situational awareness OFA 05.01.01 Airport Operations Management

Table 6: EXE-RPAS.02-006 (INSuRE #6)

Demonstration Exercise ID and Title	EXE-RPAS.02-007: INSuRE #7
Leading organization	SD
Demonstration exercise objectives	To demonstrate comparable response times between RPAS and conventional aircrafts. To demonstrate efficient communication between RPAS pilots and ATCOs. To demonstrate seamless integration of RPAS in standard ATM procedures.
High-level description of the Concept of Operations	The exercise main purpose is to integrate the RPAS in normal ATM operations. This is done coordinating the RPAS activities in a contingency situation of data link loss, verifying the awareness of the pilot, the communication with ATC and the RPAS system response to the contingency itself in order to ensure safe completion of the flight.
Applicable Operational Context	Nodes: • ATS Operation • Airport Operation • Airspace User Operation Phases of Flight: • Take off • Climb • Cruise • Arrival • Approach • Final Approach • Landing
Expected results per KPA	Airport Capacity: Neutral Airspace Capacity: Neutral Predictability: Neutral Safety: Neutral Human Performance: Neutral
Number of flight trials	1 flight trial
Related projects in the SESAR Programme	P.04.03 P 06.07.01
OFA addressed	OFA 03.01.08 System Interoperability with air and ground data sharing OFA 01.02.01 Airport Safety Nets OFA 01.02.02 Enhanced situational awareness

Table 7: EXE-RPAS.02-007 (INSuRE #7)

Demonstration Exercise ID and Title	EXE-RPAS.02-008 : INSuRE #8
Leading organization	SD
Demonstration exercise objectives	To demonstrate comparable response times between RPAS and conventional aircrafts. To demonstrate efficient communication between RPAS pilots and ATCOs. To demonstrate seamless integration of RPAS in standard ATM procedures.
High-level description of the Concept of Operations	The exercise main purpose is to integrate the RPAS in normal ATM operations. This is done coordinating the RPAS activities in an airport emergency situation. The RPAS has been requested to free the runway as soon as possible to allow for an emergency landing. The communication with ATC and the RPAS pilot and system response to the emergency situation has been timed and evaluated.
Applicable Operational Context	Nodes: • ATS Operation • Airport Operation • Airspace User Operation Phases of Flight: • Take off • Climb • Cruise • Arrival • Approach • Final Approach • Landing
Expected results per KPA	Airport Capacity: Neutral Airspace Capacity: Neutral Predictability: Neutral Safety: Neutral Human Performance: Neutral
Number of flight trials	1 flight trial
Related projects in the SESAR Programme	P 04.03 P 05.07.03 P 06.07.01 P 06.05.01 P 06.05.02 P 06.05.03 P 06.05.04 P 10.04.01
OFA addressed	OFA 03.01.08 System Interoperability with air and ground data sharing OFA 01.02.01 Airport Safety Nets OFA 05.01.01 Airport Operations Management

	OFA 01.02.02 Enhanced situational awareness

Table 8: EXE-RPAS.02-008 (INSuRE #8)

3 Programme management

3.1 Organisation

3.1.1 INSuRE Consortium

The members of the INSuRE Consortium are Ingegneria Dei Sistemi S.p.A (IDS), Air Navigation Services of the Czech Republic (ANS CR) and Sistemi Dinamici S.p.A. (SD).

IDS has been the coordinator of the consortium, responsible for the Project Management and on the technical side of the simulation campaign for validating the approach, providing expertise both at ATM level and at technical level. IDS has made available to the project its validation platform in Pisa, including an Aircraft Cockpit Simulator and an ATC Simulator and the capability to simulate and control the RPAS vehicles in the validation scenario.

The necessary and crucial role of the ANSP has been covered by Air Navigation Services of the Czech Republic (ANS CR). ANS CR led the operational activities at the selected aerodrome (LKTB Brno-Turany) and the dedicated safety analysis. The ANSP contributed also with licenced and experienced personnel (ATCO as well as ATSEP) together with a team of ANS experts.

The RPAS Manufacturer and Operator have been represented by Sistemi Dinamici S.p.A, which coordinated and led the relevant preparation and execution of the flight campaign. In 2012, Sistemi Dinamici started the "RUAS-HERO" program for the development and the production of a rotary wing RPAS with a MTOM (Maximum Take Off Mass) less than 150 Kg. HERO has been the RPAS vehicle used for the INSuRE demonstration flights.

The percentage of contribution from each partner is represented in the pie-chart in Figure 1.

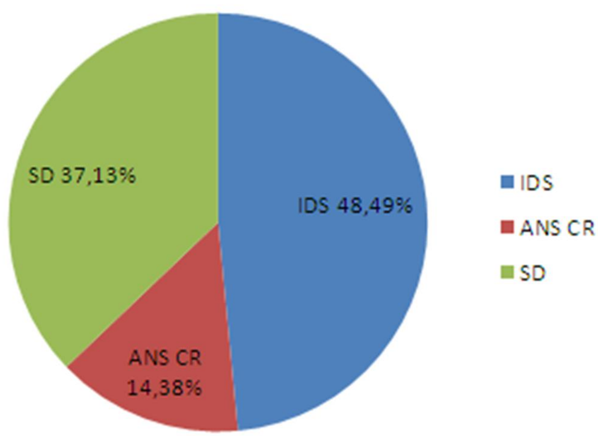


Figure 1: Consortium composition

3.1.2 INSuRE Management Structure

The following sections detail briefly the INSuRE management monitoring and control approach and procedures and show the adequacy of the INSuRE team and resources towards effectively meeting the project's objectives. The Project Management structure is depicted in Figure 2, which shows also the interfaces amongst the bodies involved.

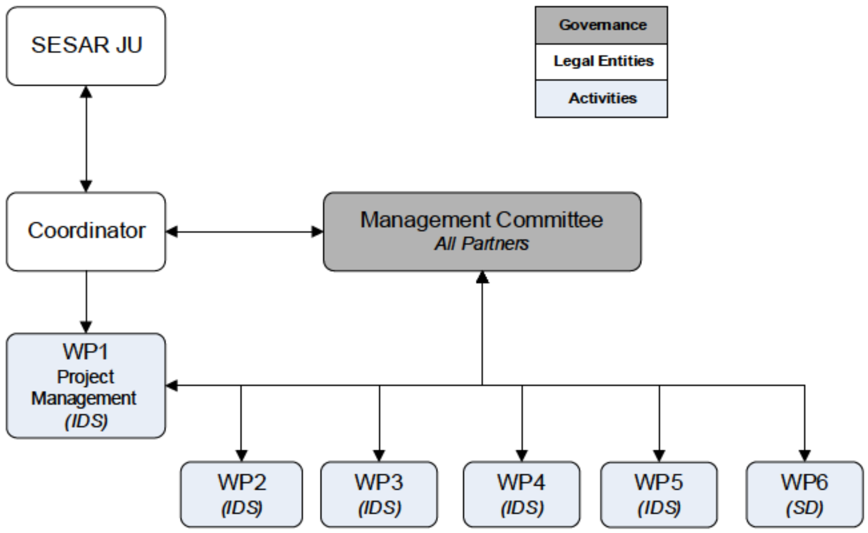


Figure 2: Project Management bodies and interfaces

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

- WP2: Operational Concept Design
- WP4: Facilities Adaptation
- WP5: Simulation Campaign
- WP6: Demonstration Flight Campaign

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

The INSuRE Project has been managed through a set of roles and corresponding responsibilities entrusted to key people, selected on purpose by each Consortium member.
Considering that INSuRE Consortium is made of three partners, a simplified, but effective, management structure has been set up and executed the management task under the coordination of the Project Manager and with the contribution of each partner representative and experts in the different areas: technical, safety quality, configuration control, risks and issues, communication, contractual (financial and legal).

3.2 Work Breakdown Structure

The Work Breakdown structure of the project shows all implemented activities and it has been 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 in Figure 3, where the workpakages and tasks decomposition is identified.

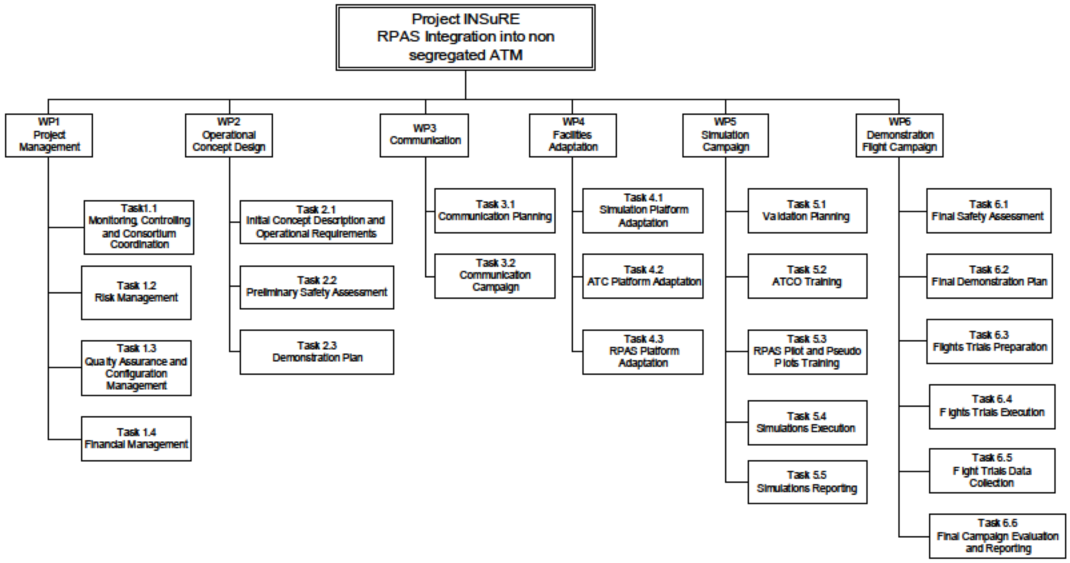


Figure 3: INSuRE WBS

Each task has been 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 have been involved as contributors to relevant tasks, where they were not acting as Leader.

Task ID	IDS	ANS CR	SD
WP1 - Project Management			
1.1 Monitoring, Controlling and Consortium Coordination	L	C	C
1.2 Risk Management	L	C	C
1.3 Quality Assurance and Configuration Management	L		
1.4 Financial Management	L		
WP2 - Operational Concept Design			
2.1 Initial Concept Description and Operation Requirements	L	C	C
2.2 Preliminary Safety Assessment	C	L	C
2.3 Demonstration Plan	L	C	C
WP3 – Communication			
3.1 Communication Planning	L		
3.2 Communication Campaign	L	C	C
WP4 – Facilities Adaptation			
4.1 Simulation Platform Adaptation	L		
4.2 ATC Platform Adaptation		L	
4.3 RPAS Platform Adaptation			L
WP5 – Simulation Campaign			
5.1 Validation Planning	L		C
5.2 ATCO Training	L	C	
5.3 RPAS Pilot and Pseudo Pilots Training	C		L
5.4 Simulation Execution	L	C	C
5.5 Simulations Reporting	L	C	C
WP6 – Demonstration Flight Campaign			
6.1 Final Safety Assessment	C	L	C
6.2 Final Demonstration Plan	C	L	C
6.3 Flight Trials Preparation	C	C	L
6.4 Flight Trials Execution	C	C	L
6.5 Flight Trials Data Collection	C	C	L
6.6 Flight Campaign Evaluation and Reporting	L	C	C

Table 9: INSuRE WBS tasks and partners' role

3.3 Deliverables

The main deliverables are summarised as:

- **INSuRE Demonstration Plan D01**– edition 00.01.01 delivered in February 2014
- **INSuRE Demonstration Report D02** (this document)
- Various communications media, workshop presentations and periodic progress reports.

The milestones for Project INSuRE, including quarterly reports, project reviews, internal reports and completion of demonstration milestones, are presented in the following table. All milestones have been completed during 2015 with the exception of the final presentation which has been planned and executed, in coordination with SESAR JU, on 19th February 2016.

Milestone name	Date
Kick Off Meeting	16 October 2013
Project Management Plan (B.1)	31 January 2014
Risk Management Plan (B.2)	31 January 2014
Quarterly Report Q1 2014	11 April 2014
Quarterly Report Q2 2014	11 July 2014
Quarterly Report Q3 2014	10 October 2014
Validation Plan (B.3)	14 November 2014
Critical Review Meeting #1	03 December 2014
Quarterly Report Q4 2014	09 January 2015
Simulation Report (B.4)	17 March 2015
Quarterly Report Q1 2015	10 April 2015
Safety Assessment (B.5)	08 May 2015
Final Demonstration Plan (B.6)	08 May 2015
Critical Review Meeting #2	19 June 2015
Quarterly Report Q2 2015	10 July 2015
Management Committee Meeting #1	17 October 2013
Management Committee Meeting #2	02 April 2014
Management Committee Meeting #3	02 October 2014
Quarterly Report Q3 2015	15 October 2015
Management Committee Meeting #4	14 May 2015
Final INSuRE Event	19 February 2016

Table 10: Key Project Milestones

3.4 Risk Management

The risks identified and handled during the lifetime of the INSuRE project are presented in this paragraph. They are documented briefly with their associated mitigation actions. A complete risk analysis and management has been performed throughout the Project in line with the "Risk Management" SESAR process defined in the SESAR Programme Management Plan and inside the INSuRE Consortium according to the Risk Management Plan (milestone B.2). All agreed actions have been discussed within the Consortium and coordinated before implementation.
The main risks were related to the contingency situations affecting potentially the flight trials and to the process linked to request and issue of the relevant Permit to Fly.

Risk No.	Description of Risk	Owned By	Agreed Mitigation Action	Impact if Risk Realised	Status	Severity
5074 (CLOSED)	Loss of connection between Control Station and RPAS.	Sistemi Dinamici (flight trials)	Automatic recovery procedure. If an unexpected data link loss happens during flight trials an automatic recovery procedure will be started from RPAS to try restoring of the datalink connection. The recovery procedures for failures are defined in the safety assessment including the data link loss recovery procedure.	During the execution of flight trials if RPAS goes beyond datalink coverage area Control Station may lose the capability to send and receive data losing the RPAS control.	CLOSED – Demonstrations undertaken without failure in the data link connection. The contingency was tested during one flight with the failure of data link created on purpose. The planned recovery procedure worked.	Medium
5075 (CLOSED)	Unavailability of RPAS Control Station during flight trials.	Sistemi Dinamici (flight trials)	A spare system was available during flight trials to be used as backup solution during, reducing the probability to interrupt the mission.	The partial or complete unavailability of the RPAS Control Station may impact the RPAS mission completion as initially planned.	CLOSED – Spare system was put in place for the trials but not used, since the main system did not have any failure.	Medium
5076 (CLOSED)	Datalink failure	Sistemi Dinamici (flight trials)	Configurable datalink architecture. C&C data-link upgraded to a 2 channel full-duplex configuration; SD implemented the capability of switching to a single channel half-duplex in real time in case of a channel failure; thus means increased reliability for fail safe operations.	Due to any reason the datalink channel transceiver on Control Station or RPAS may have a malfunction causing a poor datalink quality. Affected exchange of commands between Control Station and RPAS.	CLOSED – Demonstrations undertaken without failure in the data link connection.	Medium

Risk No.	Description of Risk	Owned By	Agreed Mitigation Action	Impact if Risk Realised	Status	Severity
5232 (CLOSED)	Permit to Fly in Brno Airport (Czech Republic) for flight campaign.	Sistemi Dinamici (flight trials)	Direct coordination between Sistemi Dinamici and the CAA of Czech Republic to assess feasibility of obtaining PtF for Brno airport operations in order to provide the required evidence of the current certification status of RPAS in Italy involving the Italian CAAs in coordination.	Feasibility to perform the flight campaign in BRNO Airport	CLOSED – Closed in favour of ISSUE #5077 Decision to perform the flight trials in Grottaglie (Italy) invalidates the risk and action.	High
5393 (CLOSED)	The flight activities with RPA HERO that Sistemi Dinamici is performing in Italy, in order to obtain the Permit to Fly in controlled airspace, might be delayed due to technical problems or adverse weather conditions.	Sistemi Dinamici (flight trials)	Sistemi Dinamici is providing information weekly on the ongoing flight trials in Italy. Delays in the completion of the Italian Flight Campaign have been reported, due to: bad weather conditions forbidding flights for a longer than expected time period and minor technical problems in the upgraded configuration of HERO. The activities in Italy are foreseen to continue in parallel with the request for PtF in Czech Republic and the evidence will feed the PtF request, as available. Eventual impact on the INSuRE project schedule will be evaluated in May timeframe, as soon as more information from both CR CAA and SD will be available.	Delay in the preparation and reference material for the Permit to Fly and consequently in a delay on the Demonstration flights.	CLOSED – Closed in favour of ISSUE #5078 Decision to perform the flight trials in Grottaglie (Italy) invalidates the risk and action.	Medium

Table 11: Risk Table

ISSUES					
Issue No.	**Description of Issue**	**Owned By**	**Agreed Corrective Action**	**Status**	**Severity**
5077 (CLOSED)	The allocated flight campaign slot is (after the change of Project schedule due to delay in PtF process) in December and falling into bad weather conditions	IDS/SD/ANS CR (Flight Campaign)	Execute the Flight Campaign in a different site, less subject to bad weather conditions in November/December. The identified site for implementing a significant flight campaign for INSuRE, as a mitigation to be able to reach the project objectives within the contractually agreed timeframe, is Grottaglie area in Italy. The RPAS Operator is foreseen to perform trials in Grottaglie with a flight envelope similar to the INSuRE flights and for which is anyhow in the process of obtaining a PtF. ANS CR will participate in the flight trials in Grottaglie to support the relevant ATC activities. The objectives of the project will be then reached mitigating the risk of further delays due to bad weather and further costs due to the logistic to get with the team and system to Brno in the winter season (highly probable that the flights will not be allowed/feasible). The Consortium agrees to perform a flight trial for Dissemination purposes outside the scope of the Project in Brno in late spring 2016, since the PtF issued in Italy and the ongoing process for Brno are compatible and will be continued.	CLOSED – Flight Campaign was executed in Grottaglie successfully implementing the corrective action.	High
5078 (CLOSED)	Time to obtain Permit to Fly for the Flight Trials in Czech Republic	IDS (Project Schedule)	The INSuRE Project Manager will issue a Change Request for the Project schedule to accommodate the delay in the issuing of the Permit to Fly affecting the schedule of the Flight Trials in Brno. A meeting with the Stakeholders (ANS CR, SD, CAA of CR and Italian CAA) is scheduled on 28th July 2015 to discuss the way ahead and agree on the proposed updated schedule. This schedule will be then presented to SESAR JU for approval as part of the CR.	CLOSED – The delay has been considered in a Contract Amendment and related CR#2301 approved by SESAR JU allowing for an extension of the Project to cover the expected delay.	Medium

Table 12: Issue Table

4 Conduct of Demonstration Exercises

4.1 Exercises Preparation

4.1.1 Simulation preparatory activities

The **INSuRE simulation campaign** set up required one week of preliminary activities aimed at putting in place the correct configuration for the exercises:

- Setting up the simulation room;
- Verifying the simulation environment for Brno airspace through dry-runs;
- Checking each position with the dedicated systems, in particular the voice frequencies connection emulating TOWER and GROUND frequencies;
- Verifying the planned RPAS missions associated to each exercise;
- Verifying that the traffic scenario planned for specific runs would be recorded and easy to reload before the relevant exercise execution;
- Preparing the supporting material for briefing and debriefing;
- Preparing and validating the pilot and controller questionnaires, to be used for collecting simulation feedback;
- Preparing the supporting material to be made available to participants and guests.

The simulation platform dedicated to the INSuRE campaign has been set up and verified through a dedicated Acceptance Test session in November 2014. During the dry run in preparation of the Simulation Campaign, all acceptance tests have been re-executed to verify the readiness of the system before starting the official exercises.

The platform used for the simulation campaign is composed by the following elements:

- RPA simulator
- Sensor simulator
- RPA control station
- ATC simulator

RPA simulator is a SW application that replicates the HERO RPA behavior and contains:

- HERO flight dynamics;
- HERO Autopilot capable of managing autonomous flight;
- STANAG 4586 protocol module to communicate with RPA control station, as HERO does;
- Network module, it modifies the message data rate;
- Simulation module, capable of changing simulation speed, day/time and weather conditions.

Hereafter, description and images of the relevant elements of the Simulation Platform are reported.

The RPA simulator element is basically the software that simulates RPA flight dynamics and autopilot.

The Sensor simulator is an application that generates a 3D representation of the view taken from a camera placed in the front part of the RPA.

HERO Control Station is composed by two modules:

- A-UCS (Aerial-Unmanned Control Station) used to control the RPA trajectory
- P-UCS (Payload-Unmanned Control Station) used to control payload placed on-board the RPA

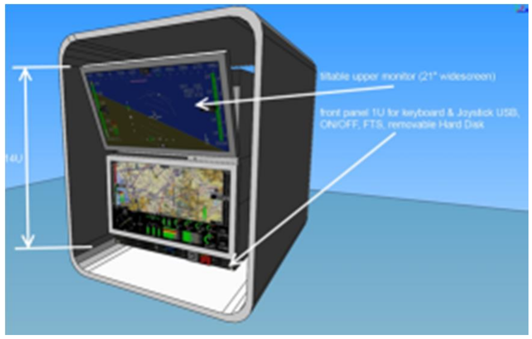


Figure 4: HERO Control Station layout

In the simulation campaign only the A-UCS was used.

The HW of both modules is similar and it is depicted in Figure 3: it is a transportable containing two 21ò LCD, the upper screen is dedicated to the visualization of the video signal coming from a camera placed in the front part of the RPA, the lower screen contains the RPA control application.

The RPA control SW holds all the safety-critical features for:

- mission planning;
- AV steering and status monitoring;
- on-board sub-systems command and status monitoring;
- warning and critical situations management;
- UCS and Data Link sub-systems status monitoring.

Status data are presented to the AV (Air Vehicle) operator in a graphical interface, with the support of a 2D map. This 2D map can visualize a wide set of elevation and vector data available in an internal database created by means of another already existent IDS software.

The interactions among the above described elements are depicted in the following diagram:

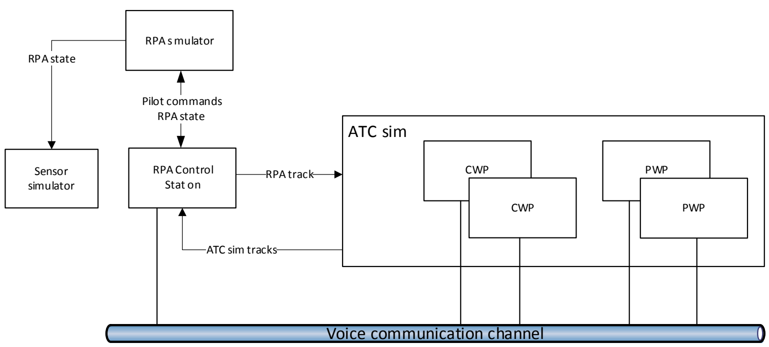


Figure 5: Simulation campaign system architecture

The RPA pilot uses the RPA Control Station to send commands to HERO as well as to know the state of the RPA (position, speed).

The simulator updates the state of the RPA according to the commands issued by the Control Station.

The state is also transmitted to the sensor simulation that modifies the point of view accordingly updating the simulated FLC view.

RPA current state is propagated to the ATC sim as an ADS-B track, similarly ATC sim broadcasts the tracks of all its traffic.

The room used for the INSuRE simulation campaign is a wide area, which is nominally hosting the simulation platform and has been structured to separate the simulation set-up area and the controllers working position from the pilots position. Figure 6 shows the layout used for the INSuRE Simulation Campaign. The two CWP position are part of the Tower/Airport simulator, while the GCS1 and GCS2 positions are the two controlling systems simulation the two RPAS. The ACS block represent the Advanced Cockpit simulator, used to emulate the behavior of the light aircraft. The PWP positions are used by pseudo pilots for controlling surrounding traffic, necessary for the purposes of EXE-RPAS.02-004 exercise.

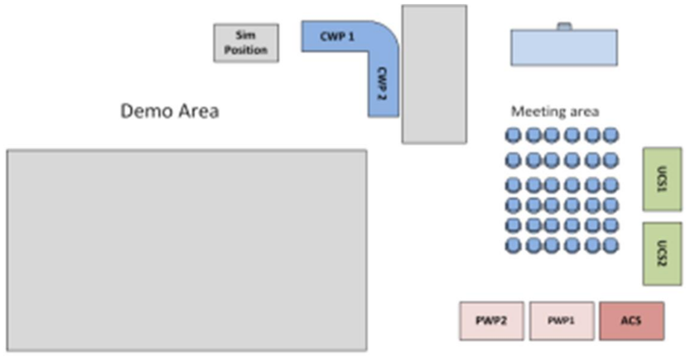


Figure 6: Simulation Room Layout

The team involved in the Simulation Campaign is composed by the following actors:

- ATC Operators to evaluate the impact of the introduction of RPAS into non-segregated areas;
- ATC Team Leader to supervise the ATCOs work and evaluate the impact of the introduction of RPAS into non-segregated areas from coordination and management point of view;
- RPAS Pilot to operate the RPA missions;
- Light aircraft Pilot to operate the light aircraft flights in presence of RPA in the same area of interest;
- Platform Development Leader to supervise the activities from the technical point of view;
- Platform Developer to support the simulation platform set-up for the exercise;
- INSuRE Project Manager to supervise the execution of the exercise and verify completeness of test wrt the project planned activities and project requirements;
- ANS CR Project Manager to supervise the execution of the exercise and perform a fist evaluation of the operational benefit coming from the integration of RPAS into non-segregated areas;
- SD Project Manager to supervise the execution of the exercise and evaluate the outcomes of the simulation relevant for the demonstration campaign;
- INSuRE System Engineer to support the activities on the adherence with the exercise definition in INSuRE and on the data collection necessary for documenting successful execution in this report;
- ATC expert to support the preparation of ATC simulator and to validate adherence to the operational expectations.
- Pseudopilots to take in control more than one aircraft in ATC simulator; they can issue the commands to determine aircraft trajectory.

The training activities required for the participants have been very limited, since:

- the pilots involved were already familiar with the simulators both for HERO Ground Control Station (RPAS) and for the ACS (light aircraft simulator);
- the pseudo-pilots were members of the platform development team, therefore already trained on the commands available at the pseudo pilot positions;
- the ATCOs are certified ATCOs for BRNO airspace and received the simulation platform material in advance for off-line review and familiarization;
- the simulation observers are members of the INSuRE project team and participated in previous SESAR Validation exercises in the context of Level3 SESAR Projects (e.g. VP-212, VP-198, VP-199).

For the Simulation Campaign, it was foreseen:

- three days for dry runs of the exercises, in order to verify that the data and scenarios were correctly prepared and ready for real time execution;
- one day for ATCO training and familiarization with the Tower/Airport CWPs configuration, console systems and voice communication system.

The training was very effective and in the training day for ATCOs, given the high skill and flexibility of the controllers, even the execution of a few simulation exercise runs was feasible, giving confidence to the team for the interactions required during the official execution of the exercises.

4.1.2 Flight Trials preparatory activities

The INSuRE flight campaign started a few weeks prior to the foreseen flights slot, with a set of preliminary activities aimed at putting in place the correct configuration for the exercises were executed:

- Planning of the details of the missions in accordance with exercises objectives;
- Update the RPAS safety documentation in accordance with the foreseen scenario to provide the civil aviation authority evidence of safe operation and obtain the required permit to fly;
- Submit a request for permit to fly to the civil aviation authority for experimental campaign;
- Submit a request of a NOTAM to temporary segregate the exercise area and avoid unwanted intrusion in the airspace during the flight campaign;
- Submit pilot licencing approval to the civil aviation authority for the specific experimental campaign;
- transfer of the RPAS system to the flight campaign location at Grottaglie airport facility
- Briefing with ATCOs in order to clarify the procedures specified in the CONOPs document defined for the flight campaign;
- Set up and functional verification of the radio links required (VHF, UHF and cell phone as back-up) for the flight campaign in coordination with airport management according to CONOPs document;
- Set up of the antennas configuration for correct radio appliance operations (C&C, ADS-B and video link).

The logistic configuration adopted for the flight campaign has been based on:

- A moving platform, based on a small truck, containing the UCS, the main pilot and the ground Hub including ADS-B receiver and all required antennas, is positioned at the airport facility in the service road aside of the runaway.
- The safety pilot (formerly the pilot in command) located in a defined spot close to the Take-off and landing point on the runaway
- A small trailer, carried by a car, to move the RPA from/to the runaway and the main recover hangar.

The team involved in the INSuRE Flight Campaign was composed by the following actors:

- ATC Operators to evaluate the impact of the introduction of RPAS into non-segregated areas;
- RPAS Pilots to operate the RPA missions: one pilot at the UCS and one safety pilot in the nearby of the RPA to recover the AV manually in case of emergency;
- Flight test engineer to keep under continuous monitoring the main RPA flight data and signaling any possible warning concerning abnormal data
- INSuRE Project Manager to supervise the execution of the exercise and verify completeness of test wrt the project planned activities and project requirements;

- SD Project Manager to supervise the execution of the flight campaign and evaluate the outcomes.

Role	Name	Company
ATC Operator	[redacted]	ANS CR
ATC Operator		ANS CR
RPAS Pilot		SD
RPAS Pilot		SD
RPAS Flight Test Engineer		SD
INSuRE Project Manager		IDS
SD Project Manager		SD

Table 13: Roles and actors in the simulation campaign

The training activities required for the participants have been carried out with respect to:

- pilots involvement with ATC communication: the simulation campaign was a good training platform to consolidate procedures and details of the communication procedures, although the pilots have already a communication license active
- pilots verification by the civil aviation authority in conformity of the new regulation issued on 15th of September 2015. This formal verification process includes a medical approval by the authorized medical center and a piloting skill verification with formal witnessing of the civil aviation authority.

In the following picture schematic system architecture is reported. The following configuration is representative of the one used during the flight campaign.
Basically we can identify the following main parts:

- The Air Vehicle: is connected to the system via C&C Data link (bi directional redundant link) and the payload Data lin (only down link)
- Ground Hub: as an hub collects the connection of all the ground segment components
- C&C DL: is the radio appliance that transmits and receives the data between the UCS and the AV
- Control UCS: is used by the pilot to control the AV
- Payload UCS (Optional): is used to control specific payload. Not used in flight campaign; it acts also as back-up UCS to increase availability of the system in case of failure of the C-UCS
- Payload and C&C DL antennas: required by the radio segments for transmission/reception

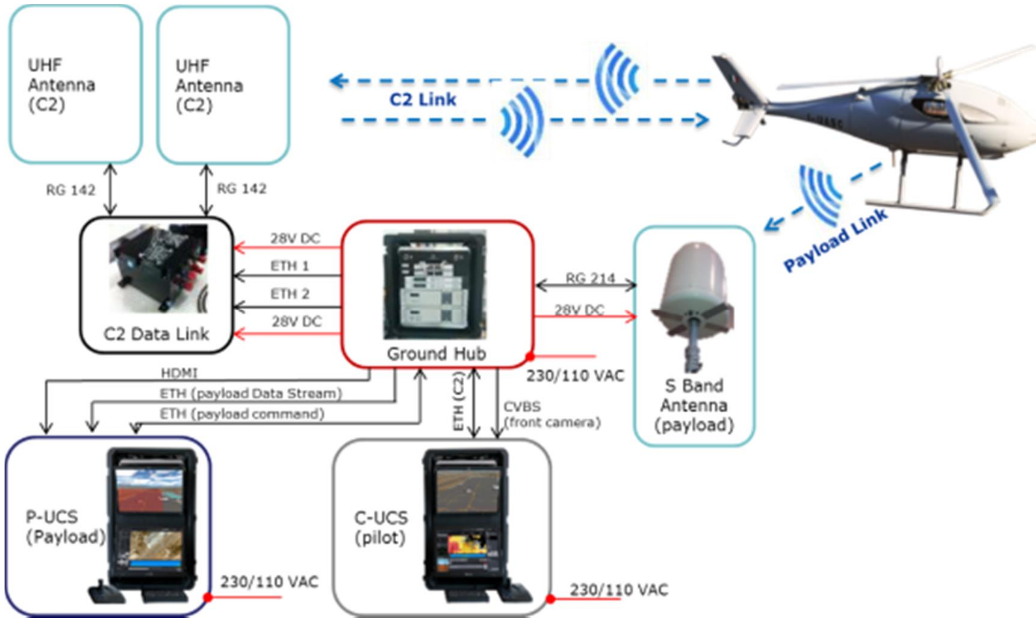


Figure 7: Flight system architecture overview

To this configuration is added an ADS-B receiver with a dedicated display that also broadcasts data to the ground hub in order to display ADS-B data on both the C-UCS and the dedicated display.

4.1.3 INSuRE Operational Scenarios

4.1.3.1 Brno-Turany Operational Scenario

This paragraph summarizes the Brno-Turany operational scenario used during the project simulation campaign.
Flight missions are planned and performed with respect to minimize the impact on other planned operations at LKTB and CTR/TMA, especially on commercial air transport. Coordination with airport authority is necessary.
All flights are carried out in CTR and TMA LKTB (up to FL 125) to ensure full control over all operations involved. RPAS is always separated from other traffic, except agreed manned light aircraft.
Permanent two-way communication on frequency 119.6 TWR or APP 127.35 is mandatory.
VHF communication is required for clearance.

RPAS operator carries a mobile phone as a backup for the communication.
RPAS take-offs and landings is performed at:
- East apron at LKTB or
- grass spot in vicinity of Tx VHF Hranický.

After preliminary coordination with ATC unit the clearance is not being issued for take-off and landing from the places outside of maneuvering area at LKTB. Compliance with the conditions set during preliminary coordination process is under RPAS pilot's responsibility.

The following suitable areas (see Figure 8) have been identified for RPAS activity in vicinity of Brno airport are:

- **Insure 1 (IN1)** – Field between airport and Slapanice
  Coordinates: 49°9'23.184"N, 16°42'56.991"E
- **Insure 2 (IN2)** – Field between Slatina and Slapanice:
  Coordinates: 49°10'1.215"N, 16°42'8.128"E
- **Insure 3 (IN3)** – Field between Bedrichovice and Slatina:

Coordinates: 49°10'33.595"N, 16°42'39.1730"E

Figure 8: BRNO airport ï view from above ï Recommended routing to/from areas IN1, IN2, IN3

To reach the project operational objectives, the ANS CR has verified that the following scenarios are suitable for the demonstration campaign.

<u>**Scenario 1** Mission in a defined area</u>

- RPAS departs outside the area LKTB (suitable area is IN3) to verify the functionality of the VHF and Datalink connection.

  The operator has still RPAS in sight (E-VLOS).

- Departure from LKTB or spot Tx Hraniļky to the airspace near the airport (area IN1 or IN2), activity in the area up to A020 (photo flight), arrival back.

  The operator has still RPAS in sight (E-VLOS).

  This scenario has been validated by means of real time simulation only and it refers to Brno airport and CTR/TMA.

<u>**Scenario 2** Departure from LKTB - RPAS and manned light aircraft</u>

- Departure from LKTB to the airspace near the airport (area IN1 and IN2), activity in the area up to A020 (photo flight), arrival at LKTB. Light airplane (pilot informed, part of the project) takes off and arrives at the same time. Separation provided is horizontal.

  The operator has still RPAS in sight (E-VLOS).

- Departure from LKTB to the airspace farther away from the airport (area IN3), activity in the area at A025 (photo flight), arrival at LKTB. Light airplane reaches the airspace at different trajectory ï separation provided is vertical.

  The operator has still RPAS in sight (E-VLOS).

  This scenario has been validated by means of real time simulation only and it refers to Brno airport and CTR/TMA.

<u>**Scenario 3** Collision avoidance - RPAS and manned light aircraft</u>

- RPAS departs from spot TX Hraniļky towards the reserved area (area IN3). Then the light aircraft takes off to the same area. RPAS executes the flight in the reserved area at the minimum speed; pilot of the light airplane ensures relevant separation. The goal is to verify the RPAS visibility from the cockpit of a light airplane.

This scenario has been validated by means of real time simulation only and it refers to Brno airport and CTR/TMA. No restriction on conventional manned traffic is required.

After that RPAS flies at normal speed and follows predefined straight trajectory. Light aircraft flies on the opposite track (with offset 100m). Both aircraft avoid to the right. Goal is to verify the mutual visibility and ability to detect small aircraft by RPAS operator.

Scenario 4 Two RPAS in controlled airspace

- This scenario has been validated by means of real time simulation only and it refers to Brno airport and CTR/TMA. No restriction on conventional manned traffic is required.

  Brno airport area is populated with aircraft and ground vehicle usually present in the airport. Standard ground maneuver, take-off and landing are performed by manned traffic. Traffic in transit in the Brno CTR/TMA is present as well.

  RPAS, subjected to ATC clearances, flies in the Brno airport and CTR/TMA.

  This scenario is characterized by the simultaneous presence of more than one RPAS.

  RPAS control strategy is alternatively as follow:

  - each RPA is controlled by one control station operator;
  - only one control station operator controls more than one RPA.

4.1.3.2 Taranto-Grottaglie Operational Scenario

This paragraph summarizes the Taranto-Grottaglie (LIBG) operational scenario used during the project demonstration campaign.
Flight missions are planned and performed within LI R315 published reserved Zone for RPAS testing activity around TARANTO Grottaglie Aerodrome, active upon notice by NOTAM.
TARANTO Airport (ICAO: LIBG) is located approximately 4 km West South West of Grottaglie city.
TARANTO Grottaglie airfield, is opened to IFR/VFR air flight operations of:

1. General Aviation traffic,
2. Domestic and Commercial traffic,
3. European Community traffic,
4. Italian Navy traffic,
5. Guardia di Finanza traffic.

The aerodrome has an elevation of 214 Ft.

Airfield Characteristics
The airport operates one runway (see fig.3):

- RWY nr 17 QFU 166°,
- RWY nr 35 QFU 346°.

Characteristics (see fig.4):

1. RWY 17 dimensions 3200 X 45 m,
2. RWY 35 dimensions 3200 X 45 m.

Coordinate ARP 40°31'02"N 017°23'59"E	**ARP coordinates** 40°31'02"N 017°23'59"E
Direzione e distanza dalla città 1.62 NM WSW di Grottaglie	**Direction and distance from city** 1.62 NM WSW of Grottaglie
Elevazione/Temperatura di riferimento 214 FT / NIL	**Elevation/Reference temperature** 214 FT / NIL
Ondulazione del geoide 141 FT	**Geoid undulation** 141 FT
Variazione magnetica/Variazione annuale 3° E (2010.0) / 4'E	**Magnetic variation/Annual change** 3° E (2010.0) / 4'E
Autorità amministrativa aeroportuale ENAC - DA Puglia-Basilicata Aeroporto "Karol Wojtyla" Viale Enzo Ferrari, 1 70128 Bari-Palese Tel: +39 080 5361400 Fax: +39 080 5361417 E-mail: pugliabasilicata.apt@enac.gov.it **Esercente** Aeroporti di Puglia S.p.A. tel +39 099 5625601/3/5 fax +39 099 5625645 **Autorità ATS** ENAV S.p.A. Centro Aeroportuale Grottaglie Tel: + 39 099 5626302; fax: + 39 099 5626306 e-mail: UAAV_Grottaglie@enav.it	**Aerodrome administration authority** ENAC - DA Puglia-Basilicata Aeroporto "Karol Wojtyla" Viale Enzo Ferrari, 1 70128 Bari-Palese Tel: +39 080 5361400 Fax: +39 080 5361417 E-mail: pugliabasilicata.apti@enac.gov.it **Aerodrome operator** Aeroporti di Puglia S.p.A. tel +39 099 5625601/3/5 fax +39 099 5625645 **ATS authority** ENAV S.p.A. Centro Aeroportuale Grottaglie Tel: + 39 099 5626302; fax: + 39 099 5626306 e-mail: UAAV_Grottaglie@enav.it

Figure 9: Aerodrome Geographical and Administrative Data

Figure 10: TARANTO Grottaglie Aerodrome Panoramic View

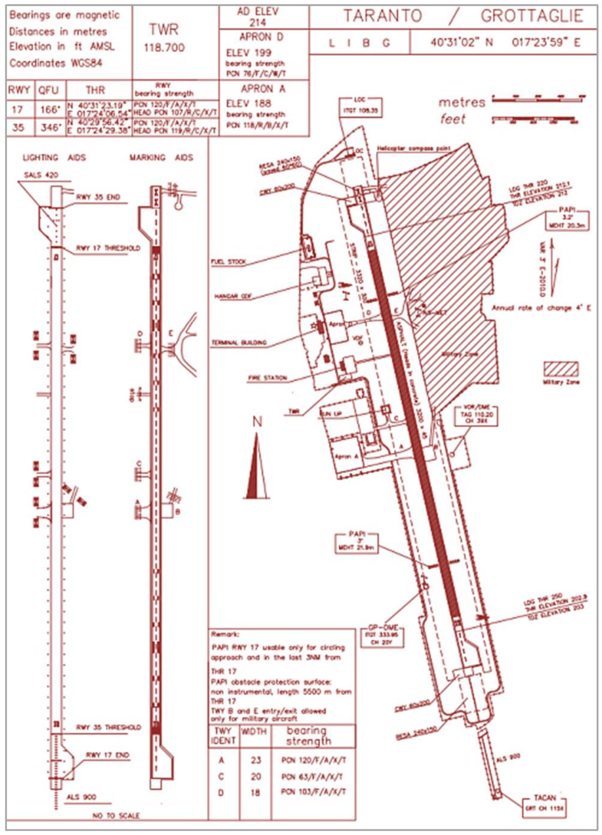


Figure 11: Aerodrome ICAO – Chart

Designazione NR RWY Designation	QFU	Dimensioni RWY Dimension of RWY (M)	Resistenza e superficie di RWY Strength and surface of RWY	Coordinate THR THR coordinates --- Coordinate RWY END RWY END Coordinates --- Ondulazione Geoide THR THR Geoid Undulation	THR ELEV, MAX TDZ ELEV della RWY per APCH di precisione THR ELEV, MAX TDZ ELEV of precision APCH RWY
1	2	3	4	5	6
17	166°	3200 x 45	PCN 120/F/A/X/T ASPH	40°31'23.19''N 017°24'06.54''E --- 40°29'48.47''N 017°24'31.47''E --- 140.9 FT	212.1 FT / 212 FT
35	346°	3200 x 45	PCN 120/F/A/X/T ASPH	40°29'56.42''N 017°24'29.38''E --- 40°31'30.18''N 017°24'04.70''E --- 140.3 FT	202.9 FT / 203 FT

Designazione NR RWY Designation	Pendenza di RWY-SWY Slope	Dimensioni SWY SWY dimension (M)	Dimensioni CWY CWY dimension (M)	Dimensioni strip strip dimension (M)	Dimensioni RESA RESA dimension (M)
1	7	8	9	10	11
17	Vedi AOC in vigore See AOC in force	NIL	60 x 200	3320 x 300	240 x 150
35	Vedi AOC in force See AOC in force	NIL	60 x 200	3320 x 300	240 x 150

Designazione NR RWY Designation	OFZ Obstacle free zone (OFZ)	Note Remarks
1	12	13
17	NIL	1) DTHR 220 m 2) Superficie: asfalto con testata in calcestruzzo / Surface: asphalt - head in concrete
35	Non applicabile Not applicable	1) DTHR 250 m 2) Superficie: asfalto con testata in calcestruzzo / Surface: asphalt - head in concrete 3) RESA parzialmente pavimentata / RESA partially paved

Figure 12: RUNWAY Physical Characteristics

Here below, in Figure 13, are highlighted the published reserved Zone for RPAS testing activity around TARANTO Grottaglie Aerodrome, active upon notice by NOTAM:

1. LI R315 Grottaglie Area 1B
2. LI R316 Grottaglie Corridoio B
3. LI R317 Grottaglie Area 2B

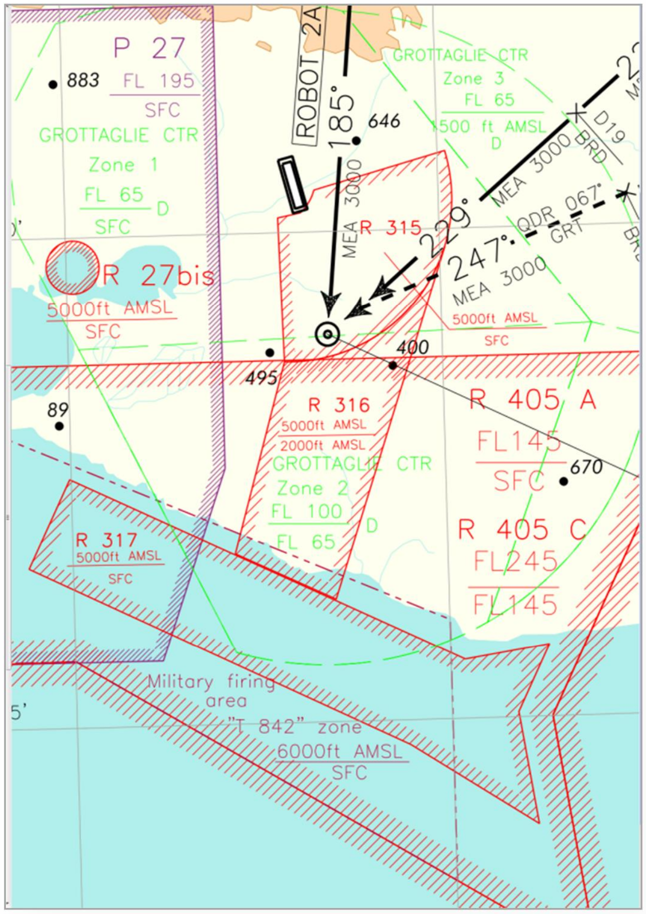


Figure 13: GROTTAGLIE Restricted Areas for RPAS testing flight activity

4.1.3.3 Safety Assessment

In the role of safety activity leader, ANS CR brought its 15 years of experience in safety management, using risk based approach.

The Safety assessment (see the resulting Safety Assessment document [11]) process has been based on the EATMN Safety Assessment Methodology (SAM, developed by EUROCONTROL) and includes procedures being developed by ANS CR or collected as the best practices.

The process used a safety argument, a tree-like structure of claims to prove that the top level argument – "RPAS Integration into non-segregated ATM is acceptably safe" – is true. The claim is accompanied with the context, assumptions and criteria.

The safety assessment produced for INSuRE includes the following phases ("SAM Process"):

- FHA (Functional Hazard Assessment), where hazards are identified and safety objectives are set;
- PSSA (Preliminary System Safety Assessment), where potential causes of hazards are identified and the related scenarios are further analysed; safety requirements (risk mitigation means needed to meet the safety objectives) are set;
- SSA (System Safety Assessment), where evidence is collected to support the safety argument and show whether the safety requirements are implemented and effective, the safety objectives are met and the overall risk is acceptable.

The safety assessment process covers all the elements of the overall system – people, procedures and equipment; together with the environment characteristics. The scenarios also consider all constituents of the system, being ground, airborne or space-based.

A specific part of the safety assessment focused on the human factor issues.

Based on the analysis done, there are no known issues to prevent the safety argument "RPAS integration into BRNO non-segregated airspace during flight trials is acceptably safe" to be valid.

4.2 Exercises Execution

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-RPAS.02-001	INSuRE #1	13/01/2015	13/01/2015	19/01/2015	06/02/2015
EXE-RPAS.02-002	INSuRE #2	13/01/2015	14/01/2015	19/01/2015	06/02/2015
EXE-RPAS.02-003	INSuRE #3	14/01/2015	14/01/2015	19/01/2015	06/02/2015
EXE-RPAS.02-004	INSuRE #4	15/01/2015	15/01/2015	19/01/2015	06/02/2015
EXE-RPAS.02-005	INSuRE Ground Test	15/12/2015	15/12/2015	17/12/2015	22/12/2015
EXE-RPAS.02-006	INSuRE #6	15/12/2015	16/12/2015	17/12/2015	22/12/2015
EXE-RPAS.02-007	INSuRE #7	15/12/2015	16/12/2015	17/12/2015	22/12/2015
EXE-RPAS.02-008	INSuRE #8	15/12/2015	16/12/2015	17/12/2015	22/12/2015

Table 14: Exercises execution/analysis dates

4.3 Deviations from the planned activities

Main deviation from planned project activities involves two main aspects:

- Time shift: the flight campaign was planned on May 2015. In agreement with CAA CR it was foreseen to endorse, with minor modification to adapt it to the Brno scenario, a permit to fly issued by the CAA IT for a similar scenario and similar kind of operation. The process for obtaining the Permit to Fly from the Italian CAA was longer than expected since there were some technical and regulatory unforeseen problems to be solved along the way. In the end, as documented also in the INSuRE RIO and Project CR approved by SESAR JU, SD was able to finalize the experimental flight campaign by the mid of November 2015.
- Change of flight test scenario: the delay cumulated in obtaining the permit to fly (both due to technical issues and to new regulation introduced in the meanwhile) led to a change of scenario from Brno airport to the Grottaglie airport, identified by the CAA IT as the national area for RPAS experimental flight campaigns; the main reasons for this choice are the extremely unfair weather conditions in Czech Republic during winter and the requirement to close the project within the end of 2015 as agreed with SESAR JU. After verification that the objectives and budget for the Project would remain unchanged, the Consortium and the SESAR JU accepted the change of scenario to a suitable spot with mild climate conditions; Grottaglie airport, in South of Italy fulfilled both those requirements.
- With respect to the Demonstration Plan the main deviation is the absence of the second manned aircraft in the flight campaign. The associated objectives have been nevertheless reached in the real time simulation relevant exercise (EXE-RPAS.02-003). The reason is that Grottaglie airport is not equipped with primary and secondary radar systems and it has been considered not safe to introduce a second manned aircraft, without increased situational awareness provided by radar tracks and transponder data available to the ATCOs.

  ADS-B data was, nevertheless, used during flight campaign to validate the system capability in detecting cooperative traffic, but no conflict situations have been created in real flights.

No major deviation has been detected during the execution of the simulation exercises in comparison to the planned simulation activities reported in the Validation Plan [8].

5 Exercises Results

5.1 Summary of Exercises Results

All objectives defined in the INSuRE Demonstration Plan [7] were fully satisfied either through simulation exercises or through flight trials (in some cases through both demonstration means) except for the following:

- Integration of multiple RPAs (one pilot controlling two RPAs from the same Ground Control Station): in the relevant simulation the pilots (two different pilots tested this case) declared that they felt not confident and safe enough in handling the two systems simultaneously and that their workload was too high in particular in the take-off and landing phases, when they had to be aware of the second vehicle position as well as manoeuvring the first.

Logs of the simulations and flights have been used to derive detailed results and, for the qualitative results, the interviews and feedback of controllers and RPAS pilots have been used.

The following table describes the exercise results in terms of the declared objectives.

Exercise ID	Demonstration Objective ID	Demonstration Objective Title	Success Criterion		Exercise Results	Demonstration Objective Status
EXE-RPAS.02-001	OBJ-RPAS.02-020	RPAS clearances compliance	ATCO clearance and RPAS response compliance will be within a defined quantitative range	No increase of complexity in operations in ATC sectors	ATCO reported no increase in complexity of operations	OK
				No degradation of the perceived level of safety in operations	ATCO reported no safety degradation in operations	OK
				No degradation of the perceived level of situation awareness in operations	ATCO reported full awareness in operations	OK
EXE-RPAS.02-006	OBJ-RPAS.02-030	RPAS reaction time	Qualitative ATCO evaluation of RPAS reaction time	No increase in controller workload in operations	ATCO workload reported low	OK
				No degradation of situational awareness in operations	ATCO reported full awareness in operations	OK
EXE-RPAS.02-006	OBJ-RPAS.02-040 OBJ-RPAS.02-140	Compliant flown trajectory	All flight procedure constraints (e.g. speed, climb rate, altitude) are followed	Adherence between RPA flown trajectory and planned mission.	RPA flown trajectory adherent with planned mission	OK
EXE-RPAS.02-006	OBJ-RPAS.02-050	ATCOs and RPAS pilot workload and situational awareness	Qualitative evaluation with HF questionnaire on ATCO and RPAS pilot	No increase in controller workload in operations for controllers	ATCO workload reported low	OK
				No increase in pilot workload in	RPAS Pilot workload	OK

Exercise ID	Demonstration Objective ID	Demonstration Objective Title	Success Criterion		Exercise Results	Demonstration Objective Status
			feedback	operations for pilots	reported to be in line with expectations for the operations performed	
				No degradation of situational awareness in operations for controllers	RPAS pilot and ATCOs reported full awareness in operations	OK
				No degradation of situational awareness in operations for pilots	RPAS pilot and ATCOs reported full awareness in operations	OK
EXE-RPAS.02-004	OBJ-RPAS.02-060	Safe integration of RPAS in airport ground traffic	Airport ground manoeuvre avoidance of collision risk is successfully tested	No increase of complexity in on-ground operations	ATCO reported no increase in complexity of ground operations with RPAS integrated in nominal traffic	OK
				No degradation of the perceived level of safety in on-ground operations	ATCO and pilots reported no degradation in perceived level of safety in ground operations with RPAS integrated in nominal traffic	OK
EXE-RPAS.02-002	OBJ-RPAS.02-070	Safe integration of RPAS in departing/arrival airport traffic	During RPAS departing procedure ATCO is able to safely manage conventional traffic and RPAS at the same time. Evaluation quantitative data of separation between departing traffic	No increase of complexity in departing/arrival operations.	ATCO management of RPAS together with another light aircraft did not increase complexity of operations	OK
				No degradation of the perceived level of safety in departing/arrival operations.	ATCO management of RPAS together with another light aircraft did not have impact on safety of operations	OK

Exercise ID	Demonstration Objective ID	Demonstration Objective Title	Success Criterion		Exercise Results	Demonstration Objective Status
				No degradation of the perceived level of situation awareness in departing/arrival operations	ATCO management of RPAS together with another light aircraft did not increase complexity of operations	OK
				No impact on departing/arrival airport capacity following the introduction of one RPAS in the airport.	Airport capacity not affected by introduction of one RPAS in operations	OK
EXE-RPAS.02-003	OBJ-RPAS.02-080 OBJ-RPAS.02-090 OBJ-RPAS.02-100	Collision detection, information and timing capability	Collision detection system able to detect under-separation condition and provides all information to the pilot in a timely manner so that avoidance action can be executed	No degradation of the perceived level of safety for RPAS pilot	Collision information received by the RPAS pilot – no safety issue detected	OK
				No increase of workload for RPAS pilot	RPAS pilot workload perceived to be in line with expectations for the operations performed	OK
				No degradation of the perceived level of safety to control the traffic	ATCO reported no degradation in perceived level of safety during RPAS detection and avoidance operations	OK
				No increase of workload to control the traffic	ATCO reported perceived nominal workload during RPAS detection and avoidance operations	OK
EXE-RPAS.02-005	OBJ-RPAS.02-110	Integrity of the RPAS Command & Control Data Link	All pre-flight tests relative to C&CDL integrity will be passed		RPAS test log reports passed integrity checks pre-flight	OK
EXE-RPAS.02-005	OBJ-RPAS.02-120	Efficient communication between RPAS	G/G radio communications are stable and clearly intelligible		Pre-flight radio check between RPAS Pilot	OK

Exercise ID	Demonstration Objective ID	Demonstration Objective Title	Success Criterion	Exercise Results	Demonstration Objective Status
		pilots and ATCOs		and ATCO passed	
EXE-RPAS.02-005	OBJ-RPAS.02-130	Integrity of ADS-B system	All pre-flight test relative to ADS-B integrity will be passed	RPAS test log reports pre-flight ADS-B test passed	OK
EXE-RPAS.02-001 EXE-RPAS.02-007 EXE-RPAS.02-008	OBJ-RPAS.02-150	Comparable response times between RPAS and conventional aircrafts	ATCO evaluates the actual response time of the RPAS to a route variation request and compare it with usual values recorded during conventional traffic management	ATCO request to change RPAS route timed and considered acceptable in all exercises and in particular in the emergency exercise 008	OK
EXE-RPAS.02-007 EXE-RPAS.02-008	OBJ-RPAS.02-160	Seamless integration of RPAS in standard ATM procedures	During nominal ATM operations, ATCOs are able to safely manage conventional traffic and RPAS at the same time	ATCOs evaluation during contingency and emergency exercise although not in presence of additional real traffic	Partly OK
EXE-RPAS.02-006	OBJ-RPAS.02-170	Human factor impact in RPAS integration in standard ATM procedures	The personnel involved in exercises is able to safely operate and communicate	The log of the RPAS pilot operations on UCS as well as radio communication recording has been the criterion for human factor and HMI efficiency evaluation	OK
EXE-RPAS.02-003	OBJ-RPAS.02-180	Efficient detection of arising trajectory conflicts	Detection of trajectory conflicts reach a successful rate of 100% within a time lapse of 4 minutes before the expected conflict event	Evaluated and measured in real time simulation – logs available	OK
EXE-RPAS.02-003	OBJ-RPAS.02-190	Capability of the RPAS to efficiently avoid detected conflict situations	The avoidance manoeuvre is completed maintaining during the whole trajectory at the prescribed safe space separation between involved aircrafts	Evaluated and measured in real time simulation – logs available	OK
EXE-RPAS.02-004	OBJ-RPAS 02-200	Safe integration of multiple RPA controlled by multiple RPAS	Awareness of surrounding traffic – pilot No increase of complexity in operations in ATC sector.	Complexity of operation in ATC sector was reported	OK

Exercise ID	Demonstration Objective ID	Demonstration Objective Title	Success Criterion		Exercise Results	Demonstration Objective Status
		pilots (each for one RPA) in a non-segregated airport/airspace	workload evaluation		by ATCOs and pilot to be nominal with integration of two RPAS.	
				No degradation of the perceived level of safety in operations.	ATCO and pilots reported no degradation in perceived level of safety in operations with two RPAS integrated in nominal traffic	OK
				No degradation of the perceived level of situation awareness in operations.	ATCO and pilots reported no degradation in perceived situational awareness in operations with two RPAS integrated in nominal traffic	OK
				No increase of workload in operations.	ATCOs workload was not impacted by introduction of two RPAS in nominal traffic	OK
				No increase of workload for RPAS pilot to control one RPAS in a situation with no traffic restriction	RPAS pilots reported no increase of perceived workload when piloting one RPAS in nominal traffic operations	OK
EXE-RPAS.02-004	OBJ-RPAS 02-210	Integration of multiple RPAs (one pilot - two RPAs)	Evaluation of response time of the pilot to ATC, pilot workload and pilot reaction time to warning/alert	No increase of complexity in operations in ATC sector.	RPAS pilot response to ATCO clearance was slower when controlling two RPAS from the same UCS	NOK
				No degradation of the perceived level of safety in operations.	RPAS pilot reported to feel not in safe operations while controlling two RPAS from the same UCS	NOK

Exercise ID	Demonstration Objective ID	Demonstration Objective Title	Success Criterion		Exercise Results	Demonstration Objective Status
				No degradation of the perceived level of situation awareness in operations.	RPAS pilot perceived a decreased awareness due to the switch of control between one RPAS and the other on the same UCS	NOK
				No increase of workload in operations.	The RPAS pilots perceived increased workload and level of stress while piloting two RPAS from the same UCS	NOK

Table 15: Summary of Demonstration Exercises Results

5.2 Choice of metrics and indicators

The choice of metrics and indicators used in the INSuRE demonstration evaluation is summarized in the following table:

Supported Metric / Indicator	Platform / Tool	Method or Technique
Complexity RPAS Trajectory adherence to planned mission ATCO CWP intent data for conflicting traffic	IDS Simulation Platform RPAS flight logs	Real Time Simulation logs RPAS Flight logs
ATCO Workload	Questionnaires	ATCO questionnaires Debriefing Observation
Pilot Workload	Questionnaires	Pilot questionnaires Debriefing Observation
Perceived Level of Safety	Questionnaires	ATCO questionnaires Pilot questionnaires Debriefing Observation
Perceived Level of Situation Awareness	Questionnaires	ATCO questionnaires Pilot questionnaires Debriefing Observation

Table 16: Methods and Techniques

All the methods applied in the collection of demonstration results are not-intrusive.

TECHNIQUE/METHOD	DATA TYPE					
	Qualitative	Quantitative	Objective	Subjective	Binary	Not-binary
Direct Over-the-shoulder not intrusive observation	X			X		X
Questionnaires	X	X		X	X	X
Debriefings	X			X		X
System Data Logs		X	X		X	X

Table 17: Data Collection Methods and Data Types

5.3 Summary of Assumptions

The following tables detail the specific assumptions applicable to the whole INSuRE demonstration campaign. The assumptions ID and numbering is kept in line with the Demonstration Plan [7].

Identifier	ASP-RPAS.02-001
Title	Airport and TMA traffic conditions
Type of Assumption	Traffic
Description	No aircraft other than RPAS will be present in the specific area defined as destination for the RPAS simulated mission. Traffic of any kind (either airborne or on the ground) will not interfere with RPAS manoeuvre along all planned flight paths within the controlled airspace.
Justification	Correct evaluation of the RPAS performances in the ATM environment is needed to avoid external interference.
Flight Phase	Take-off, route, cruise, mission simulation, landing
KPA Impacted	Workload, Safety
Source	NA
Value(s)	NA
Owner	ANS CR
Impact on Assessment	High

Table 18: Demonstration Exercise Assumption ASP-RPAS.02-001

Identifier	ASP-RPAS.02-002
Title	Data Link Coverage
Type of Assumption	Flight Planning
Description	Planned RPAS flight paths must be compliant with the Data Link coverage range.
Justification	Because of RPAS must be always in contact with ground station (no autonomous flight allowed), Data Link range must be respected in flight planning.
Flight Phase	Take-off, route, cruise, mission simulation, landing
KPA Impacted	Safety
Source	NA
Value(s)	NA
Owner	IDS
Impact on Assessment	Low

Table 19: Demonstration Exercise Assumption ASP-RPAS.02-002

Identifier	ASP-RPAS.02-003
Title	RPAS PtF in segregated area
Type of Assumption	Flight Planning
Description	A permission to fly for RPAS must be granted by Italian CAA.
Justification	Flight permission must be granted by the CAA in order to perform the flight trials in segregated area.
Flight Phase	Take-off, cruise, climb, approach, landing
KPA Impacted	Workload, Safety
Source	NA
Value(s)	NA
Owner	CR CAA
Impact on Assessment	High

Table 20: Demonstration Exercise Assumption ASP-RPAS.02-003

Identifier	ASP-RPAS.02-005
Title	RPAS PtF in controlled non-segregated area
Type of Assumption	Flight Planning
Description	Flight permission for RPAS must be granted by CAA.
Justification	Flight permission extended to controlled non-segregated area must be granted by the CAA in order to perform the flight trials and demonstrate the integration of the RPAS in ATM environment.
Flight Phase	Take-off, cruise, climb, approach, landing
KPA Impacted	Workload, Safety
Source	NA
Value(s)	NA
Owner	CR CAA
Impact on Assessment	High

Table 21: Demonstration Exercise Assumption ASP-RPAS.02-005

Identifier	ASP-RPAS.02-006
Title	Light aircraft permission for trials in controlled non-segregated area
Type of Assumption	Flight Planning
Description	Light aircraft authorization to perform experimental flight in controlled non-segregated area must be granted by CAA.
Justification	Flight permission extended to non-segregated area must be granted by the CAA in order to perform the flight trials and interact with RPAS.
Flight Phase	Take-off, cruise, climb, approach, landing
KPA Impacted	Workload, Safety
Source	NA
Value(s)	NA
Owner	CR CAA
Impact on Assessment	High

Table 22: Demonstration Exercise Assumption ASP-RPAS.02-006

Identifier	ASP-RPAS.02-007
Title	RPAS operational limits
Type of Assumption	Flight Planning
Description	All planned flight paths and manoeuvres must be inside the operational envelope of the RPAS system.
Justification	Design constraints of HERO RPAS, in terms of service ceiling, maximum speed, etc. cannot be violated. All flight planning must be inside of the operational envelope of the HERO system defined in the operational flight manual.
Flight Phase	Take-off, cruise, climb, approach, landing
KPA Impacted	Safety
Source	NA
Value(s)	NA
Owner	SD
Impact on Assessment	Low

Table 23: Demonstration Exercise Assumption ASP-RPAS.02-007

Identifier	ASP-RPAS.02-008
Title	ATC surveillance
Type of Assumption	Flight Planning
Description	During all flight phases an adequate surveillance level must be ensured by the ATC. The surveillance visibility of the RPAS must be verified and VHF communication granted.
Justification	ATC has to be able to monitor and check RPAS operation during all planned flight phases of the exercises.
Flight Phase	Take-off, cruise, climb, approach, landing
KPA Impacted	Safety
Source	NA
Value(s)	NA
Owner	ANS CR
Impact on Assessment	High

Table 24: Demonstration Exercise Assumption ASP-RPAS.02-008

5.3.1 Results per KPA

The relevant KPAs, impacted from the introduction of RPAS in non-segregated ATM, have been identified in the INSuRE Demonstration Plan and have been considered as the areas to be evaluated in the simulation campaign, as well as during the live trials.
For each of the KPA listed here:

- Predictability
- Safety
- Human Performance

have been identified (in the Demonstration Plan [7]) specific metrics and their evaluation has been associated to the exercises and objectives success criteria.

KPAs	KPIs	Results
Predictability	RPAS Trajectory adherence to planned mission ATCO CWP intent data for conflicting traffic	The mission was consistent with the planned waypoints ATCO was able to predict through the speed vector information the intent of relevant traffic
Safety	Complexity Perceived Level of Safety Perceived Level of Situation Awareness	ATCOs and Pilots feedback showed no increased complexity in operation, no impact on safety level and maintained good situational awareness Pilots reported some difficulties in feeling safe only in the specific case of one pilot managing two RPAs.

	Distance between RPA and the surrounding traffic Time between ATC conflict detection and conflict alert notification to pilot Time between conflict alert notification to pilot and reaction time to perform the proper manoeuvre	Graphical report of distance between RPAS and surrounding traffic showing different expected separation events, below minimum prescribed separation distance (2 NM horizontal, 500ft vertical) Measured response time in response to conflict detection is comparable with response time to similar detection for manned aircraft.
Human Performances	Situation Awareness Workload Perceived Level of Safety	ATCOs were always aware of the traffic intent for RPAS as well as for nominal traffic. ATCOs feedback showed no increased workload in handling RPAS operations, also in presence of high traffic situation. Pilots were aware of the operational situation in every phase of flight where RPAS was inserted in low traffic scenario. Pilots reported some difficulties in having complete awareness in case of high traffic or when one pilot managed two RPAs. Therefore the situation awareness and perceived level of safety were negatively impacted while controlling two RPASô from a single GCS (single pilot). Pilot feedback showed no increased workload in handling RPAS operations in all runs except when piloting two RPAs from the same control station.

5.3.2 Impact on Safety, Capacity and Human Factors

No specific impacts on Human Factors have been observed.

For what concern impacts on Safety and Capacity the importance of the implementation of collision detection technologies, starting from the usage of ADS-B for detection of cooperative traffic, as performed in INSuRE demonstration, is highlighted as a must to maintain the required level of safety in a normal civil traffic scenario.

5.3.3 Description of assessment methodology

The assessment methodology used in the project was not directly supported by WP16 although WP16 guidance available at the time of the demonstration execution has been taken into consideration by the project team.

Direct and non-intrusive over-the-shoulder observation was carried out by human factors (HF) during the runs. With reference to KPAs, this technique mainly allows to address topics related to Human Performances and Safety.

In INSuRE exercises, direct over-the-shoulder not-intrusive observation was used to collect insights about the ATCOs and pilots performance, including aspect related to application of working methods and procedures, cooperation within the team and with ATCOs.

During the run the observers were sitting behind the controllers, listening to R/T and inter-sector communications, observing the radar display and taking time-coded notes of anything considered relevant.

Questionnaires allowed a wide variety of views to be obtained from the controllers and pilots involved in the exercises, who might have different but equally relevant perspectives about the use and the impact of the integration of RPAS in non-segregated environment.

Two different questionnaires were proposed to controllers and pilots. The Questionnaires were filled in at the end of each exercise and a general questionnaire was filled at the end of the simulation session.

The forms contained questions addressing the Human Performances issues associated to the mental workload and situational awareness perceived by the ATCOs and Pilots.

In INSuRE demonstration campaign, debriefings were used to address aspects of Human Performances, Safety and Predictability. During the debriefing sessions the ATCOs and pilots were provided with different kinds of information and were asked to:

- discuss the human performance of the system (accuracy, representation, reliability and so on) used during the simulation;
- controllers and pilots were asked to envision the use of the information provided by the system and the effectiveness of the system itself;
- discuss the human performance of the controllers considering the whole experiment session;
- discuss the human performance of the pilots considering the whole experiment session.

Debriefings, questionnaire and over-the-shoulders observations are interconnected techniques. This means that on one hand, data collected though observations and questionnaire are then verified and discussed during the debriefings, and on the other hand insights that come out during the debriefings are then used to guide the following observations.

This combination of techniques enforces the quality of the data collected and contributes to get reliable results.

System quantitative data were collected by the extraction of log files from the platform. They were used to address aspects of almost all the KPAs interested, namely Safety, Human Performances, Efficiency/Environment, Capacity, Cost Effectiveness and Predictability.

The log files record the ATCOsôinteractions with HMI, R/T and telephone line.

5.3.4 Results impacting regulation and standardisation initiatives

It has been considered helpful and important for the execution of the demonstration flights to have operational procedures in place defining the expected interaction between the RPAS pilot, the Airport authorities (responsible for the availability of the airport site and facilities including the runways), the ANSP representatives including ATCOs and the National CAA (ENAC in Italy). The operational procedure put in place to handle RPAS operations in Grottaglie and implemented for the first time for supporting the INSuRE demonstrations allowed a smooth execution of all needed steps, from the submission of the NOTAM request to the completion of the flight activities.

As input for regulations and standardization activities, it was discussed the responsibility of the pilot in all activities related to the take-off phase, when they are performed from outside the airport site, e.g. take-off directly from a parking site not on the runway and without a taxiing procedures using the defined airport taxiways. The procedures between pilots and ATCOs for the required information to take-off can be standardised with ATCOs proving relevant information (e.g. flight information service) without providing clearances to take-off, which responsibility is left to the pilot. After take-off TOWER ATCO controls the RPAS flight in CTR/TMA.

As input for regulations and standardization activities, coming from exercise EXE-RPAS.02-003, is the attention required to the implementation of E-LOS with a ñpilot in commandò that is a different person from the pilot operating the RPAS from the Ground Control Station. The ñpilot in commandò would be the one having the RPAS in her/his line of sight at any moment, with the capability of taking over control for contingency reasons (becoming a safety pilot).
The pilot in command needs to have a free line of sight to the air-vehicle and integrate the information with the ADS-B data to avoid perspective mistakes. The two RPAS pilots shall be always in voice contact with each other.

5.4 Analysis of Exercises Results

A summary of the INSuRE exercises result has been presented in section 5.1. Detailed exercise per exercise report is provided in chapter 6.

5.4.1 Unexpected Behaviours/Results

No unexpected behaviour was detected during the demonstration exercises.
As shown by the pilot feedback in EXE-RPAS.02-004 (see dedicated entries in Table 15), the workload and stress level in handling two RPAs from the same ground control station was unexpectedly increased. It could be caused by the configuration of HMI in exchanging control or by a limited pilot training for the specific situation.
The multiple RPAs scenario could be further investigated in future simulations or experimental studies to verify the feasibility to simultaneously control multiple RPAS into civil airspaces.

5.5 Confidence in Results of Demonstration Exercises

5.5.1 Quality of Demonstration Exercises Results

The simulation platform reproduces the scenario in Brno airport and its surrounding in accurate way from controllersô and pilotsô point of view. Therefore the quality of results and feedback collected by actors during the execution of the exercise can be considered highly reliable.
The simulation platform allows logging of all data related to the performed exercises, RPAS and other aircraft flight paths. Logs have all known formats (standard, e.g. ASTERIX-21 or IDS proprietary, e.g. RPAS mission data format) and the data could be used to support quantitative result assessment.

The flight campaign, even if performed at a different site and with different logistics, is however a controlled flight zone with usual air traffic engaging the airport all over the day. In this sense the exercise results, both in terms of collected data, pilot and controllers feedback, can be considered highly reliable.
The UCS in conjunction with ADS-B receiver and Flight test instrumentation was continuously collecting data during all the flight campaign; the logs are in proprietary format and can be used for flight data post processing in order to support quantitative evaluation of RPAS performance during mission.

5.5.2 Significance of Demonstration Exercises Results

The results collected during the runs of the simulation campaign have a good significance from an operational point of view since the missions simulated were realistic and the scenario has been reproduced accurately.
Moreover, the first three exercises (those representative in preparation of the live trials) has been run officially one time for recording the logs but several dry runs and tests have been carried out to verify that the missions were reproduced consistently. The simulation campaign and its results provide

confidence to the operators on the feasibility and the behaviour that was planned to be reproduced in Brno in the Flight Campaign on controlling systems and on the consolidated operational procedure put in place.
The significance of the validation through the real time simulation is also supported by the fact that the team participating is composed by skilled and certified personnel that is foreseen to participate in the Campaign of RPAS flights in Brno.
The data collected during the exercises, specifically referring to the mission execution (flight logs from the RPAS simulator) and interaction between the ATCO and pilots via voice loops, are highly representative of the real operational data, since:

- the RPAS ground station used in simulations is developed by the RPAS manufacturer and used for testing with the real avionic system;
- although the communication system used for simulation was not the operational one in use in Brno, the voice loops were used by certified ATCO and by a certified light aircraft pilot, according to the voice procedures and protocols in place for aircraft operations.

The results collected during the runs of this exercise have a good significance from an operational point of view since the flights performed were in close cooperation with ATCO and includes emergency situation simulation and contingency procedure evaluation. The lack of second manned aircraft, due to the unavailability of radar appliance at Grottaglie airport (both primary and secondary) has limited the possibility to extend the flight campaign results to the detect and avoidance of conflicting traffic, but the data collected during the whole flight campaign has to be considered highly significant in RPAS and ATCO interaction as well as workload evaluation.

5.5.3 Conclusions and recommendations

The objectives of the demonstrations were overall reached, with only one exception (the objective in EXE-RPAS.02-004 related to the piloting of two RPAS from the same control station and by only one pilot).

A high level of situational awareness shown by the Controllers has been recorded during the whole execution of this campaign.
The workload of controllers was in general low in all exercises due to limited or nominal traffic planned in the scenarios.
The feeling of controllers on safe integration of RPAs in controlled airspace derived from simulation and flight campaign experience was good.

Nevertheless, controllers underlined the importance in cases of converging traffic ï RPAS vs AIRCRAFT:

- traffic information available on instruments and consistent for each stakeholder is necessary, as it was during the simulations;
- pilots need to respond with quick answer on the voice loop and their RPAS command in reaction should follow the operational rules for mid-air collision avoidance. This case was tested successfully in EXE-RPAS.02.003.

As general feedback from pilots, three different communication media (cell phone, VHF and UHF radio) can be somewhat confusing if each channel is used at the same time. An integrated multi-frequency voice segment in the UCS should represent a good upgrade reducing the need of using three different appliances to keep communication under control. During exercise, due to limited traffic present, it was not a particular problem, but in more congested situation it can represent a real limitation.

The situational awareness of RPAS pilots during the set of simulation exercises was considered very good.
As general feedback from pilot, the simulation platform was good but the interfaces of the unmanned ground system should be improved.
For pilot, it was very easy to see the difference between the planned route and the flown route and to see the warning messages for conflict detection and hear the associated audio alert.

The feeling of pilot on safe integration of RPAs in controlled airspace derived from simulation experience was good.

The simulation campaign was performed successfully also from a human performance point of view.

It is worth to mention that the exercise with two RPAs (integrated in non-segregated airport/airspace in no traffic restriction at Brno airport and CTR/TMA with nominal surrounding traffic) was performed successfully from a human performance, workload and situational awareness point of view, when multiple RPAs are controlled by multiple RPAS pilots (one per each RPA).

The main recommendations resulting from the INSuRE simulation campaign are:

1. It must be carefully considered the <u>operational procedure for an RPAS taking-off from outside the runway or defined helipad and not following a preliminary taxiing phase using defined taxiways</u>. ATCOs recommendation was to make clear that the responsibility for take-off lies, in these cases, on the RPAS pilot exclusively and that GROUND ATCOs would have a role of monitoring and providing general information on weather, traffic, etc. but they would not provide a clearance for take-off. The RPAS goes under control responsibility of TOWER ATCO once it has taken-off and flies in the controlled airspace. This operational agreed procedure has been used throughout the INSuRE simulation campaign where applicable and positive feedback has been provided on its implementation for the flight trials, both by ATCOs and RPAS pilots.

2. For the flight trial implementation of the detection and avoidance exercise, a set of recommendation coming from the real time simulation have been implemented:
   - Suggested to have an additional pilot with RPA in V-LOS during the critical part of the mission with capability of taking over control for safety reasons. There is a station identified in the area Charlie, where the RPAS Ground Control station can be positioned to allow the pilot to keep the RPAS in visual line of sight. The other RPAS pilot, "safety pilot", shall follow the requirement of being at the edge of the area Charlie to be an additional safety net and also detect eventual cases of intruders getting close to the RPAS mission area.
   - A temporary NOTAM will inform that demonstration exercises are on-going in the area for a specific timeframe.
   - The validated trajectories for both flights (RPA and light aircraft) are considered feasible in real life but they are too much dependent on synchronization in order for the conflicting conditions to happen. The recommendation is to keep the RPAS mission very regular and predictable so that the light aircraft can perform the necessary adjustments to establish the under-separation condition;
   - Relying only on ADS-B data can be sufficient in this case where both aircrafts are equipped but additional radar tracks (CAT-62) could be used to have higher knowledge of traffic if not all cooperating, since in the Czech Republic National law it is not required for very light and light aircraft to be ADS-B equipped; additional CAT-62 radar data have to be intended only as a safety back-up for aircrafts position awareness in case of ADS-B failure; it is not required by the collision detection system;
   - The RPAS "pilot to pilot" communication can be performed using very shortly the operational frequency for the live trial and defining a list of short messages for communicating with TOWER for info on repetition of activities, without congesting the voice link.

3. An integrated multi-frequency voice segment in the RPAS UCS should represent a good upgrade for future operations, reducing the need of potentially using three different appliances to ensure communication (prime and back-up means).

6 Demonstration Exercises reports

6.1 Demonstration Exercise EXE-RPAS.02-001 Report

EXE-RPAS.02-001 is the first exercise related to INSuRE project demonstration.

6.1.1 Exercise Scope

EXE-RPAS.02-001 focuses on the operational procedures between RPAS pilot and ATCOs for the integration of RPAS into a non-segregated area. This exercise is performed in real time simulation for the Brno CTR and Terminal Area (TMA), assuming that traffic of any kind (either airborne or on the ground) does not interfere with RPAS manoeuvre.

6.1.2 Conduct of Demonstration Exercise EXE-RPAS.02-001

6.1.2.1 Exercise Preparation

The preparatory activities for the exercise consisted in a pre-briefing meeting with all actors involved in which:

- the configuration and roles during the mission were reviewed and shared;
- the operational set up was discussed (including voice procedures, runway usage, SSR code associated to the RPA);
- understanding of the exercise scope (start to end) was shared.

For this exercise, the following configuration was set up:

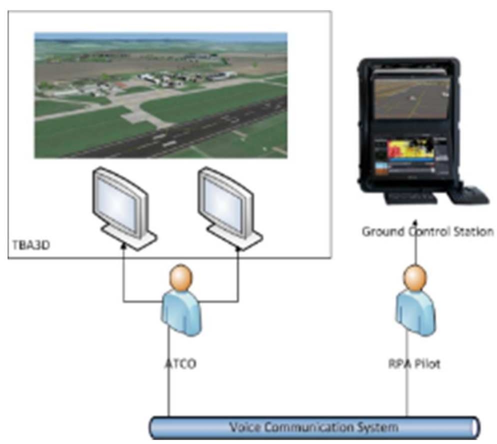


Figure 14: Configuration for EXE-RPAS.02-001

Specific RPA missions have been designed for specific runs for EXE-RPAS.02-001. The take-off position for the RPA was agreed to be one dedicated point outside the runway, with the following operational implication, agreed during the pre-briefing:

- ATCO does not give a clearance for take-off;
- Ground ATCO is contacted on GND frequency by the RPA pilot;
- Ground ATCO is informed by the pilot about the intention to take off and provides back relevant information about eventual surrounding traffic and weather conditions;
- The RPA pilot is solely responsible in the take-off phase, until entering TWR control.

The RPAS mission, as planned and displayed in the main window of the GCS, is reported in the figure below:

Figure 15: RPA Mission for Run#1.2 and Run#1.4 (green line)

6.1.2.2 Exercise execution

EXE-RPAS.02-001 execution was composed of six runs.
For the execution of each run the operational procedure steps for interaction between ATCO and pilot has been:

1) Voice check on GROUND frequency;
2) RPA Pilot starts communication with GROUND controller for departure info;
3) Transfer communication to TOWER controller after take-off;
4) Authorization request from the pilot to perform the mission within the area defined for the specific run;
5) TOWER clearance to execute the missions in Alfa area up to 2500ft (in Bravo area up to 2000ft);
6) Reporting to TOWER controller upon reaching the mission area;
7) Reporting to TOWER controller upon completion of RPAS activity for authorization to return to the identified parking area for landing;
8) Transfer to GROUND for final communication after landing.

The exercise runs are summarised hereafter:

- Run #1.1 Free flight to Alfa area

  The RPAS took off from Brno airport (LKTB) and flew in accordance with the planned procedure towards the Alfa area. ATC clearance was not required for take-off (since the take-off position was not on the runway) while it was required from TOWER to authorize the mission execution, providing general information about weather and traffic, to authorize return from the mission area to the landing place. This run has foreseen small interaction between RPAS pilot and ATC. RPA flown mission is highlighted as light-blue line in Figure 16.

  This run has been used as a baseline for the evaluation of the following run#1.3, where the ATC and communication procedures have been included.

- Run#1.2 Free flight to Bravo area

  The RPAS took off from Brno airport (LKTB) and flew in accordance with the planned procedure towards the Bravo area. ATC clearance was required (same procedure as in Run #1.1) but this run has foreseen small interaction between RPAS pilot and ATC. RPA flown mission is highlighted as yellow line in Figure 16.

  This run has been used as a baseline for the evaluation of the following run#1.4, where the ATC and communication procedures have been included.

- Run#1.3 Flight to Alfa area subjected to ATC clearance

  This run was similar to run#1.1 with the exception that RPAS complied to ATC clearances although still not required for take-off (since the take-off position was not on the runway). The interaction was required for information on departure (RPAS pilot - GROUND ATCO) and then between Pilot and TOWER, for TOWER ATCO to authorize the mission execution, providing general information about weather and traffic, to authorize return from the mission area to the landing place. During all phases of flight RPAS pilot and ATCOs were to be in constant voice communication contact. All the ATC operational procedures were to be followed. RPA flown mission is highlighted as purple line in Figure 16.

- Run#1.4 Flight to Bravo area subjected to ATC clearance

  This run was similar to run#1.2 with the exception that RPAS complied to ATC clearances although still not required for take-off (since the take-off position was not on the runway). The interaction was required for information on departure (RPAS pilot - GROUND ATCO) and then between Pilot and TOWER, for TOWER ATCO to authorize the mission execution, providing general information about weather and traffic, to authorize return from the mission area to the landing place. During all phases of flight RPAS pilot and ATCOs were to be in constant voice communication contact. All the ATC operational procedures were to be followed. RPA flown mission is highlighted as turquoise-blue line in Figure 16.

The following two runs in EXE-RPAS.02-001 represent non nominal situations (contingencies) related to the voice communication capability between ATCO and RPAS Pilot. They were executed to identify the operational approach to be followed in case the communication link is working partly (one way) or not working at all. In case of full loss of communication (both ways voice communication loss) the operational approach to be followed is the same as the one simulated in Run#1.7.

- Run#1.7 VHF voice communications failure - Pilot unable to hear the communication of controller
  The RPAS took off from Brno airport (LKTB) and flew in accordance with the planned procedure towards the Alfa area. While RPA was executing the mission in Alfa area, a VHF voice communications failure happened. Pilot was unable to hear the communication of controllers. Therefore pilot switched the squat to 7600 - loss of communication - and executed the contingency procedure, landing to the ground in a specific position within the Alfa area, without any ATCO instruction. RPA flown mission is highlighted as green line in Figure 16.

- Run#1.8 VHF voice communications failure - ATCOs unable to heard the communication of pilot
  The RPAS took off from Brno airport (LKTB) and flew in accordance with the planned procedure towards the Alfa area. While RPA was executing the mission in Alfa area, a VHF voice communications failure happened. ATCO was unable to hear the communication of pilot. The controller asked to pilot to change the squat to verify if the pilot could listen the ATCO clearances. The pilot could hear the indications giving confirmation through the change of the squat, as required by ATCO. Therefore, the controllers continued to give pilot indications without feedback to perform the return and landing procedure. RPAS came back to the east apron following the controller indications. The controller monitored the procedure execution according to instruction on the CWP system, showing the RPAS track. The whole RPA flown mission is highlighted as violet line in Figure 16.

Mobile phones (that were foreseen to be used in Run#1.5, as per Validation Plan) are still identified as backup way to communicate, but cannot be accepted for flight-trial operational instruction, therefore it is meaningful to simulate the contingency without using non-operational devices.

All missions executed by RPA have been logged.

6.1.2.3 Deviation from the planned activities

The initially foreseen data link loss contingency has been agreed not to be meaningful in the real time simulation since:

- The data link loss is handled by the on-board RPAS system, which implements, after a predefined number of attempt to recover communication, an automated landing procedure (effectively aborting the mission in a safe manner) pre-defined in the FMS and associated to the designed mission;
- Simulating in real time the data link loss has been agreed not to have added value. The contingency procedure execution following a data link loss is tested by the RPAS team using the on-board system directly, since its activation does not involve operators' interaction, and its results have been provided as part of material supporting the Permit to Fly request.

It was agreed to skip the runs above and to perform two additional runs (Run#1.7 and Run#1.8 already detailed in section 6.1.2.2) more meaningful from an operational point of view. Their outcomes is considered valuable to test that operationally these cases are handled by the controllers in a nominal way with appropriate reaction of the RPAS Pilot supported by the Ground Control Station capabilities.

6.1.3 Exercise Results

6.1.3.1 Summary of Exercise Results

All RPA missions performed in the runs of EXE-RPAS.02-001, impacting Alfa and Bravo areas, have been highlighted in the picture below with different colour (according to the legend shown in the left panel of the window). The picture has been produced importing in Google Earth all RPA logs files, properly converted to KML.

Figure 16: Flown RPA Missions in EXE-RPAS.02-001

The following picture report a screenshot of UCS (Unmanned Control System) containing the RPA planned mission (in light blue) and the trajectory flown (in green), as evidence of compliance between designed (planned) flight procedure and the flown trajectory if no deviation from nominal path are executed (OBJ-RPAS.02-040). Each waypoint is flown correctly by RPA according to fly-by or fly-over mode defined in the corresponding flight mission.

Figure 17: Planned (light blue) and flown RPA Mission (green) in Run#1.4

The following picture shows RPAS Trajectory adherence to planned mission for run #1.4. The 3D view highlights a good adherence of the RPAS mission to the RPA flight plan waypoints.

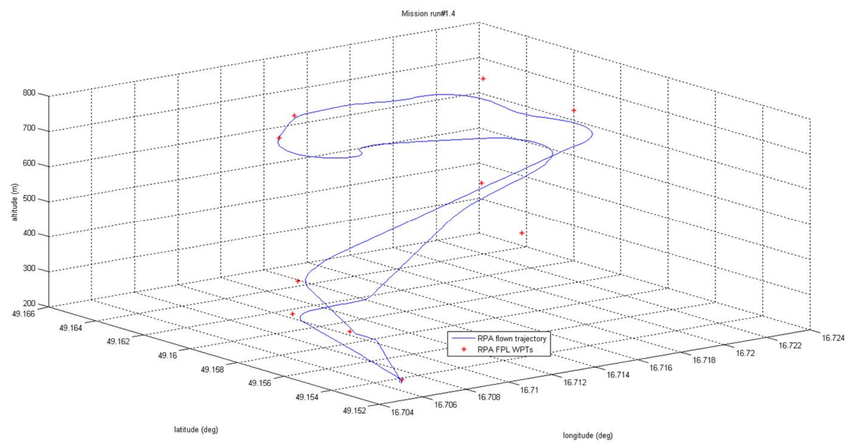
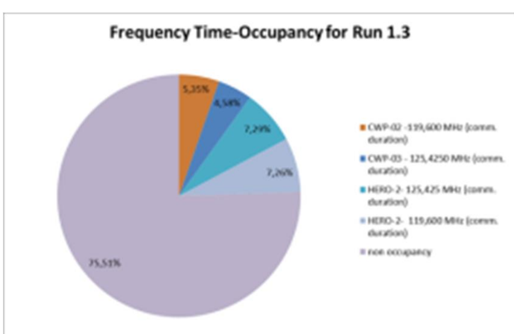
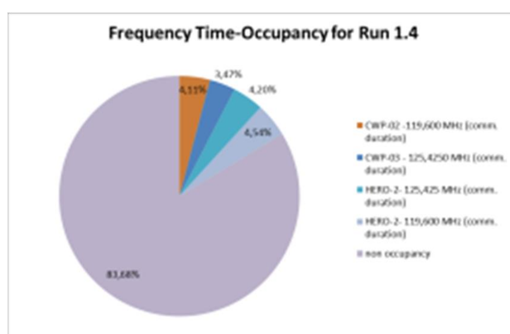
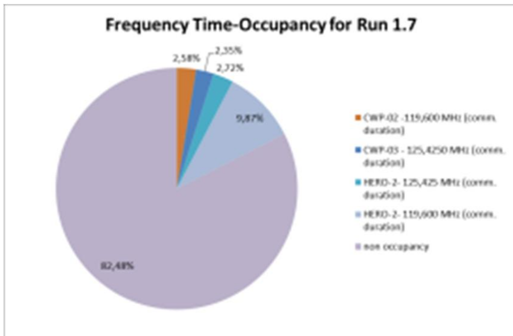


Figure 18: RPAS Trajectory adherence to planned mission for the run#1.4 (RPA flown trajectory in blue and RPA flight plan waypoints in red)

The following pictures show the frequency time-occupancy for communications between ATCOs and pilot for runs related to EXE-RPAS.02-001 where an active role of ATCOs was foreseen. As visible, the time-occupancy of the different frequencies (119,600 MHz ï TOWER, 125,450 MHz GROUND, 121,500 MHz - EMERGENCY) is limited enough compared to the duration of the RPA simulated mission.







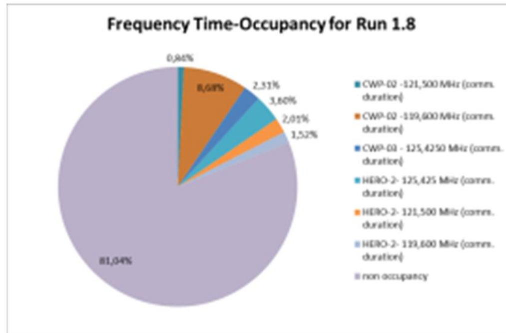


Figure 19: Frequency time occupancy for EXE-RPAS.02-001

From the RPAS Pilot and from the ATCOs point of view, the exercise demonstrated that both stakeholders maintained full awareness of the mission while it was executed, that the interaction foreseen via voice communication was successfully performed within the nominal workload for controlling/handling the RPAS as any other air-vehicle in the airspace. No deviation from the nominal operational procedures was necessary or recorded. The only difference in the clearances, from the ATCO point of view, is in the responsibility for take-off from a position outside the runway:

- The ATCOs are not responsible to provide clearance for air-systems taking off from a position that is not a runway nor an identified helipad;
- ATCO therefore provide only relevant information and note down the intention of taking-off reported by the pilot;
- The take-off phase is under full responsibility of the RPAS pilot;
- The ATCO takes responsibility for controlling the RPAS once it has taken-off, hence enters the controlled BRNO airspace.

The exercise has been successfully testing the above operational procedure, which is in general deemed acceptable from both ATCOs and RPAS Pilot.

6.1.3.1.1 Results per KPA

A summary of results per KPA is presented in 5.3.1.

6.1.3.1.2 Results impacting regulation and standardisation initiatives

There is no specific result from this exercise that can be seen as input for regulations and standardization activities. Nevertheless, it was discussed the responsibility of the pilot in all activities related to the take-off phase, when they are performed from outside the airport site, e.g. take-off directly from a parking site not on the runway and without a taxiing procedures using the defined airport taxiways.
A general input on operational procedures to be followed, responsibility in the various phases of flight and regulatory aspects is provided for all exercises at the end of simulation campaign and recorded in paragraph 5.5.3.

6.1.3.1.3 Unexpected Behaviours/Results

No unexpected behaviours/results have been detected during the execution of this exercise.

6.1.3.1.4 Quality of Demonstration Results

The simulation platform reproduces the scenario in Brno airport and its surrounding in accurate way from controllersôand pilotsôpoint of view. Therefore the execution of the exercise is representative of the actual execution of RPAS flight into non-segregated airspace with no traffic in the surrounding area. The Real Time Simulation for EXE-RPAS.02-001 provided results and feedback collected from the actors during and after the execution of the exercise, which can be considered highly reliable.

6.1.3.1.5 Significance of Demonstration Results

The results collected during the runs of this exercise have a good significance from an operational point of view since the missions simulated were realistic and the scenario has been reproduced accurately. They allow full operational assessment of the mission and give confidence in the feasibility of the corresponding flight trial, in Brno real operational scenario.
Even if the runs have been performed in a limited situation of traffic, their results are relevant about the perception of RPAS performance from controllersôperspective in order to monitor and manage the RPAS into controlled airspace.

6.1.4 Conclusions and recommendations

6.1.4.1 Conclusions

The objectives of this exercise were fully reached.
A high level of situational awareness shown by the Controllers has been recorded during the whole execution of this exercise:

- simulated scenario was considered realistic from controllers point of view and it was accurate enough for on-ground validation purposes;
- controllers were always aware of the RPA position during the execution of RPA mission;
- controllers were able to communicate with RPA pilot on expected voice frequency;
- RPAS response following a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft.

The workload of controllers was very low in this exercise due to limited traffic in the scenario (i.e. no aircraft other than RPAS is present in the Brno Terminal Area). Therefore:

- mental and perceptual activity to control one RPA was not higher than the one related to a light manned aircraft;
- time pressure due to the rate of pace at which the task elements occurred to control RPA was not higher than the one related to a manned aircraft and the pace was slow;
- very limited work (mentally and physically) to accomplish the level of performance;
- controllers felt secure, gratified, content, relaxed and complacent during the task;
- controllers were satisfied of their performance in accomplishing the goals foreseen in this exercise.

The situational awareness of pilot can be considered very good since:

- simulated scenario was considered realistic sufficiently from pilot point of view and it was accurate enough for on-ground validation purposes;
- pilot was aware of the RPA position always during the execution of RPA mission;
- pilot was able to communicate with ATCO on expected voice frequency;
- RPAS response following to a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft.

The workload of pilot was not too high in this exercise also due to limited need to manoeuvre and to the non-existing additional traffic in the scenario (i.e. no aircraft other than RPAS is present in the Brno Terminal Area). Therefore:

- lower impact on mental and perceptual performance to pilot the RPA compared to a light manned aircraft, since the RPA was manoeuvred from ground and pilot, being on-ground, reported that he could manage the system with more calmness;
- mental and perceptual activity of pilot has been reported to be simple, therefore the risk of forgetting something important was mentioned in the pilot feedback associated with such a relaxed activity;
- physical activity to pilot one RPA was not higher than the one related to a light manned aircraft;
- time pressure due to the rate of pace at which the task elements occurred to control RPA is not higher than the one related to a manned aircraft and the pace was low in this exercise due the simple scenario;
- pilot considered his work (mentally and physically) suitable to accomplish the expected level of performance;
- pilot felt neither relaxed nor stressed during the exercise;

- pilot was enough satisfied of its performance in accomplishing the goals foreseen in this exercise.

As general feedback from pilot, the simulation platform was good. Just a little improvement of interfaces (specifically, in this case, for the voice communication system usage) could be desirable.
For pilot, it was very easy to see the difference between the planned route and the flown route.
The feeling of pilot on safe integration of RPAs in controlled airspace derived from this simulation experience was good.
Furthermore, pilot felt more secure in controlled airspace than in not-controlled airspace. Coordination offered by controllers give pilot a greater feeling of safe operations.
Therefore, the exercise was performed successfully, from operational and human performance point of view.

6.1.4.2 Recommendations

As general feedback from controllers, the simulation platform was working well and represented the real operational environment, except for the functionality of push-to-talk of the radio. The radio communication (implemented on the platform via a touch screen sliding button) could be improved pressing a physical single button to activate the communication.
This aspect was only affecting the start of the simulation runs. The voice capability is not implemented in the same way in the operational environment and the controllers in Brno plan to use the certified voice system available on their console for the flight trials. Therefore, the initial problems caused in the simulation by the voice system interface, have not impacted in any way the results of the Flight Campaign trials, and by extension of the project as a whole.

The controllers reported a positive feeling on safe integration of RPAs in controlled airspace, derived from this simulation experience.
It must be carefully considered the operational procedure for an RPAS taking-off from outside the runway or defined helipad and not following a preliminary taxiing phase using defined taxiways.
ATCOs recommendation was to make clear that the responsibility for take-off lies, in these cases, on the RPAS pilot exclusively and that GROUND ATCOs would have a role of monitoring and providing general information on weather, traffic, etc. but they would not provide a clearance for take-off. The RPAS goes under control responsibility of TOWER ATCO once it has taken-off and flies in the controlled airspace.
This operational agreed procedure has been used throughout the INSuRE simulation campaign where applicable and positive feedback has been provided on its implementation both by ATCOs and RPAS pilots.

6.2 Demonstration Exercise EXE-RPAS.02-002 Report

EXE-RPAS.02-002 is the second exercise related to INSuRE project demonstration.

6.2.1 Exercise Scope

EXE-RPAS.02-002 focuses on the operational procedures between RPAS pilot and ATCOs for the integration of RPAS into a non-segregated area in presence of a light manned aircraft in the same area and at the same time in Brno scenario. RPAS and light aircraft ground manoeuvres and departing and arrival procedure are performed simultaneously and no aircraft other than RPAS and one light manned aircraft fly in that area.

6.2.2 Conduct of Demonstration Exercise EXE-RPAS.02-002

6.2.2.1 Exercise Preparation

The preparatory activities for the exercise consisted in a pre-briefing meeting with all actors involved in which:

- the configuration and roles during the mission were reviewed and shared;
- the operational set up was discussed (including voice procedures, runway usage, SSR code associated to the RPA and to the light aircraft);
- understanding of the exercise scope (start to end) was shared;
- Run#2.1 has no RPAS mission planned, RPAS pilot is executing a VFR mission without a loaded flight plan and focusing on the taxiing phase.

For this exercise, the following configuration was set up:

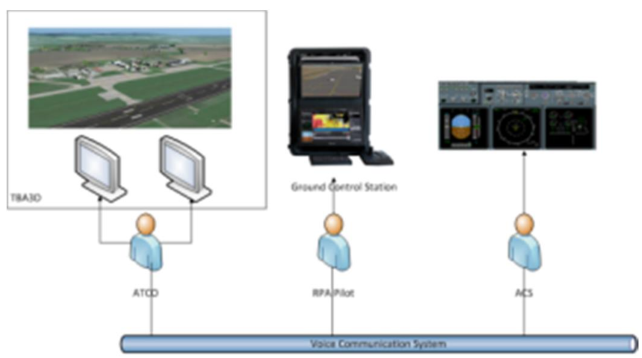


Figure 20: Configuration for EXE-RPAS.02-002

Specific RPA missions are planned for this exercise for Run#2.2, Run#2.3 and Run#2.4. Planned mission (green path) for Run#2.2 and Run#2.3 is reported hereafter:

Figure 21: RPA Mission for Run#2.2 and Run#2.3

6.2.2.2 Exercise execution

The exercise execution was composed by four runs.
For the execution of each run the operational procedure steps for interaction between ATCO, RPAS pilot and light aircraft pilot has been:

1) Voice check on GROUND frequency;
2) RPA Pilot starts communication with GROUND controller for departure info;
3) Light Aircraft pilot requests due clearances;
4) Transfer communication to TOWER controller after RPAS take-off;
5) Authorization request from the RPAS pilot to perform the mission within the area defined for the specific run;
6) TOWER clearance to execute the RPAS missions in Alfa area up to 2500ft (in Bravo area up to 2000ft);
7) Reporting to TOWER controller upon reaching the mission area;
8) Reporting to TOWER controller upon completion of RPAS activity for authorization to return to the identified parking area for landing;
9) Transfer to GROUND for final communication after landing;
10) Nominal controlling procedures for light aircraft;
11) Nominal controlling procedures for monitoring separation between RPAS and light aircraft.

The exercise runs are summarised hereafter:

- <u>Run#2.1 RPAS ground movement with manned traffic</u>

  RPAS moved inside the airport from the parking position to the take-off area following the taxi route cleared by the GROUND ATCOs. Simultaneously the light manned aircraft performed the same type of manoeuvres. Constant VHF voice communication contact with ATCOs is required for both RPAS and the aircraft.

- <u>Run#2.2 RPAS and light manned aircraft horizontal separation</u>

  The RPAS took off from Brno airport (LKTB) and flew in accordance with the planned procedure towards the Bravo and Alfa areas. Then it executed the planned photo flight mission up to FL020 and returned again to the Brno airport. A light manned airplane took off at the same time and it reached the Bravo and Alfa areas as well but with a different trajectory. Horizontal separation was applied.

- <u>Run#2.3 RPAS and light manned aircraft vertical separation</u>

  The RPAS took off from Brno airport (LKTB) and flew in accordance with the planned procedure towards the Bravo and Alfa area. Then it executed the planned photo flight mission up to FL020 and returned again to the Brno airport. The light manned airplane took off and consequently landed at the Brno airport. Departure and arrival procedures were performed at the same time by RPAS and light airplane. Separation provided was vertical.

- <u>Run#2.4 RPAS and light manned aircraft with low visibility</u>

  The RPAS took off from Brno airport (LKTB) and flew in accordance with the planned procedure. Then it executed the planned photo flight mission up to A025 and returned again to the Brno airport. A light manned airplane took off at the same time and it reached the Bravo area as well but with a different trajectory. Sudden change in visibility conditions was simulated. Vertical separation was applied.

6.2.2.3 Deviation from the planned activities

No deviation from the planned activities has been recorded during the execution of this exercise.

6.2.3 Exercise Results

6.2.3.1 Summary of Exercise Results

The RPA mission, performed in each run of EXE-RPAS.02-02, has been reported in Google Earth together with the corresponding trajectory executed by manned light aircraft.

Furthermore, for each run, the horizontal, vertical and 3D distance in meters between RPAS and light manned aircraft are reported.

Run#2.1

Figure 22: Flown RPA Mission (purple) and light aircraft trajectory (yellow) for Run#2.1 (in bottom the elevation profile of RPA mission)

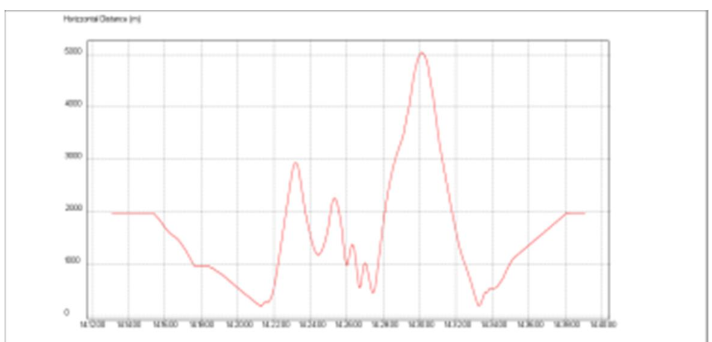


Figure 23: Horizontal distance between RPAS and aircraft for Run#2.1

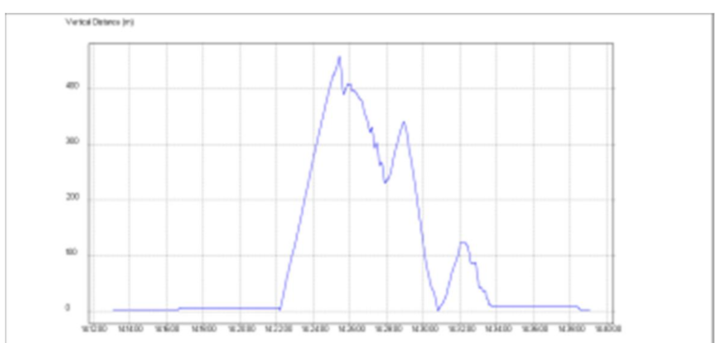


Figure 24: Vertical distance between RPAS and aircraft for Run#2.1

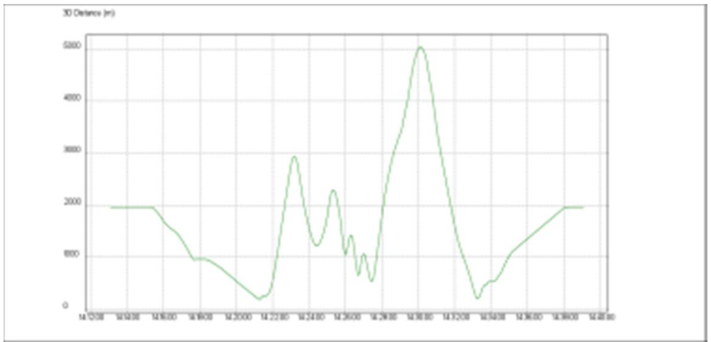


Figure 25: 3D distance between RPAS and aircraft for Run#2.1

No TCAS alert has been detected during this simulation.

Run#2.2

Figure 26: Flown RPA Mission (purple) and light aircraft trajectory (yellow) for Run#2.2 (in bottom the elevation profile of RPA mission)

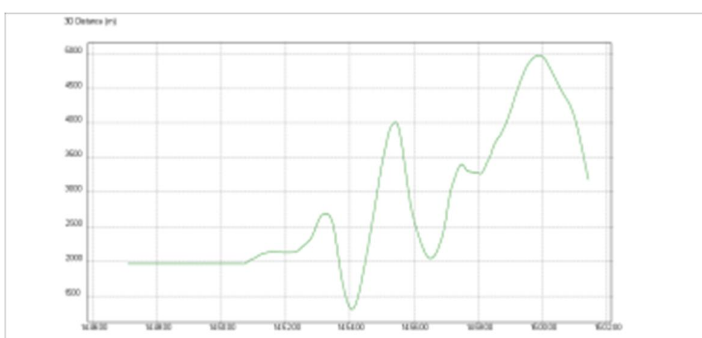


Figure 27: 3D distance between RPAS and aircraft for Run#2.2

No TCAS alert has been detected during this simulation.

Run#2.3

Figure 28: Flown RPA Mission (purple) and light aircraft trajectory (yellow) for Run#2.3 (in bottom the elevation profile of RPA mission)

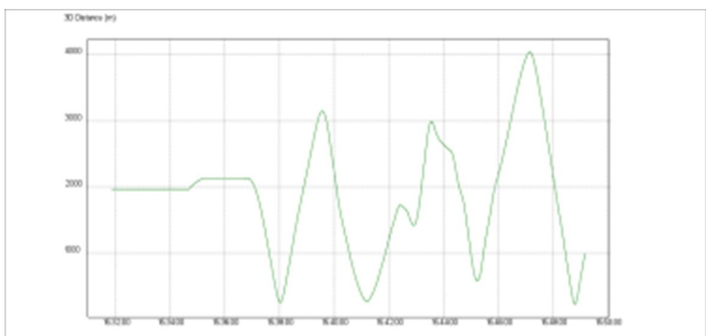


Figure 29: 3D distance between RPAS and aircraft for Run#2.3

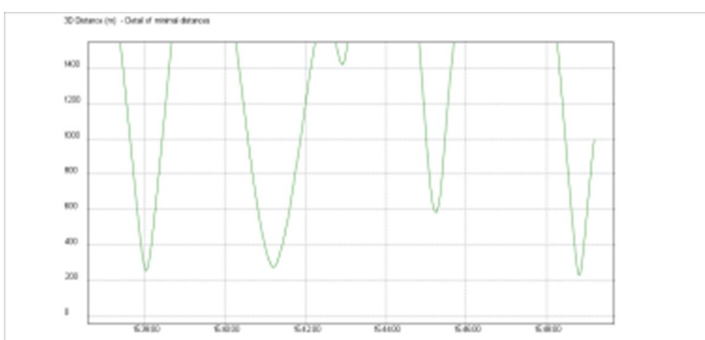


Figure 30: Detail of 3D distance between RPAS and aircraft for Run#2.3

No TCAS alert has been detected during this simulation.

Run#2.4

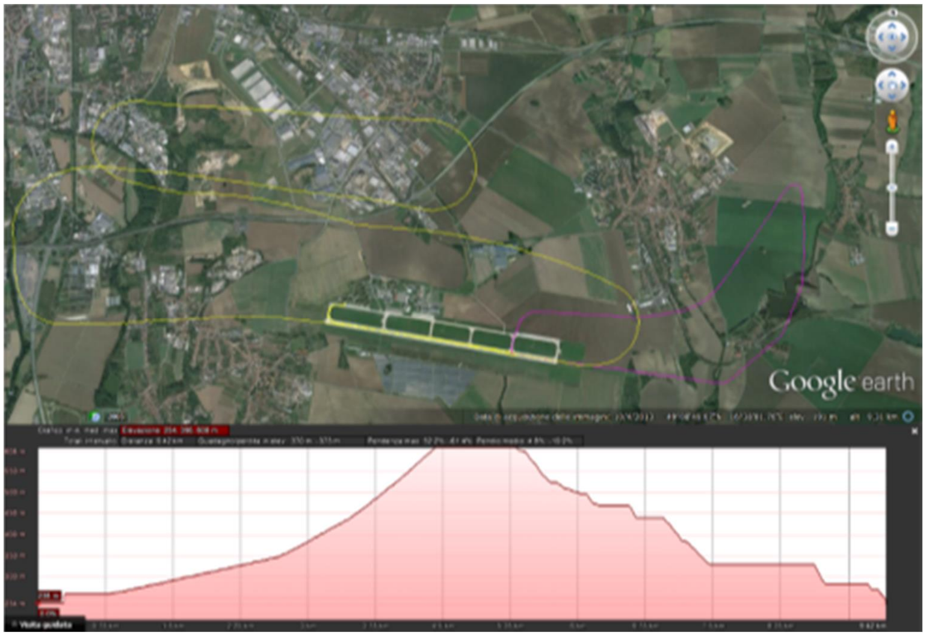


Figure 31: Flown RPA Mission (purple) and light aircraft trajectory (yellow) for Run#2.4 (in bottom the elevation profile of RPA mission)

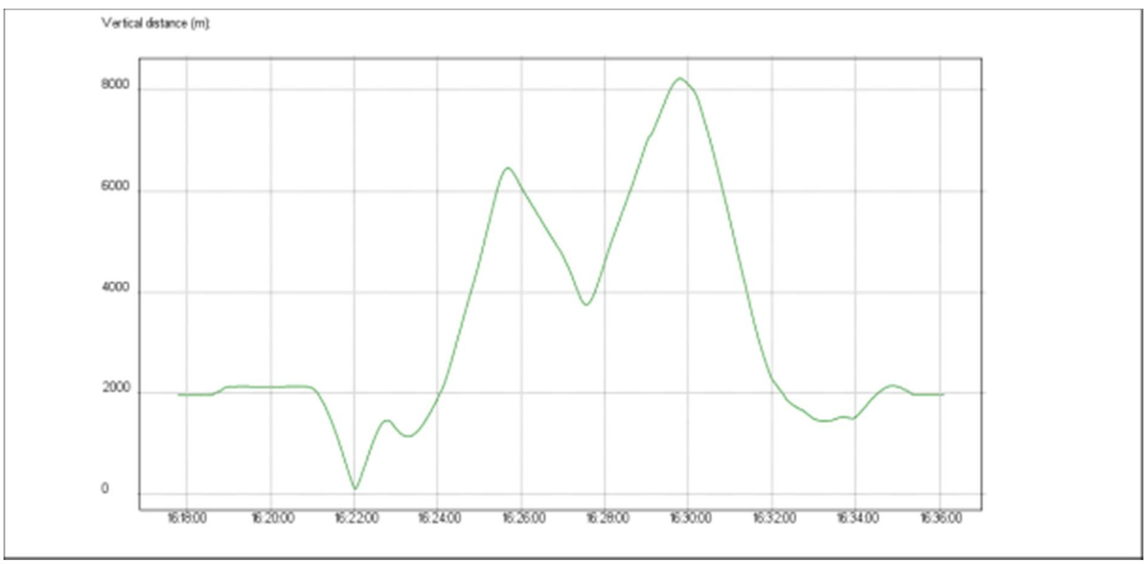


Figure 32: 3D distance between RPAS and aircraft for Run#2.4

No TCAS alert has been detected during this simulation.

It has to be noted that the Run 2.4, simulating a sudden low visibility condition, was a dedicated contingency aimed at verifying both the fact that safety could be maintained through vertical separation and also to test the operational procedure execution related to the low visibility condition.

With the visibility lowering below 1500m, ATCO instructed both light aircraft and RPAS, specifically in that order given the behaviour and speed allowed, to return for landing at airport. It was noted that the possibility to continue the flights as "special VFR" flight would have needed an authorization. For Brno operational rules only one aircraft in CTR would anyhow be allowed in very low visibility.

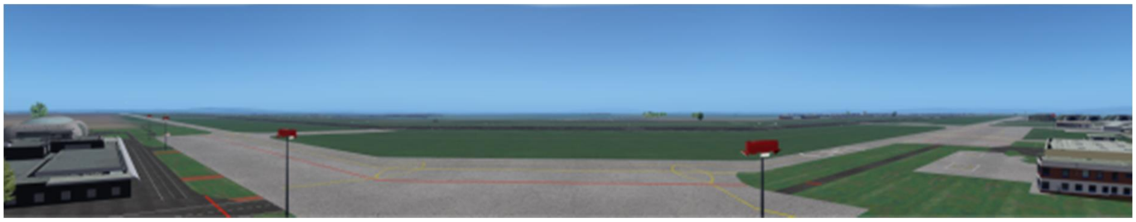


Figure 33: Initial visibility from Tower (Run#2.4)

Figure 34: Lower visibility from Tower (Run#2.4)

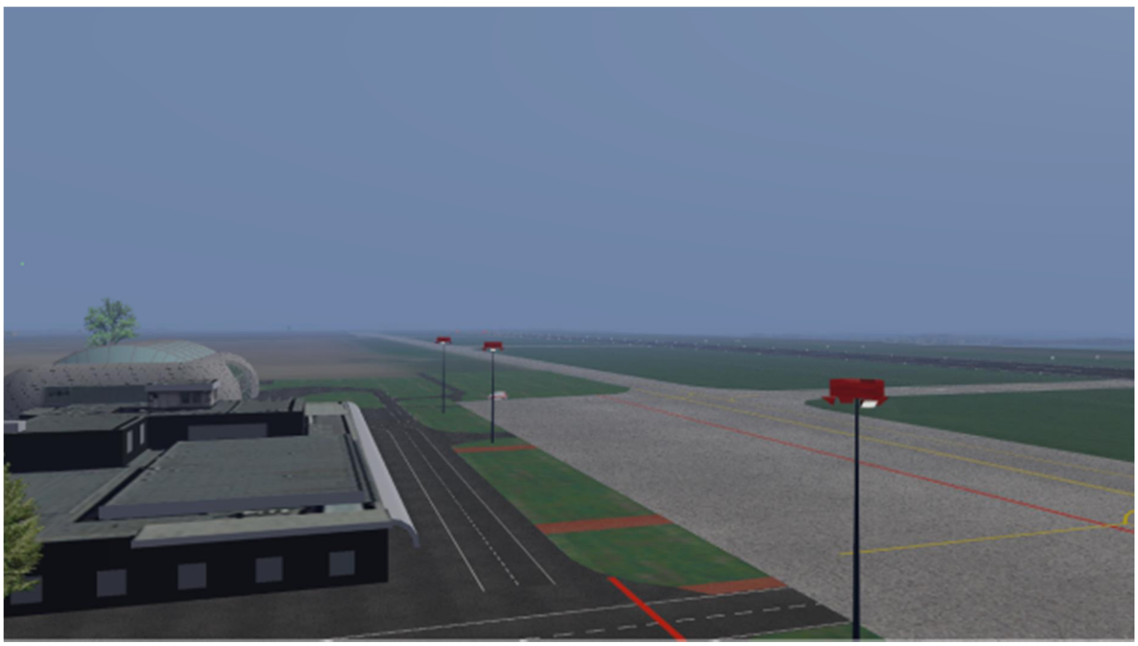


Figure 35: Zoom of lower visibility from Tower (Run#2.4)

The following images show the frequency time-occupancy for communications between ATCOs, RPAS pilot and light aircraft pilot for runs related to EXE-RPAS.02-002. As visible, the time-occupancy of the different frequencies (119,600 MHz, 125,450 MHz) is limited enough compared to the duration of the run.

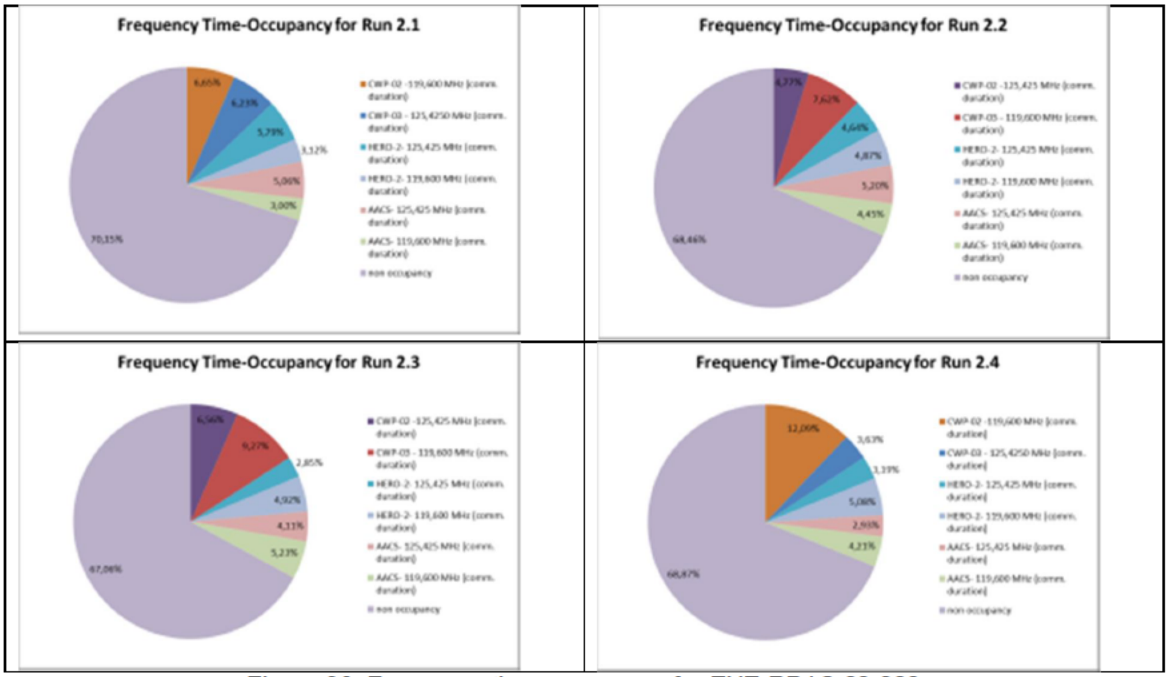


Figure 36: Frequency time occupancy for EXE-RPAS.02-002

6.2.3.1.1 Results per KPA

KPA	Objective ID	Objective Description	Success Criterion	Success Criterion	Result of Validation
Safety	OBJ-RPAS.02-020	To demonstrate the RPAS clearances compliance.	ATCO clearance and RPAS response compliance will be within a defined quantitative range.	No increase of complexity in operations in ATC sectors.	ATCO feedback showed not increased complexity in ATC sectors since RPAS response is complaint with ATCO clearance within an acceptable quantitative range.
Safety	OBJ-RPAS.02-020	To demonstrate the RPAS clearances compliance.	ATCO clearance and RPAS response compliance will be within a defined quantitative range.	No degradation of the perceived level of safety in operations	ATCO feedback showed no degradation of the perceived level of safety since RPAS response is complaint with ATCO clearance within an acceptable

					quantitative range.
Safety	OBJ-RPAS.02-020	To demonstrate the RPAS clearances compliance.	ATCO clearance and RPAS response compliance will be within a defined quantitative range.	No degradation of the perceived level of situation awareness in operations	ATCO feedback showed no degradation of the perceived level of situation awareness since RPAS response is complaint with ATCO clearance within an acceptable quantitative range.
Workload (controllers)	OBJ-RPAS.02-050	To evaluate the impact on ATCOs and RPAS pilot workload and situational awareness.	Qualitative evaluation with HF questionnaire on ATCO and RPAS pilot feedback.	No increase in controller workload in operations	Based on HF questionnaire, ATCO feedback showed not increased workload in operations.
Workload (pilots)	OBJ-RPAS.02-050	To evaluate the impact on ATCOs and RPAS pilot workload and situational awareness.	Qualitative evaluation with HF questionnaire on ATCO and RPAS pilot feedback.	No increase in pilot workload in operations	Based on HF questionnaire, pilot feedback showed not increased workload in operations.
Situational awareness (controllers)	OBJ-RPAS.02-050	To evaluate the impact on ATCOs and RPAS pilot workload and situational awareness.	Qualitative evaluation with HF questionnaire on ATCO and RPAS pilot feedback.	No degradation of situational awareness in operations	Based on HF questionnaire, ATCO feedback showed no degradation of situational awareness in operations.
Situational awareness (pilots)	OBJ-RPAS.02-050	To evaluate the impact on ATCOs and RPAS pilot workload and situational awareness.	Qualitative evaluation with HF questionnaire on ATCO and RPAS pilot feedback.	No degradation of situational awareness in operations	Based on HF questionnaire, pilot feedback showed no degradation of situational awareness in operations.
Safety	OBJ-RPAS.02-060	To demonstrate safe integration of RPAS in airport ground traffic.	During simulated airport ground manoeuvre avoidance of collision risk is successfully tested.	No increase of complexity in on-ground operations	ATCO feedback showed not increased complexity in in on-ground operations.

Safety	OBJ-RPAS.02-060	To demonstrate safe integration of RPAS in airport ground traffic.	During simulated airport ground manoeuvre avoidance of collision risk is successfully tested.	No degradation of the perceived level of safety in on-ground operations	ATCO feedback showed no degradation of the perceived level of safety in on-ground operations.
Safety	OBJ-RPAS.02-060	To demonstrate safe integration of RPAS in airport ground traffic.	During simulated airport ground manoeuvre avoidance of collision risk is successfully tested.	No degradation of the perceived level of situation awareness in on-ground operations	ATCO feedback showed no degradation of the perceived level of situation awareness in on-ground operations.
Capacity	OBJ-RPAS.02-060	To demonstrate safe integration of RPAS in airport ground traffic.	During simulated airport ground manoeuvre avoidance of collision risk is successfully tested.	No impact on airport capacity following the introduction of one RPAS in the airport.	Airport capacity is not impacted by the introduction of one RPAS in the airport based on controllers' feedback.
Safety	OBJ-RPAS.02-070	To demonstrate safe integration of RPAS in departing/arrival airport traffic.	During RPAS departing procedure ATCO is able to safely manage conventional traffic and RPAS at the same time. Evaluation quantitative data of separation between departing traffic.	No increase of complexity in departing/arrival operations.	ATCO feedback showed not increased complexity in in departing/arrival operations.
Safety	OBJ-RPAS.02-070	To demonstrate safe integration of RPAS in departing/arrival airport traffic.	During RPAS departing procedure ATCO is able to safely manage conventional traffic and RPAS at the same time. Evaluation quantitative data of separation	No degradation of the perceived level of safety in departing/arrival operations.	ATCO feedback showed no degradation of the perceived level of safety in departing/arrival operations.

			between departing traffic.		
Safety	OBJ-RPAS.02-070	To demonstrate safe integration of RPAS in departing/arrival airport traffic.	During RPAS departing procedure ATCO is able to safely manage conventional traffic and RPAS at the same time. Evaluation quantitative data of separation between departing traffic.	No degradation of the perceived level of situation awareness in departing/arrival operations.	ATCO feedback showed no degradation of the perceived level of situation awareness in departing/arrival operations.
Capacity	OBJ-RPAS.02-070	To demonstrate safe integration of RPAS in departing/arrival airport traffic.	During RPAS departing procedure ATCO is able to safely manage conventional traffic and RPAS at the same time. Evaluation quantitative data of separation between departing traffic.	No impact on departing/arrival airport capacity following the introduction of one RPAS in the airport.	Departing/arrival airport capacity is not impacted by the introduction of one RPAS based on controllers' feedback.

6.2.3.1.2 Results impacting regulation and standardisation initiatives

No relevant results from this specific exercise as input for regulations and standardization activities.
A general input on operational procedures to be followed, responsibility in the various phases of flight and regulatory aspects is provided for all exercises at the end of simulation campaign and recorded in paragraph 5.5.3.

6.2.3.1.3 Unexpected Behaviours/Results

No unexpected behaviours/results have been detected during the execution of this exercise.

6.2.3.1.4 Quality of Demonstration Results

The simulation platform reproduces the scenario in Brno airport and its surrounding in accurate way from controllers' and pilots' point of view. Therefore the quality of results and feedback collected by actors during the execution of the exercise can be considered highly reliable.

6.2.3.1.5 Significance of Demonstration Results

The results collected during the runs of this exercise have a good significance from an operational point of view since the missions simulated were realistic and the scenario has been reproduced accurately.

Even if the runs have been performed in a limited situation of traffic, its results are relevant about the perception of RPAS performance from controllersô perspective in order to monitor and manage the RPAS into controlled airspace.
This exercise was deemed significant for the preparation of the following exercise, in which avoidance manoeuvres need to be executed. The awareness of the relative position and of the type of mission planned in this exercise has given necessary background information for a good understanding of the type of manoeuvres that are feasible, given the limited area in which the RPAS executes its mission and the very different behaviour of the two aircrafts.

6.2.4 Conclusions and recommendations

6.2.4.1 Conclusions

The objectives of this exercise were fully reached.
The situational awareness of controllers can be considered high during the whole execution of this exercise, since:

- simulated scenario was considered realistic from controllers point of view and it was accurate enough for on-ground validation purposes;
- controllers were aware of the RPA position always during the execution of RPA mission;
- controllers were able to communicate with RPA pilot on expected voice frequency;
- RPAS response following to a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft;
- controllers remembered the RPAS flight missions and potential conflict situation that occurred during the taxiing and landing after the conclusion of the exercise, during the compilation of the questionnaire.

The workload of controllers was very low in this exercise due to limited traffic in the scenario (i.e. no aircraft other than RPAS is present in the Brno Terminal Area). Therefore:

- mental and perceptual activity to control one RPA was not higher than the one related to a light manned aircraft;
- mental and perceptual activity to control one RPA (deciding, looking) is simple;
- time pressure due to the rate of pace at which the task elements occurred to control RPA was not higher than the one related to a manned aircraft; the pace was slow;
- very limited work (mentally and physically) to accomplish the level of performance
- controllers felt secure during the task;
- controllers were satisfied of their performance in accomplishing the goals foreseen in this exercise;
- controllers highlighted that there is a risk of forgetting something important and the need of strictly following given instructions by ATC to avoid conflict (e.g. ñHold short ofé ò, ñStay north of the airportò)

As general feedback from controllers, the simulation platform was ok.
The feeling of controllers on safe integration of RPAs in controlled airspace derived from simulation experience was good.

The situational awareness of pilot can be considered quite well since:

- simulated scenario was considered realistic sufficiently from pilot point of view and it was accurate enough for on-ground validation purposes;
- pilot was aware of the RPA position always during the execution of RPA mission;
- pilot was able to communicate with ATCO on expected voice frequency;
- RPAS response following to a specific ATCO clearance happen within reasonable time range and it could be considered comparable with the response of a manned aircraft;
- pilot declared that he remembered the RPAS flight missions and potential conflict situation that occurred after the conclusion of the exercise, during the compilation of the questionnaire.

The workload of pilot was not too high in this exercise also due to limited traffic in the scenario (i.e. just one light manned aircraft other than RPAS is present in the Brno Terminal Area). Therefore:

- mental and perceptual activity of pilot has been considered quite simple but there was a certain probability to forget something important;

- physical activity to pilot one RPA was not higher than the one related to a light manned aircraft;
- time pressure due to the rate of pace at which the task elements occurred to control RPA is not higher than the one related to a manned aircraft; but it was quite rapid and frenetic in certain segments of the mission;
- pilot considered his work (mentally and physically) suitable to accomplish the level of performance;
- pilot felt a little bit insecure and stressed;
- pilot was satisfied of its performance in accomplishing the goals foreseen in this exercise.

As general feedback from both pilots, the simulation platform was good. Traffic information provided to pilots by ATCO was confirmed immediately by both pilots being fully aware, during every moment of the mission execution, of the surrounding traffic.
For RPAS pilot, it was very easy to see the difference between the planned route and the flown route.
The feeling of pilot on safe integration of RPAs in controlled airspace derived from simulation experience was good.
The exercise was performed successfully from an operational and human performance point of view.

6.2.4.2 Recommendations

No relevant recommendations derived from the execution of this exercise from operational point of view.

6.3 Demonstration Exercise EXE-RPAS.02-003 Report

EXE-RPAS.02-003 is the third exercise related to INSuRE project demonstration.

6.3.1 Exercise Scope

EXE-RPAS.02-003 focuses on the operational procedures between RPAS pilot and ATCOs for the integration of RPAS into a non-segregated area in presence of a light manned aircraft in the same area and at the same time, in order to evaluate the RPAS behaviour when a conflict situation arises. No aircraft other than RPAS and one light manned aircraft fly in the Brno CTR and Terminal Area (TMA).

6.3.2 Conduct of Demonstration Exercise EXE-RPAS.02-003

6.3.2.1 Exercise Preparation

The preparatory activities for the exercise consisted in a pre-briefing meeting with all actors involved in which:

- the configuration and roles during the mission were reviewed and shared;
- the operational set up was discussed (including voice procedures, runway usage, SSR code associated to the RPA and to the light aircraft);
- understanding of the exercise scope (start to end) was shared.

For this exercise, the following configuration was set up:

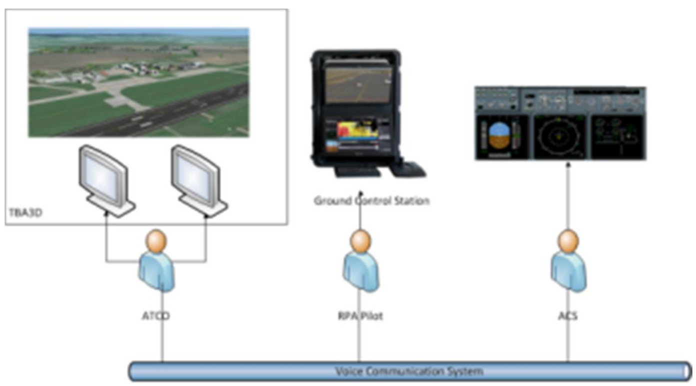


Figure 37: Configuration for EXE-RPAS.02-003

Specific RPA missions are planned for this exercise for the different runs.
RPA mission (green path) planned for Run#3.3 is reported below:

Figure 38: RPA Mission for Run#3.3

The following flight plan (dotted green line) is foreseen for the manned light aircraft for Run#3.3:

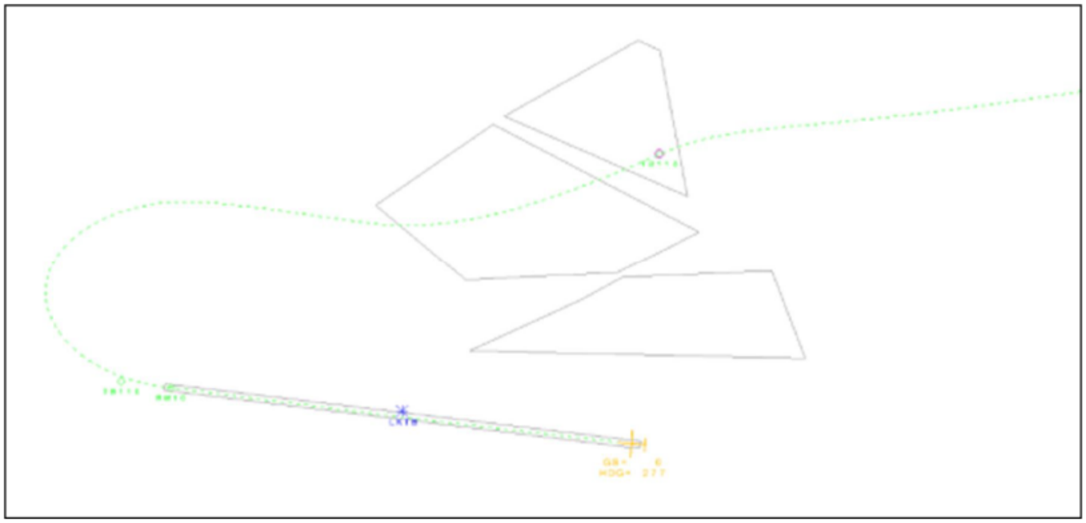


Figure 39: Manned light aircraft flight plan for Run#3.3

For the preparation of all runs in EXE-RPAS.02-003, the take-off time of the light aircraft has been timed with respect to the take-off time of the RPAS in order to make sure that the relative position needed for testing the under-separation condition would be verified. This has been necessary due to the limited area in which the RPAS executes its mission and to the non-comparable behaviour of the light aircraft.

6.3.2.2 Exercise execution

For the execution of each run the operational procedure steps for interaction between ATCO, RPAS pilot and light aircraft pilot has been:

1) Voice check on GROUND frequency;
2) RPA Pilot starts communication with GROUND controller for departure info;
3) Light Aircraft pilot requests due clearances;
4) Transfer communication to TOWER controller after RPAS take-off;
5) Authorization request from the RPAS pilot to perform the mission within the area defined for the specific run;
6) TOWER clearance to execute the RPAS missions in Alfa area up to 2500ft (in Bravo area up to 2000ft);
7) Reporting to TOWER controller upon reaching the mission area;
8) Reporting to TOWER controller upon completion of RPAS activity for authorization to return to the identified parking area for landing;
9) Transfer to GROUND for final communication after landing;
10) Nominal controlling procedures for light aircraft;
11) Nominal controlling procedures for monitoring separation between RPAS and light aircraft.

The exercise execution was composed by five runs and they summarised hereafter:

- <u>Run #3.1 Conflict detection capability</u>
  RPAS took off from a place out of the airport and then flew towards the reserved Charlie area. In the meanwhile a light aircraft took off from LKTB airport and reached Charlie area as well. RPAS executed the flight in the reserved area at the minimum speed; pilot of the light airplane ensured relevant separation. After that, RPAS flew at normal speed and followed specified straight trajectory. Light aircraft flew on the opposite track (with offset 100m). Both aircraft avoided to the right. This pre-planned conflict resolution was useful to safely check that all the collision detection functionalities were working properly and it also allowed the RPAS pilot to concentrate only on the warning message the control station displayed when a conflict arose without thinking about the conflict resolution.

- Run #3.1 with observer - Conflict detection capability
  This run was not present in the Validation plan but it was performed to evaluate the implementation of E-LOS with a "pilot in command" that is a different person from the pilot operating the RPAS from the Ground Control Station. This run has been executed using the same configuration and data of run#3.1.

- Run #3.2 Loss of Longitudinal separation
  RPAS departed from LKTB and flew towards the Charlie reserved airspace, where it executed its planned photo flight mission. Activity in the area was allowed up to A025. The light aircraft took off from LKTB and reached the same target area. RPAS flew at normal speed following predefined route. Light aircraft performed a maneuver that induced a longitudinal separation loss. RPAS pilot, warned by collision detection system, performed a maneuver to restore the proper longitudinal separation.

- Run #3.3 Loss of lateral separation
  RPAS departed from a place out of the airport and flew towards the Charlie reserved airspace, where it executed its planned photo flight mission. Activity in the area was allowed up to A025. The light aircraft took off from LKTB and reached the same target area. RPAS flew at normal speed following predefined route. Light aircraft performed a maneuver that induced a lateral separation loss. RPAS pilot, warned by collision detection system, performed a maneuver to restore the proper lateral separation.

- Run #3.4 Loss of vertical separation
  RPAS departed from LKTB and flew to the Charlie reserved airspace, where it executed its planned photo flight mission. Activity in the area was allowed up to 2500ft AGL. The light aircraft took off from LKTB and overflew the Charlie area at a specified altitude.
  RPAS, while was executing its mission, reached an altitude too close to the light aircraft inducing a vertical separation loss. RPAS pilot, warned by collision detection system, performed a maneuver to restore the proper vertical separation.

6.3.2.3 Deviation from the planned activities

No deviation from the planned activities has been recorded during the execution of this exercise.

6.3.3 Exercise Results

6.3.3.1 Summary of Exercise Results

The RPA mission, performed in each run of EXE-RPAS.02-03, has been reported in Google Earth together with the corresponding trajectory executed by manned light aircraft. Furthermore, additional figures have been reported to show specific results for each run.

Run#3.1

Figure 40: Flown RPA Mission (purple) and light aircraft trajectory (yellow) for Run#3.1 (in bottom the elevation profile of RPA mission)

The following figures have been produced processing the data collected during the Run#3.1 for RPA mission and light aircraft trajectory and TCAS levels have been highlighted. Furthermore, 3D trajectories distance has been reported to show the time slot in which conflict detection occurs. As shown in Figure 41 , the alarm does not depend only on geometric air-vehicles separation but also on velocity and air-vehicles direction, according to TCAS model implemented.

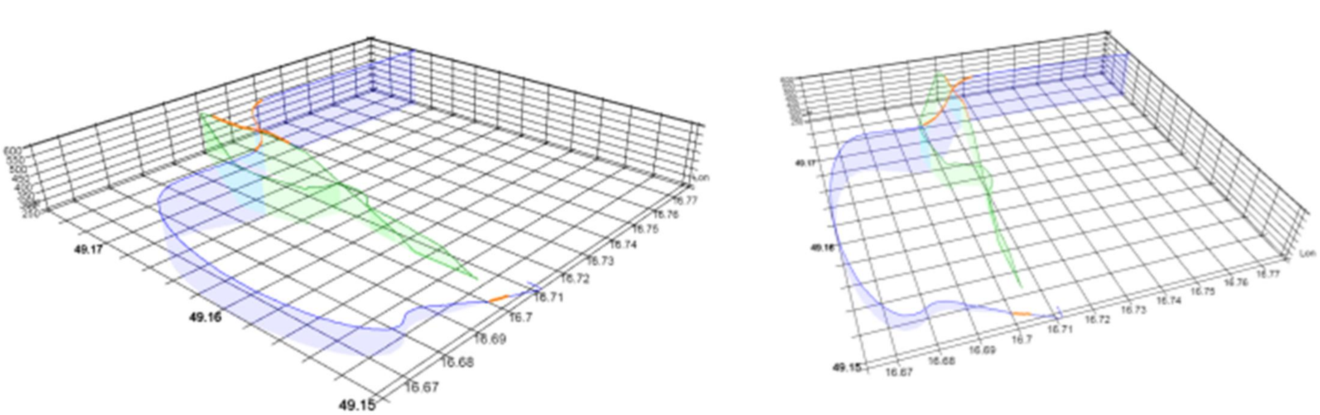


Figure 41: 3D Trajectories and TCAS level for Run#3.1

Run#3.1 with observer

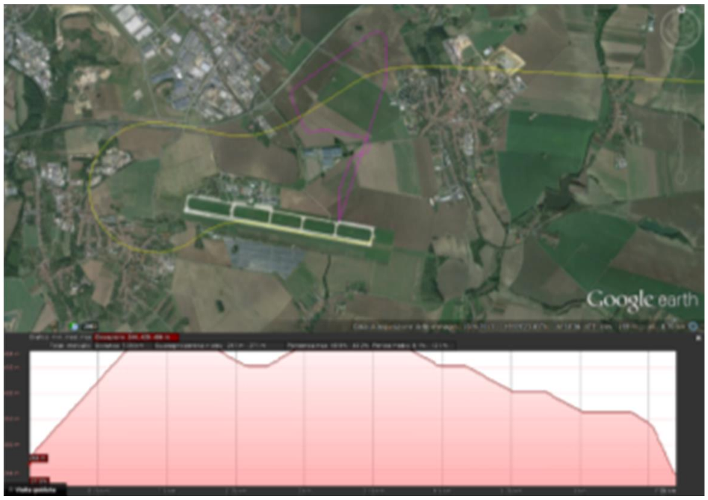


Figure 42: Flown RPA Mission (purple) and light aircraft trajectory (yellow) for Run#3.1 with observer (in bottom the elevation profile of RPA mission)

The following figures have been produced processing the data collected during the Run#3.1 with observer for RPA mission and light aircraft trajectory and TCAS levels have been highlighted. Furthermore, 3D trajectories distance has been reported to show the time slot in which conflict detection occurs. As shown in Figure 43, the alarm does not depend only on geometric air-vehicles separation but also on velocity and air-vehicles direction, according to TCAS model implemented.

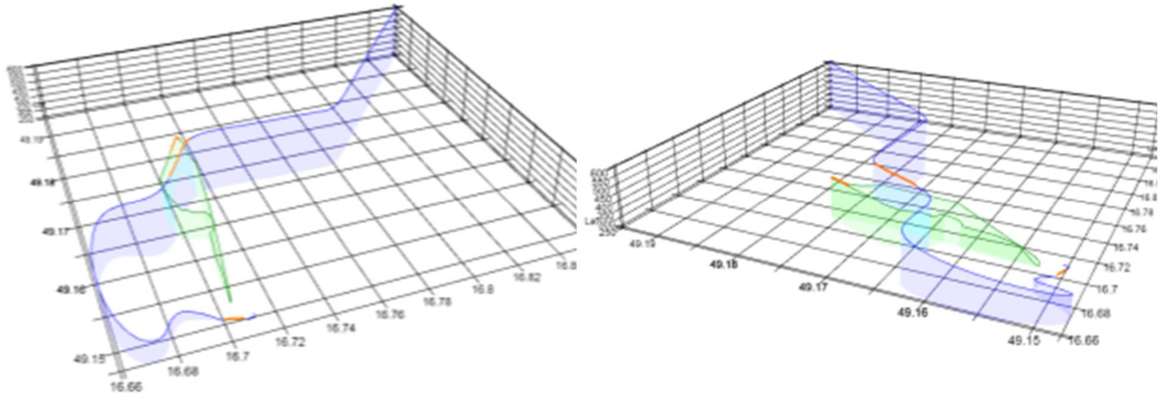


Figure 43: 3D Trajectories and TCAS level for Run#3.1 with observer

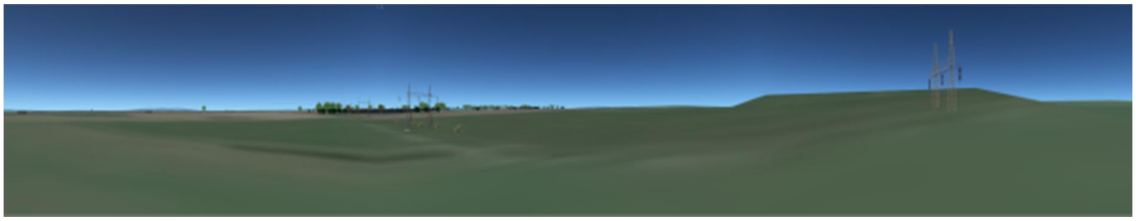


Figure 44: Observer view (run#3.1)

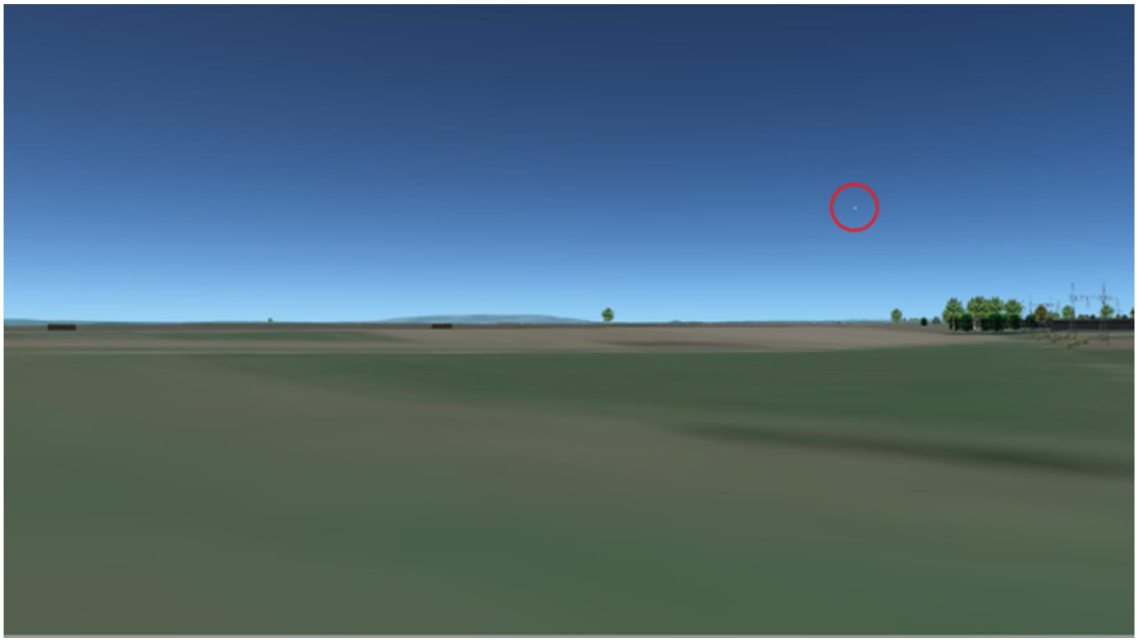


Figure 45: Detail of observer view (run#3.1)

Run#3.2

Figure 46: Flown RPA Mission (purple) and light aircraft trajectory (yellow) for Run#3.2 (in bottom the elevation profile of RPA mission) in Google Earth

The following figures have been produced processing the data collected during the Run#3.2 for RPA mission and light aircraft trajectory and TCAS levels have been highlighted. Furthermore, 3D trajectories distance has been reported to show the time slot in which conflict detection occurs.

As shown in Figure 47, the alarm does not depend only on geometric air-vehicles separation; TCAS collision detection only appears around 12:57:00, even if the 3D distance around time 12:01:00 has a comparable value. Beyond geometric separation, the collision detection logic depends also on velocity and air-vehicles direction, according to TCAS model implemented.

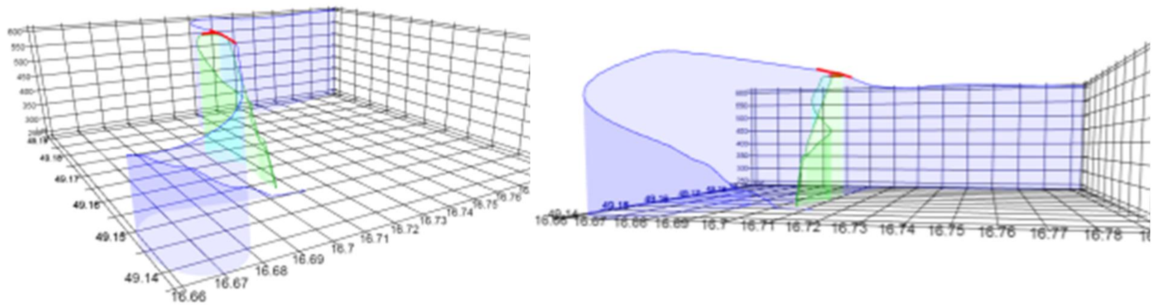


Figure 47: 3D Trajectories and TCAS level for Run#3.2

Run#3.3

Figure 48: Flown RPA Mission (purple) and light aircraft trajectory (yellow) for Run#3.3 (in bottom the elevation profile of RPA mission)

The following figures have been produced processing the data collected during the Run#3.3 for RPA mission and light aircraft trajectory and TCAS levels have been highlighted. Furthermore, 3D trajectories distance has been reported to show the time slot in which conflict detection occurs.

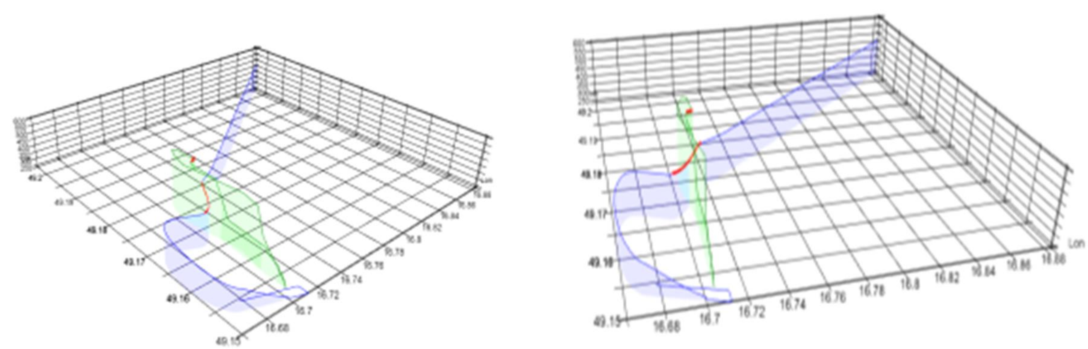


Figure 49: 3D Trajectories and TCAS level for Run#3.3

Run#3.4

Figure 50: Flown RPA Mission (purple) and light aircraft trajectory (yellow) for Run#3.4 (in bottom the elevation profile of RPA mission)

The following figures have been produced processing the data collected during the Run#3.4 for RPA mission and light aircraft trajectory and TCAS levels have been highlighted. Furthermore, 3D trajectories distance has been reported to show the time slot in which conflict detection occurs.

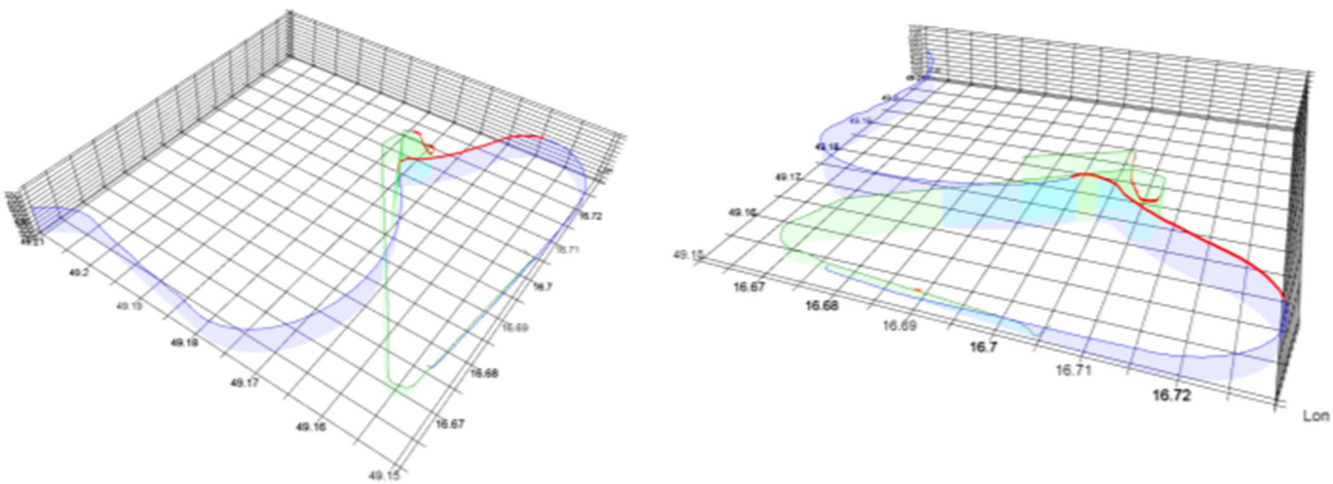


Figure 51: 3D Trajectories and TCAS level for Run#3.4

Frequency Time-Occupancy

The following images show the frequency time-occupancy for communications between ATCOs, RPAS pilot and light aircraft pilot for runs related to EXE-RPAS.02-003. As visible, the time-occupancy of the different frequencies (119,600 MHz, 125,450 MHz) is enough limited compared to the duration of Run #3.2, Run#3.3 and Run#3.4. The frequency time-occupancy for Run#3.1, as first run, instead is higher due to several interactions between ATCOs and pilots in order to safely check that all the collision detection functionalities and procedures were implemented properly.

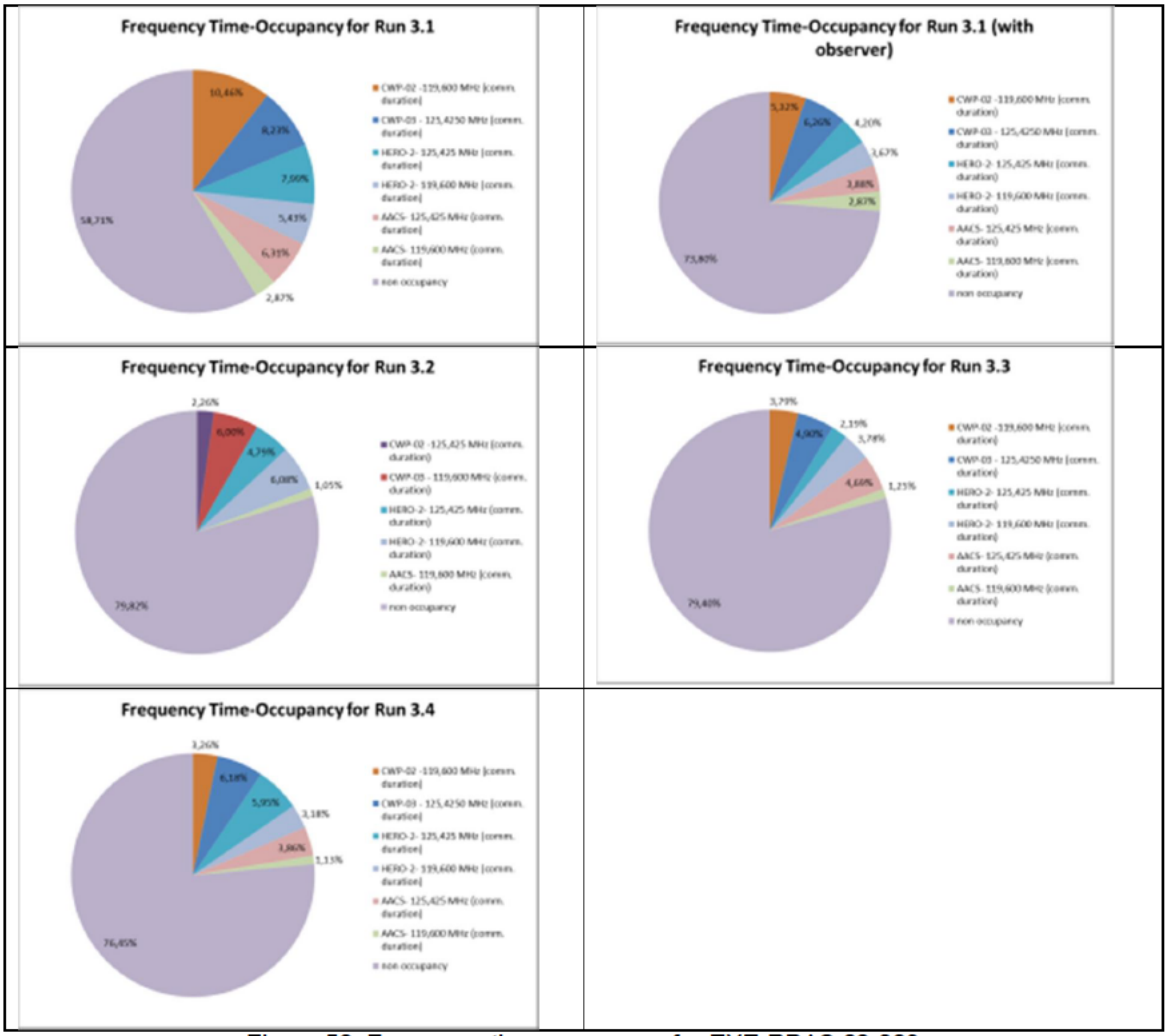


Figure 52: Frequency time occupancy for EXE-RPAS.02-003

6.3.3.1.1 Results per KPA

KPA	Objective ID	Success Criterion	Result of Validation
Safety	OBJ-RPAS.02-080 OBJ-RPAS.02-090 OBJ-RPAS.02-100	No degradation of the perceived level of safety to pilot the RPAS	Pilot feedback showed no degradation of the perceived level of safety to pilot RPAS following a conflict situation.
Safety	OBJ-RPAS.02-080 OBJ-RPAS.02-090 OBJ-RPAS.02-100	No increase of workload to pilot the RPAS	Pilot feedback showed no increase of workload to pilot RPAS following a conflict situation.
Safety	OBJ-RPAS.02-080 OBJ-RPAS.02-090 OBJ-RPAS.02-100	No degradation of the perceived level of safety to control the traffic	ATCO feedback showed degradation of the perceived level of safety to control the traffic following a conflict situation.

Safety	OBJ-RPAS.02-080 OBJ-RPAS.02-090 OBJ-RPAS.02-100	No increase of workload to control the traffic	ATCO feedback showed no increase of workload in ATC sectors following a conflict situation.
Safety	OBJ-RPAS.02-080	Time between the detection of a conflict from the system and the notification to the RPAS pilot of the potential conflict is minimum.	Data analysis and pilot feedback showed that time between the detection of a conflict from the system and the notification to the RPAS pilot of the potential conflict is minimum.
Safety	OBJ-RPAS.02-090	Visualization on UCS of relevant information (colliding aircraft id, relative lateral, vertical and along track distance) about the conflicting aircraft.	Pilot feedback showed that all relevant information about the conflicting aircraft is visible in the UCS.
Safety	OBJ-RPAS.02-100	Availability for RPAS pilot of all the information required to perform the proper manoeuvre.	Pilot feedback showed that all the information required to perform the proper manoeuvre in a conflict situation are available.

6.3.3.1.2 Results impacting regulation and standardisation initiatives

As input for regulations and standardization activities, from this exercise, is the attention required to the implementation of E-LOS with a ñpilot in commandò that is a different person from the pilot operating the RPAS from the Ground Control Station. The ñpilot in commandò would be the one having the RPAS in her/his line of sight at any moment, with the capability of taking over control for contingency reasons (becoming a safety pilot).
The pilot in command needs to have a free line of sight to the air-vehicle and integrate the information with the ADS-B data to avoid perspective mistakes. The info available through the instruments on ground is more reliable than the perspective from ground that the pilot can have, especially in terms of heading.
This exercise opened a long discussion in the debriefing about operational procedures and responsibility:

- ATCO calls the pilot for ñtraffic in sightò. Nominally a positive response from the pilot is ensuring that the pilot can take responsibility for separation and all data are available.
- Can the pilot say that he has traffic in sight when the ñin sightò means only on the Ground Control Station instruments?
- In cases where the E-LOS must be implemented, it is important to know where lies the responsibility at any moment. Pilots suggested to split the responsibility of the RPAS flight between two people, one dedicated to visual contact and the other one on the Ground Station commanding the RPAS. These two pilots shall be always in voice contact with each other.

A general input on operational procedures to be followed, responsibility in the various phases of flight and regulatory aspects is provided for all exercises at the end of simulation campaign and recorded in paragraph 5.5.3.

6.3.3.1.3 Unexpected Behaviours/Results

No unexpected behaviours/results have been detected during the execution of this exercise.

6.3.3.1.4 Quality of Demonstration Results

The simulation platform reproduces the scenario in Brno airport and its surrounding in accurate way from controllersô and pilotsô point of view. The aircraft and RPAS flight behaviour and response to commands was also considered adherent to what is experienced in real flight. Therefore the quality of results and feedback collected by actors during the execution of the exercise can be considered highly reliable.

6.3.3.1.5 Significance of Demonstration Results

The results collected during the runs of this exercise have a good significance from an operational point of view since the missions simulated were realistic and the scenario has been reproduced accurately.
Even if the runs have been performed in a limited situation of traffic, their results are relevant about the perception of RPAS performance from controllersôperspective in order to monitor and manage the RPAS into controlled airspace also in a conflict situation.
From the operational point of view, this exercise provided a very good understanding of a situation in which, for safety reasons, the RPAS flight is allowed only in V-LOS or E-LOS. Nevertheless, it was reported by the pilot that he could not only rely on the information in sight but had to integrate it (for the complete awareness) with the supporting data from the ADS-B system.

6.3.4 Conclusions and recommendations

6.3.4.1 Conclusions

The objectives of this exercise were fully reached.
The situational awareness of controllers can be considered high during the whole execution of this exercise, since:

- simulated scenario was considered realistic from controllers point of view and it was accurate enough for on-ground validation purposes;
- the controllers were aware of the RPA position always during the execution of RPA mission;
- controllers were able to communicate with RPA pilot on expected voice frequency;
- RPAS response following to a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft;
- controllers remembered the RPAS flight missions and potential conflict situation that occurred during the execution of the exercise.

Nevertheless, controllers underlined the importance in cases of converging traffic ï RPAS vs AIRCRAFT:

- traffic information available on instruments and consistent for each stakeholder is necessary;
- pilots need to respond with quick answer and reaction following the operational rules for mid-air collision avoidance.

The workload of controllers was low in this exercise due to limited traffic in the scenario (i.e. just one light aircraft other than RPAS is present in the Brno Terminal Area). Therefore:

- mental and perceptual activity to control one RPA was not higher than the one related to a light manned aircraft;
- mental and perceptual activity to control one RPA (deciding, looking) is simple; it was an easy task to monitor the traffic, looking and searching potential conflict and informing pilot;
- time pressure due to the rate of pace at which the task elements occurred to control RPA was not higher than the one related to a manned aircraft for one controller; for the other controller, the physical activity was a little bit higher due to the dimension of the RPAS (RPAS is smaller than other traffic and therefore sometimes less visible);
- very limited work (mentally and physically) to accomplish the level of performance
- the rate of pace at which controllers performed their tasks was slow;
- controllers felt secure during the task;
- controllers were enough satisfied of their performance in accomplishing the goals foreseen in this exercise.

As general feedback from controllers, the simulation platform should be improved allowing RPAS ground station operator to view the other traffic. There is the need of proving that RPAS pilot is able to use the traffic information given by ATCOs and to react accordingly to avoid other traffic.
The feeling of controllers on safe integration of RPAs in controlled airspace derived from simulation experience was sufficient.

The situational awareness of pilot can be considered quite high since:

- simulated scenario was considered realistic sufficiently from pilot point of view and it was accurate enough for on-ground validation purposes;
- the pilot was aware of the RPA position always during the execution of RPA mission;
- the pilot was able to communicate with ATCO on expected voice frequency;
- RPAS response following to a specific ATCO clearance happen within reasonable time range and it could be considered comparable with the response of a manned aircraft;
- pilot declared that he remembered the RPAS flight missions and potential conflict situation that occurred after the conclusion of the exercise, during the compilation of the questionnaire, but he highlighted that there was a slow response in avoid action due to the simulation exercise.

The workload of pilot was not too high, indeed:

- physical activity to pilot one RPA was not higher than the one related to a light manned aircraft;
- mental and perceptual activity of RPAS pilot to perform his tasks has been considered the same one for a real aircraft;
- pilot task was simple but there was a quite high probability to forget something important;
- time pressure due to the rate of pace at which the task elements occurred to control RPA is low;
- pilot considered his work (mentally and physically) suitable to accomplish the level of performance;
- pilot felt no stressed;
- pilot was satisfied of its performance in accomplishing the goals foreseen in this exercise.

As general feedback from pilot, the simulation platform was good but the interfaces of the unmanned ground system should be improved.
For pilot, it was very easy to see the difference between the planned route and the flown route and to see the warning messages for conflict detection and hear the associated audio alert.
The feeling of pilot on safe integration of RPAs in controlled airspace derived from simulation experience was good.

The exercise was performed successfully from a human performance point of view.

6.3.4.2 Recommendations

Recommendations for the implementation of the detection and avoidance operations:

- Suggested to have an additional pilot with the RPA in V-LOS during the critical part of the mission, with capability of taking over control for safety reasons;
- There is a station identified in the area Charlie, where the RPAS Ground Control station can be positioned to allow the pilot to keep the RPAS in visual line of sight;
- The other RPAS pilot, "safety pilot", shall follow the requirement of being at the edge of the area Charlie to be an additional safety net and also detect eventual cases of intruders getting close to the RPAS mission area;
- A temporary NOTAM shall inform that demonstration exercises are on-going in the area for a specific timeframe.
- The validated trajectories for both flights are considered feasible in real life but they are too much dependent on synchronization in order for the conflicting conditions to happen: the recommendation is to keep the RPAS mission very regular and predictable so that the light aircraft can perform the necessary adjustments to establish the under-separation condition;
- Relying only on ADS-B data can be sufficient in this case where both aircrafts are equipped but additional radar tracks (CAT-62) could be used to have higher knowledge of traffic if not

all cooperating, since in the Czech Republic National law it is not required for very light and light aircraft to be ADS-B equipped;

- The RPAS õpilot to pilotö communication can be performed using very shortly the operational frequency for the live trial and defining a list of short messages for communicating with TOWER for info on repetition of activities, without congesting the voice link;
- CPDLC messages could be used as additional way of communicating but the system in Brno for operations is not mature enough and is not foreseen to be installed for the purposes of the demo. It is currently only used for specific operations in upper airspace.

6.4 Demonstration Exercise EXE-RPAS.02-004 Report

EXE-RPAS.02-004 is the fourth exercise related to INSuRE project demonstration.

6.4.1 Exercise Scope

EXE-RPAS.02-004 focuses on the operational procedures between RPAS pilots and ATCOs for the integration of RPAS into a non-segregated area in presence of nominal traffic and two RPAS in the same area.

In this exercise, the simulation is executed at Brno airport and in CTR/TMA. No restriction on manned airborne and ground are required.

6.4.2 Conduct of Demonstration Exercise EXE-RPAS.02-004

6.4.2.1 Exercise Preparation

The preparatory activities for the exercise consisted in a pre-briefing meeting with all actors involved in which:

- the configuration and roles during the mission were reviewed and shared;
- the operational set up was discussed (including voice procedures, runway usage, SSR code associated to the RPA and to the surrounding simulated traffic);
- understanding of the exercise scope (start to end) was shared.

For this exercise, the following configuration was set up:

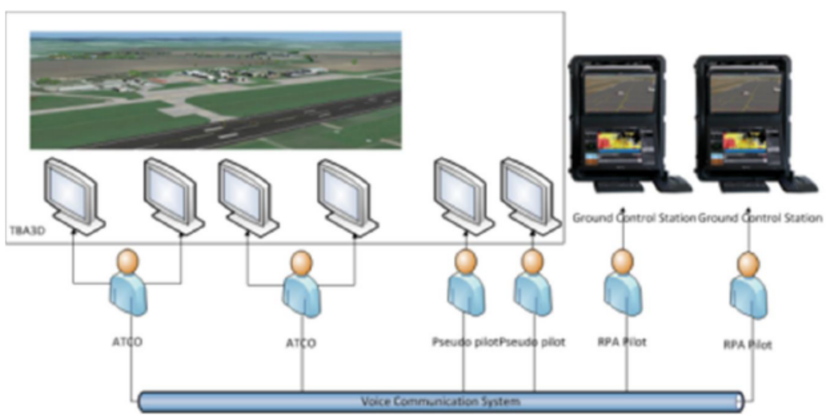


Figure 53: Configuration for EXE-RPAS.02-004

Specific missions are planned for this exercise for the different runs.

Traffic is simulated as reported in the tagle below, using the following colour coding:

IFR Arrival Flights	
IFR Departure Flights	
RPAS Flight	

Traffic Informations for Run#4.0

AIRLINE/OPERATOR	FLIGHT ident	OPs	Adep	Adest	ACF	RWY	PK B	ETD	ETA	STAR/IAP-SID	ROUTE	LEVEL	N LIST
ALITALIA	AZA240	D		LIRF	A320	28	X	08.50		MKOV1A	M748	FL250	1
IDS	HERO1	D	LKTB	LKTB	RPAH	28	E/A	08.54		BRAV0 POINT LND 28		2000Ft	2
AIR FRANCE	AFR350	A	LFPO		A319	28	X		08.57	TUMKA2C ILS28	M748	FL110	3
ENI SNAM	ISNAM	D		LIRA	F900	28	X	09.01		MKOV1A	M984	FL230	5
TRAVEL SERVICE	TVS2555	A	HEGN		B738	28	X		09.04	MAVOR1C ILS28		FL120	4
TNT AIRWAYS	TAY91R	D		LKPR	B463	28	X	09.08		TUMKA2A	M748	FL260	6
RYANAIR	RYR48LB	A	EGSS		B738	28	X		09.10	TUMKA2C ILS28	M748	FL110	7

Traffic Information for Run#4.1a (only one ATC sector)

AIRLINE/OPERATOR	FLIGHT ident	OPs	Adep	Adest	ACF	RWY	PK B	ETD	ETA	STAR/IAP-SID	ROUTE	LEVEL	N LIST
CZECH AIRLINES	CSA870	A	LGTS		ATR72	10	X		10.30	MAVOR1Q IAFROGAD	M748	FL250	1
LUFTHANSA	DLH458	D		EDDF	A319	10	X	10.33		TUMKA1D	M748	FL270	2
IDS	HERO2	D		LKPD	RPAH	10	E/A	10.35		TUMKA1D	M748	FL100	3
TURKISH AIRLINES	THY322	A	LTBA		A319	10	X		10.38	MAVOR1Q IAFROGAD		FL120	4
IDS	HERO1	D	LKTB	LKTB	RPAH	10	E/A	10.40		BRAVO POINT	ECHO	2000Ft	5
RYANAIR	RYR32DZ	D		EGSS	B738	10	X	10.44		TUMKA1D	M748	FL260	6
MERIDIANA	ISS355	A	LIRF		MD82	10	X		10.46	LEDVA1R IAFROGAD	L156	FL110	7

Traffic Information for Run#4.1b (two ATC sectors)

AIRLINE/OPERATOR	FLIGHT ident	OPs	Adep	Adest	ACF	RWY	PK B	ETD	ETA	STAR/IAP-SID	ROUTE	LEVEL	N LIST
AIR FRANCE	AFR670	A	LFPO		A320	10	X		12.15	TUMKA2R IAFROGAD	M748	FL110	1
TURKISH AIRLINES	THYJ50	D		LTBA	A319	10	X	12.16		ODNEM1D	M748	FL270	2
IDS	HERO1	D	LKTB	LKTB	RPAH	10	E/A	12.17		ALPHA POINT	ZULU	2000Ft	3
RYANAIR	RYR32DZ	D		EGSS	B738	10	X	12.23		TUMKA1D	M748	FL260	4
TRAVEL SERVICE	TVS65H	A	LBBG		A320	10	X		12.25	MAVOR1Q IAFROGAD		FL120	5
IDS	HERO2	D		LKPD	RPAH	10	E/A	12.27		TUMKA1D	M748	FL80	6
CZECH AIRLINES	CSA870	D		LGTS	ATR72	10	X	12.33		ODNEM1D	M748	FL250	7
RYANAIR	RYR48LB	A	EGSS		B738	10	X		12.35	TUMKA2R IAFROGAD	M748	FL110	8

Traffic Informations for Run#4.2

AIRLINE/OPERATOR	FLIGHT ident	OPs	Adep	Adest	ACF	RWY	PK B	ETD	ETA	STAR/IAP-SID	ROUTE	LEVEL	N LIST
IDS	HERO1	A	LKTB	LKTB	RPAH	28	E/A		15.17	ZULU	ALPHA	2500Ft	1
KLM	KLM211	D		EHAM	B737	28	X	15.19		TUMKA2A	M748	FL260	2
ALITALIA	AZA270	A	LOWW		A320	28	X		15.22	LEDVA1C IAFBUKAP	L156	FL100	3
RYANAIR	RYR32DZ	D		EGSS	B738	28	X	15.24		TUMKA2A	M748	FL260	4
MERIDIANA	ISS266	A	LIRF		MD82	28	X		15.27	LEDVA1C IAFBUKAP	L156	FL120	5
IDS	HERO2	A	LKPD		RPAH	28	E/A		15.30	TUMKA2C	M748	FL80	6
ALITALIA	AZA240	D		LIRF	A321	28	X	15.34		MKOV1A	M984	FL230	7
CZECH AIRLINES	CSA270	A	LGTS		ATR72	28	X		15.37	MAVOR1C IAFBUKAP	M748	FL120	8

6.4.2.2 Exercise execution

For the execution of each run the operational procedure steps for interaction between ATCO, RPAS pilot/s and pseudo pilots has been:

1) Voice check on GROUND frequency;
2) Pseudo pilot start their flights handling communicating to TOWER and GROUND as required for clearances;
3) RPA Pilots starts communication with GROUND controller for departure info;
4) Transfer communication to TOWER controller after RPAS take-off;
5) Authorization request from the RPAS pilot to perform the mission within the area defined for the specific run;
6) TOWER clearance to execute the RPAS planned missions;
7) Reporting to TOWER controller upon reaching the mission area or transfer control if exiting CTR;
8) Reporting to TOWER controller upon completion of RPAS activity for authorization to return to the identified parking area for landing;
9) Transfer to GROUND for final communication after landing;
10) Nominal controlling procedures are followed for surrounding traffic and for monitoring the separations.

The following runs have been executed in the exercise and summarised hereafter:

- Run #4.0 One operator - one RPAS

  In this run one RPAS is controlled by unique RPAS operator and subjected to ATCOs clearances. No restriction to the Brno airport and TMA traffic. RPAS moves in the simulated surrounding traffic replicating a realistic traffic load for Brno.

- Run #4.1 One operator for each RPAS

  In this run each RPAs is controlled by unique RPAS operator and subjected to ATCOs clearances. Ground operations, take-off and landing procedures of both RPAS are performed at the same time. No restriction to the Brno airport and TMA traffic is required.

  One RPA departs from LKTB and flies to a reserved airspace, where it executes its planned photo flight mission. From a different position in the Brno airport another RPA takes off and reaches the reserved area. Then both RPAs return to the LKTB airport.

  Run #4.1 has been executed in two different configurations, therefore split into:

  - Run #4.1a with one ATC controller only (one sector configuration);
  - Run #4.1b with two ATC controllers (two sectors, one GROUND and one TOWER)

- Run #4.2 One operator for two RPAS

  In this run both RPAS are controlled by only one RPAS operator and subjected to ATCOs clearances. No restriction to the Brno airport and TMA traffic is required.

  One RPA departs from LKTB and flies to a reserved airspace, where it executes its planned photo flight mission. During the execution of the mission another RPA, controlled by the same pilot, takes-off from the Brno airport and reaches the reserved area where executes a photo flight mission. At the end of each mission, each RPA returns to the airport and lands.

  This run has been repeated twice to have the chance of validating the operations with each of the two pilots in the team running the same exercise, therefore piloting two RPASs from one Ground Control Station in the same configuration and executing the same RPAS missions. The runs are identifiable in the following paragraphs as: run #4.2a and run #4.2b.

6.4.2.3 Deviation from the planned activities

No relevant deviation from the planned activities has been recorded during the execution of this exercise.

It was agreed, before the execution of the exercise, to repeat two times the execution of Run #4.2 since, having two RPA pilots in the team with different piloting background and experience: it was considered significant to validate how much the activities in piloting two RPAs at the same time could be affected by the skills, experience and behaviour of the pilot.

6.4.3 Exercise Results

6.4.3.1 Summary of Exercise Results

Figure 54: Trajectories overview for Run#4.0

Figure 55: Trajectories overview for Run#4.1a

Figure 56: Trajectories overview for Run#4.1b

Figure 57: Trajectories overview for Run#4.2a

Figure 58: Trajectories overview for Run#4.2b

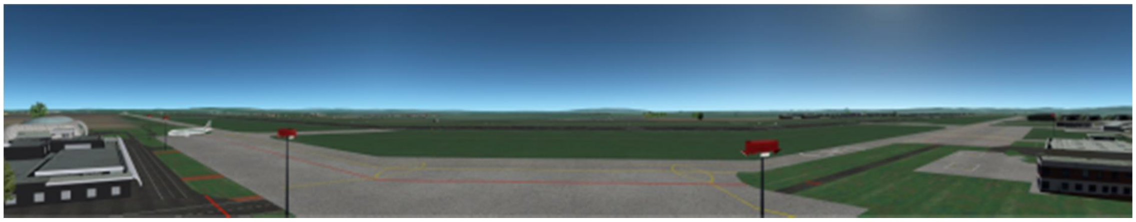


Figure 59: Traffic view from Tower

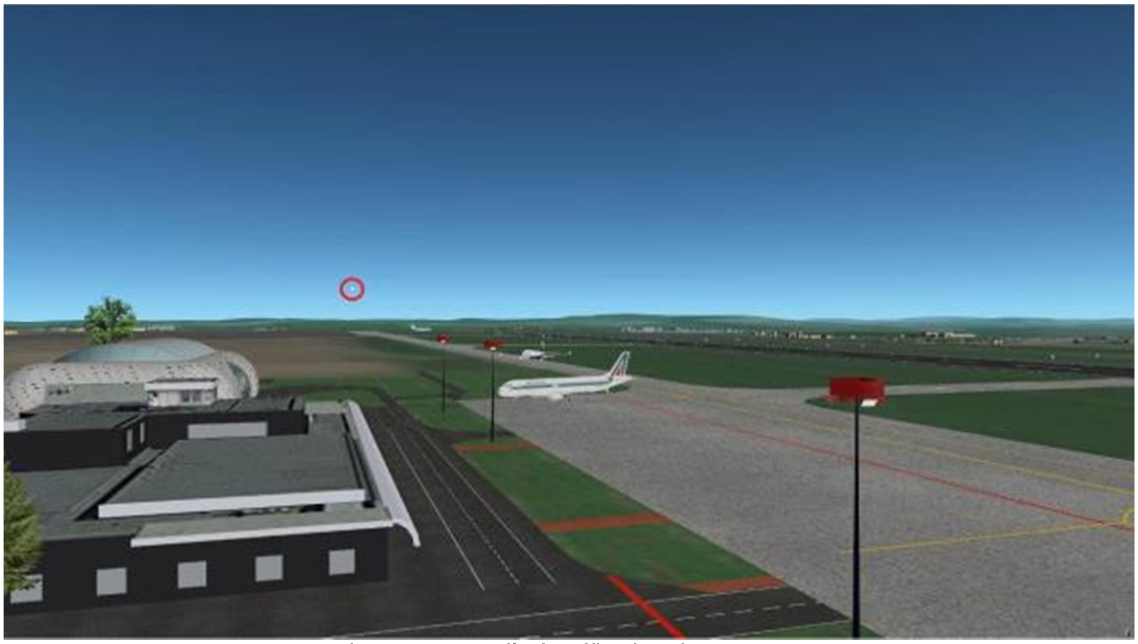
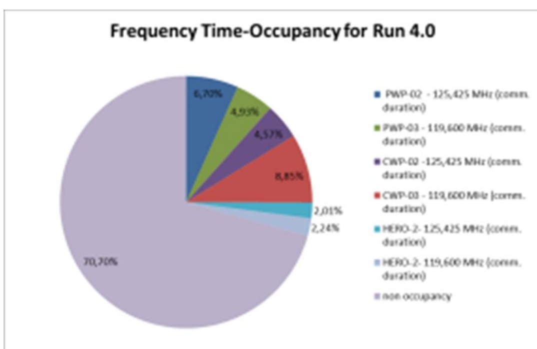
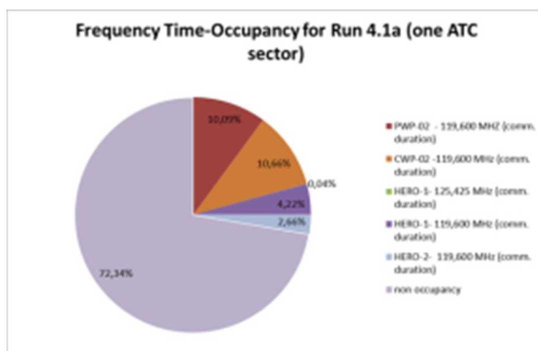
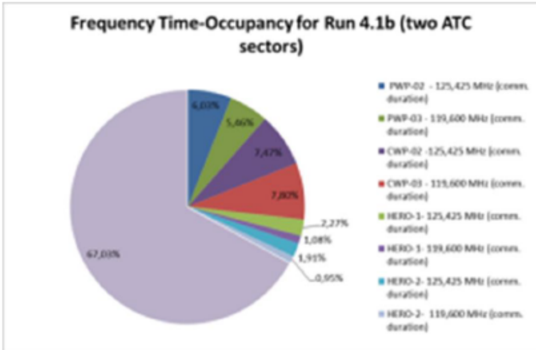


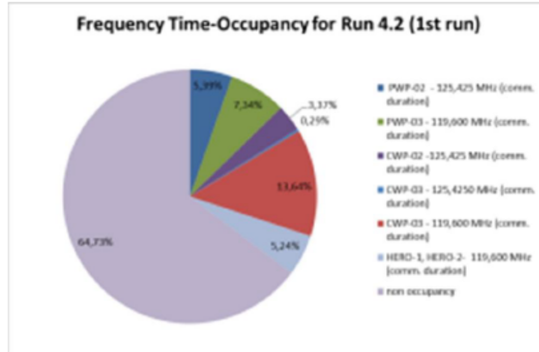
Figure 60: Detail of traffic view from Tower

The following images show the frequency time-occupancy for communications between ATCOs, RPAS pilot and light aircraft pilot for runs related to EXE-RPAS.02-004. As visible, the time-occupancy of the different frequencies (119,600 MHz, 125,450 MHz) is limited enough compared to the duration of run session.









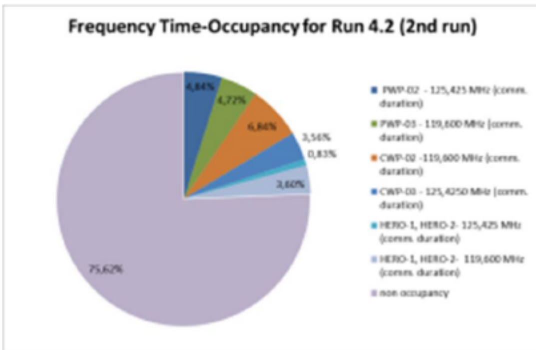


Figure 61: Frequency time occupancy for EXE-RPAS.02-004

6.4.3.1.1 Results per KPA

KPA	Objective ID	Success Criterion	Result of Validation
Safety	OBJ-RPAS.02-060	No increase of complexity in on-ground operations	ATCO feedback showed not increased complexity in in on-ground operations.
Safety	OBJ-RPAS.02-060	No degradation of the perceived level of safety in on-ground operations	ATCO feedback showed no degradation of the perceived level of safety in on-ground operations.
Safety	OBJ-RPAS.02-060	No degradation of the perceived level of situation awareness in on-ground operations	ATCO feedback showed no degradation of the perceived level of situation awareness in on-ground operations.
Capacity	OBJ-RPAS.02-060	No impact on airport capacity following the introduction of one RPAS in the airport.	Airport capacity is not impacted by the introduction of one RPAS in the airport based on controllers' feedback.
Safety	OBJ-RPAS.02-070	No increase of complexity in departing/arrival operations.	ATCO feedback showed not increased complexity in in departing/arrival operations.

Safety	OBJ-RPAS.02-070	No degradation of the perceived level of safety in departing/arrival operations.	ATCO feedback showed no degradation of the perceived level of safety in departing/arrival operations.
Safety	OBJ-RPAS.02-070	No degradation of the perceived level of situation awareness in departing/arrival operations.	ATCO feedback showed no degradation of the perceived level of situation awareness in departing/arrival operations.
Capacity	OBJ-RPAS.02-070	No impact on departing/arrival airport capacity following the introduction of one RPAS in the airport.	Departing/arrival airport capacity is not impacted by the introduction of one RPAS based on controllersôfeedback.
Safety / Human Performance	OBJ-RPAS.02-200	No increase of complexity in operations in ATC sector.	ATCO feedback showed not increased complexity in ATC sectors into a non-segregated area.
Safety / Human Performance	OBJ-RPAS.02-200	No degradation of the perceived level of safety in operations.	ATCO feedback showed no degradation of the perceived level of safety into a non-segregated area in presence of multiple RPAS (two RPAs) and nominal traffic.
Safety / Human Performance	OBJ-RPAS.02-200	No degradation of the perceived level of situation awareness in operations.	ATCO feedback showed no degradation of the perceived level of situation awareness into a non-segregated area in presence of multiple RPAS (two RPAs) and nominal traffic.
Safety / Human Performance	OBJ-RPAS.02-200	No increase of workload in operations.	ATCO feedback showed not increased complexity in ATC sectors.
Human Performance	OBJ-RPAS.02-200	No increase of workload for RPAS pilot to pilot one RPAS in a situation with no traffic restriction	Pilot feedback showed no increase of workload for RPAS pilot to pilot one RPAS in a situation with no traffic restriction.
Safety / Human Performance	OBJ-RPAS.02-210	No increase of complexity in operations in ATC sector.	ATCO feedback showed increased complexity in ATC sectors into a non-segregated area.

Safety / Human Performance	OBJ-RPAS.02-210	No degradation of the perceived level of safety in operations.	ATCO feedback showed degradation of the perceived level of safety into a non-segregated area in presence of multiple RPAS (two RPAs) and nominal traffic.
Safety / Human Performance	OBJ-RPAS.02-210	No degradation of the perceived level of situation awareness in operations.	ATCO feedback showed degradation of the perceived level of situation awareness into a non-segregated area in presence of multiple RPAS (two RPAs) and nominal traffic.
Safety / Human Performance	OBJ-RPAS.02-210	No increase of workload in operations.	ATCO feedback showed increased complexity in ATC sectors.
Human Performance	OBJ-RPAS.02-210	No increase of workload for RPAS pilot to pilot two RPAS in a situation with no traffic restriction	Pilot feedback showed increase of workload for RPAS pilot to pilot two RPAS in a situation with no traffic restriction.

6.4.3.1.2 Results impacting regulation and standardisation initiatives

No relevant results from this specific exercise as input for regulations and standardization activities. However, a general input for regulatory aspects is provided in paragraph 5.3.4.

6.4.3.1.3 Unexpected Behaviours/Results

No unexpected behaviours/results have been detected during the execution of this exercise.

6.4.3.1.4 Quality of Demonstration Results

The simulation platform reproduces the scenario in Brno airport and its surrounding in accurate way from controllersôand pilotsôpoint of view. Therefore the quality of results and feedback collected by actors during the execution of the exercise can be considered highly reliable.

6.4.3.1.5 Significance of Demonstration Results

The results collected during the runs of this exercise have a good significance from an operational point of view since the missions simulated were realistic and the scenario has been reproduced accurately.
The runs have been performed in a likelihood situation of traffic in Brno therefore their results are relevant about the:

- perception of RPAS performance from controllersô perspective in order to monitor and manage the RPAS into controlled airspace.
- perception of RPAS performance from pilotsô perspective in order to pilot the RPAS into controlled airspace.

6.4.4 Conclusions and recommendations

6.4.4.1 Conclusions

The objectives of this exercise were not all reached. In particular, one objective (OBJ-RPAS.02-210) related to integration of multiple RPAs (one pilot- two RPAs) could not be successfully proven. The pilot perception in terms of situational awareness and workload was not satisfactory and gave no confidence that this type of operation can be executed in the configuration used.

In this exercise, the human performance analysis reports very different results between runs#4.0-#4.1 and run#4.2. Performance changes completely if multiple RPAS (two RPAs in this case) are piloted by a single pilot.

The situational awareness of controllers can be considered high during the execution of this exercise for runs#4.0 and run#4.1, where each RPA is piloted by one pilot, since:

- simulated scenario was considered realistic from controllers point of view and it was accurate enough for on-ground validation purposes;
- the controllers were aware of the RPA position always during the execution of RPA mission;
- controllers were able to communicate with RPA pilot on expected voice frequency;
- RPAS response following to a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft;
- controllers remembered the RPAS flight missions and potential conflict situation that occurred during the execution of the exercise.

As the RPAS is very slow, ATCO has to wait an extra time to let other (faster) traffic go (depart in same direction)

The workload of controllers was low in this exercise for runs#4.0 and run#4.1, indeed:

- mental and perceptual activity to control one RPA was not higher than the one related to a light manned aircraft;
- mental and perceptual activity to control one RPA is simple;
- time pressure due to the rate of pace at which the task elements occurred to control RPA was not higher than the one related to a manned aircraft for one controller; for the other controller, the physical activity was a little bit higher due to the dimension and speed of the RPAS ;
- very limited work (mentally and physically) to accomplish the level of performance
- the rate of pace at which controllers performed their tasks was slow;
- controllers felt secure during the task;
- the controllers were enough satisfied of their performance in accomplishing the goals foreseen in this exercise;

The situational awareness of pilots can be considered quite well in runs#4.0 and run#4.1, since:

- simulated scenario was considered realistic sufficiently from pilot point of view and it was accurate enough for on-ground validation purposes;
- the pilot was aware of the RPA position always during the execution of RPA mission;
- the pilot was able to communicate with ATCO on expected voice frequency;
- RPAS response following to a specific ATCO clearance happen within reasonable time range and it could be considered comparable with the response of a manned aircraft;

The workload of pilot was not too high. The situational awareness of pilots can be considered quite well in runs#4.0 and run#4.1, indeed:

- physical activity to pilot one RPA was not higher than the one related to a light manned aircraft;
- mental and perceptual activity of RPAS pilot to perform his tasks has been considered the same one for a real aircraft with some improvements in situational awareness due to a 2D map;
- pilot task was simple but there was a quite high probability to forget something important;
- time pressure due to the rate of pace at which the task elements occurred to control RPA is the same one related to a light manned aircraft; the pace was neither slow nor rapid;
- pilot considered his work (mentally and physically) suitable to accomplish the level of performance;

- pilot felt during the task neither stressed neither relaxed
- pilot was satisfied of its performance in accomplishing the goals foreseen in this exercise.

The exercise was performed successfully from a human performance point of view when multiple RPAs are controlled by multiple RPAS pilots (one per each RPA) in non-segregated airport/airspace in no traffic restriction at Brno airport and TMA.

The situational awareness of controllers can be considered low during the execution of this exercise for runs#4.2, where two RPAs are piloted by one pilot, since:

- simulated scenario was not considered realistic from controllers point of view and it was not accurate enough for on-ground validation purposes;
- controllers were not aware of the RPA position always during the execution of RPA mission;
- controllers were able to communicate with RPA pilot on expected voice frequency;
- RPAS response following to a specific ATCO clearance did not happen within reasonable time range and it could not be considered comparable with the response of a manned aircraft;
- controllers remembered the RPAS flight missions and potential conflict situation that occurred during the execution of the exercise:
  - faster IFR (CSA560) approaching to the slower one RPAS
  - CSA560 and RPAS unable to comply ATCOés commands

The workload of controllers was low in this exercise for runs#4.2, indeed:

- mental and perceptual activity to control one RPA was not higher than the one related to a light manned aircraft;
- controllersô task was neither easy nor complex;
- there is a risk of forgetting something important
- workload to control VFR RPAS activities was easier than IFR RPAS activities;
- there was not different workload perceived for controlling RPAS surface or in-flight operations;
- time pressure related to the rate of pace at which the task elements occurred to control RPA was a lot;
- rate of work (mentally and physically) to accomplish the level of performance was medium;
- controllers felt insecure and stressed;
- the controllers, however, were enough satisfied of their performance in accomplishing the goals foreseen in this exercise.

As general feedback from controllers, the simulation platform could be improved, adding possible commands to pseudo-pilots and improving radio-working only ñnow and thenò.
The feeling of controllers on safe integration of RPAs in controlled airspace derived from simulation experience was however quite good

For the situational awareness of pilots, even if:

- simulated scenario was considered realistic sufficiently from pilot point of view and it was accurate enough for on-ground validation purposes;
- the pilot was aware of the surrounding traffic during the RPAS mission execution;

some problems occurred:

- RPAS response following to a specific ATCO clearance did not happen within reasonable time range, comparable with the response of a manned aircraft, due to little but significant complication in interface;
- pilot had difficulties to communicate with ATCO on expected voice frequency;
- pilot was a few aware of the position of the RPA during the execution of the RPAS mission.

The workload of pilot was high in runs#4.2, indeed:

- mental and perceptual activity to pilot two RPAs simultaneously was very high;
- task was demanding and complex but not forgiving;
- there was a high risk of forgetting something important;
- time pressure due to the rate of pace at which the task elements occurred to control RPA was higher than the one related to a light manned aircraft; the pace was rapid and frenetic in some moments;

- pilot considered his work (mentally and physically) suitable to accomplish the level of performance;
- pilot felt neither very irritated and stressed during the task, mainly in the final phase;
- pilot was quite unsatisfied of its performance in accomplishing the goals foreseen in the runs#4.2.

As general feedback from pilot, piloting two RPAS at the same time in a crowed environment could be very demanding for RPAS pilot.
For pilot, it was very easy to see the difference between the planned route and the flown route and to see the warning messages for conflict detection and hear the associated audio alert.
The feeling of pilot on safe integration of multiple RPAs controlled by a single RPAS pilot (one per two RPAs) in non-segregated airport/airspace was not good. In the future, it could be investigated further this scenario improving UCS interfaces and finding a solution for communication between RPAS and several ATC sectors (e.g. ground and tower).

The runs#4.2 were performed successfully but the results were not much positive: piloting two RPAS at the same time in a crowed environment could be very demanding for RPAS pilot.

6.4.4.2 Recommendations

No relevant recommendations derived from the execution of this exercise from operational point of view for runs 4.0 and 4.1.

Some recommendations derived from the execution of this exercise from operational point of view for runs 4.2.
Below the issues, which are relevant for future improvement to the Ground Control Station capability of piloting multiple RPAS from one station:

- UCS interfaces
  - It is important to have some fast way to leave the RPAS in hover disregarding all previous operations. For fast way, pilot means one (and only one) pressure switch.
  - The three flight modes (JOY LWSPD, JOY GSPD, JOY IAS) must be activated by three different push buttons, better if replicated on the screen in touchscreen conf. Every single button must activate the corresponding mode without ambiguity and ñhoverò button must be activated and available in every moment.
  - Changing from a RPA to another does not have to provoke change in the UCS configuration. At the moment, if you were in JOY GSPD mode, when switch back you find the RPA cockpit in ñHOVERò mode and you have to re-toggle between modes in a pretty complex way.
  - It could be truly useful if the OTW screen could be split in two allowing to maintain some situational awareness of the ñnot controlledò RPAS while controlling the other one.

- General
  - Pilot must remember to remain in contact with all the sectors the RPAS are occupying. As an example, if Hero1 is with ground, HERO2 is with tower, pilot must listen both.
    What if two sectors simultaneously talk with the pilot to emit a clearance? The best simulated approach was to force both RPAS in the same sector by clearing an RPAS and putting in hold the other, to avoid potential hazard in communication misunderstanding.

6.5 Demonstration Exercise EXE-RPAS.02-005 Report

EXE-RPAS.02-005 is the fifth exercise related to INSuRE project demonstration.

6.5.1 Exercise Scope

EXE-RPAS.02-005 focuses on the pre-flight ground test of the main RPAS capabilities necessary to perform the flight trials:

- RPAS Command and Control data link
- Communication capability between RPAS pilot and ATCOs
- Integrity of the ADS-B system.

This exercise is executed at Grottaglie airport where the RPAS system and its supporting systems (e.g. data link and ADS-B antennas) have been re-located for the flight trials.
No restriction on manned airborne and ground are required during this exercise since it does not encompass an RPAS occupation of the airspace.

6.5.2 Conduct of Demonstration Exercise EXE-RPAS.02-005

6.5.2.1 Exercise Preparation

The preparatory activities for the exercise consisted in a pre-briefing meeting with all actors involved in which:

- the configuration and roles during the exercise were reviewed and shared;
- the operational set up was discussed (including voice procedures, runway usage, SSR code associated to the RPA);
- understanding of the exercise scope (start to end) was shared.

On the field there was also preparatory activities involving the flight team and in particular:

- Deploying the RPAS in the defined spot for take-off in cooperation with airport personnel responsible for logistics.

6.5.2.2 Exercise execution

The following three types of main tests were executed in the scope of exercise 005:

- All pre-flight tests relative to C&CDL integrity (system test passed);
- G/G radio communications are stable and clearly intelligible (radio check on VHF radio between the RPAS pilot and the ATCO verifying that the voice communication was working both ways and the quality of the communication was “5 by 5”);
- All pre-flight test relative to ADS-B integrity (system test passed).

6.5.2.3 Deviation from the planned activities

No deviation from initial plan was recorded or occurred during this exercise.

6.5.3 Exercise Results

6.5.3.1 Summary of Exercise Results

The results of EXE-RPAS.02-005 are summarized in the relevant entries of Table 15.

6.5.3.1.1 Results per KPA

Not applicable to this exercise.

6.5.3.1.2 Results impacting regulation and standardisation initiatives

No impact on regulation and standardization resulting from EXE-RPAS.02-005.

6.5.3.1.3 Unexpected Behaviours/Results

No unexpected behaviour or results were recorded during the RPAS ground system tests.

6.5.3.1.4 Quality of Demonstration Results

The quality of the executed ground test is relevant for the following flight trials exercises since it ensures that the systems are properly working, in particular the critical RPAS on-board systems, the data link communication for Command&Control and the ground-ground communication radio link with the ATC.

6.5.3.1.5 Significance of Demonstration Results

Not applicable to this exercise.

6.5.4 Conclusions and recommendations

6.5.4.1 Conclusions

Ground and on-board RPAS systems, located at the flight test defined positions in the Grottaglie airport within the temporary restricted area R315, are properly functioning and the team is ready to execute the flight trials.

6.5.4.2 Recommendations

No recommendations were resulting from the RPAS ground system test.

6.6 Demonstration Exercise EXE-RPAS.02-006 Report

EXE-RPAS.02-006 is the sixth exercise related to INSuRE project demonstration.

6.6.1 Exercise Scope

EXE-RPAS.02-006 focuses on the operational procedures between RPAS pilot and ATCOs for the integration of RPAS into a non-segregated area. This exercise is meant to simulate a typical photo flight mission over the airport CTR and evaluates the interaction of the RPAS with ATCOs.

6.6.2 Conduct of Demonstration Exercise EXE-RPAS.02-006

6.6.2.1 Exercise Preparation

The preparatory activities for the exercise consisted in a pre-briefing meeting with all actors involved, in which:

- the configuration and roles during the mission were reviewed and shared;
- the operational set up was discussed (including voice procedures, runway usage, SSR code associated to the RPA);
- understanding of the exercise scope (start to end) was shared.

On the field there was also preparatory activities involving the flight team and in particular:

- Deploying the RPAS in the defined spot for take-off in cooperation with airport personnel responsible for logistics;
- Perform all required pre-flight checks in order to grant the RPA integrity before flight (including the ground tests described in EXE-RPAS.02-005).

An operational procedure was agreed amongst the Airport personnel, ATCOs and RPAS flight team, including the main following pre-flight activities:

- Contact TWR via radio link half an hour prior to the exercise start to give enough time to free the runaway from any other on-going operation;
- Contact TWR 5 minutes before take-off; at this point TWR gives confirmation of the airspace engagement by the RPAS.
- At this point the NOTAM active on the area becomes effective for all the flight exercise duration.

For this exercise, the following crew configuration was set up:

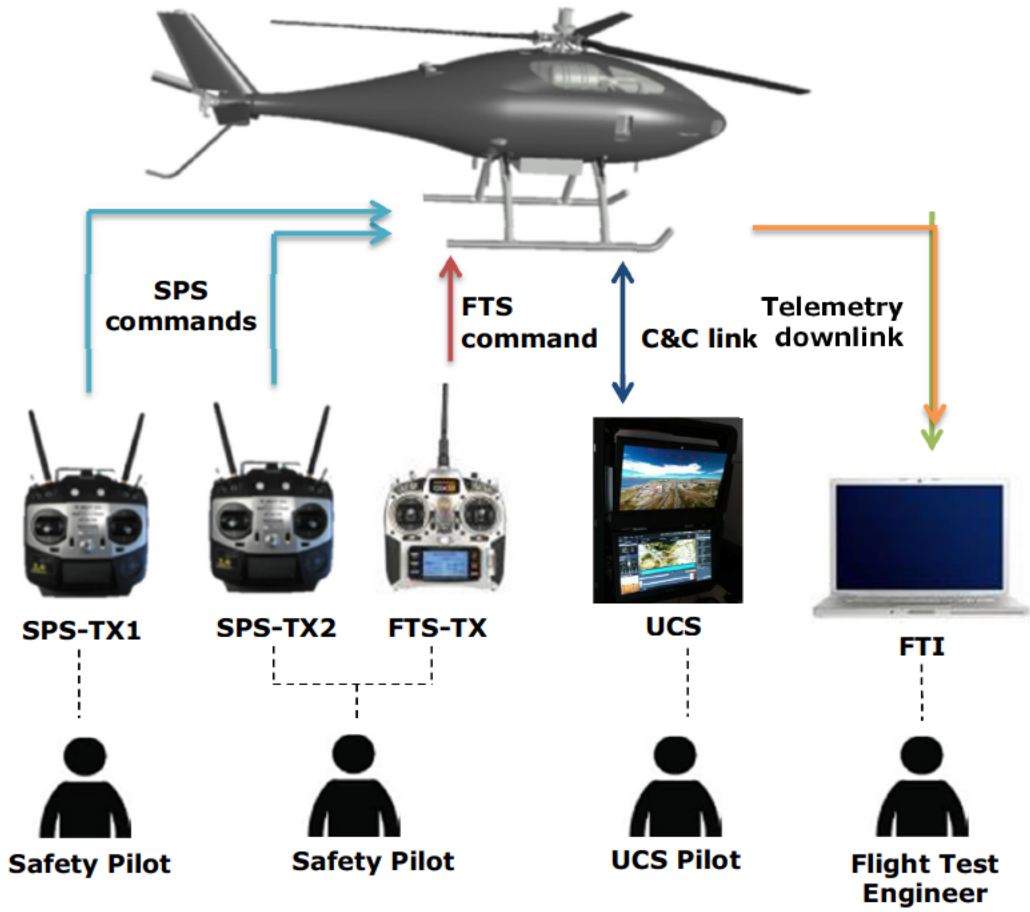


Figure 62: Crew configuration for EXE-RPAS.02-006

The RPA missions (Figure 63) have been designed for specific runs (as indicated in the caption) for EXE-RPAS.02-006. The take-off position for the RPA was agreed to be one dedicated point aside the runway, with the following operational implication, agreed during the pre-briefing:

- ATCO does not give a clearance for take-off;
- ATCO is contacted on TWR frequency by the RPA pilot;
- ATCO is informed by the pilot about the intention to take off and provides back relevant information about eventual surrounding traffic and weather conditions;
- The RPA pilot is solely responsible in the take-off phase, until entering TWR control.

Figure 63: RPA Mission

6.6.2.2 Exercise execution

For the execution of the flight the operational procedure steps for interaction between ATCO and pilot has been:

1) Voice check on TWR frequency; this check is performed half an hour before the foreseen take-off time;
2) TWR provides to free the runaway by the foreseen take-off time;
3) RPA Pilot starts communication with TWR controller five minutes in advance to take-off asking for departure info (this step determines the airspace engagement by the RPAS);
4) RPA Pilot communicate to TWR controller the take-off;
5) Reporting to TWR controller upon completion of RPAS activity for authorization to return to the identified area for landing;
6) Reporting to TWR for final communication after landing.

The RPAS take-off from the Grottaglie airport, makes a climb over the runaway in a spiral path, makes a fly over the runaway simulating a photo mission and then engages the descent in order to land.
Close coordination with ATCO as agreed is on-going during the exercise.

Mobile phones were used for inter-pilot (between the Ground Station pilot and the Safety pilot, having the RPAS in visual line of sight) communication and are still identified as backup way to communicate; VHF radio is the usual operational way to communicate to ATCOs and a UHF radio (430Mhz frequency) is identified as the emergency mean of communication.

All missions executed by RPA have been logged.

6.6.2.3 Deviation from the planned activities

Although the scenario (in terms of the location of the flight) has been changed with respect to the demonstration plan, the foreseen objectives of the flight trials have been attained.

6.6.3 Exercise Results

6.6.3.1 Summary of Exercise Results

The following pictures show RPAS Trajectory (flown trajectory in blue) adherence to planned mission (in dashed green) for the Flight#1. The 3D view highlights a good adherence of the RPAS mission to the RPA flight plan waypoints. Furthermore, the correctness of the flown trajectory compared to the planned waypoints, is confirmed also from the 2D views (longitude-latitude).

The small offset in altitude is due to the Barometric altimeter setting that may have a slight variation with respect to the TWR reported conditions. The entity of the variation is contained in a few meters that are quite irrelevant with respect to ATC integration of the RPAS.

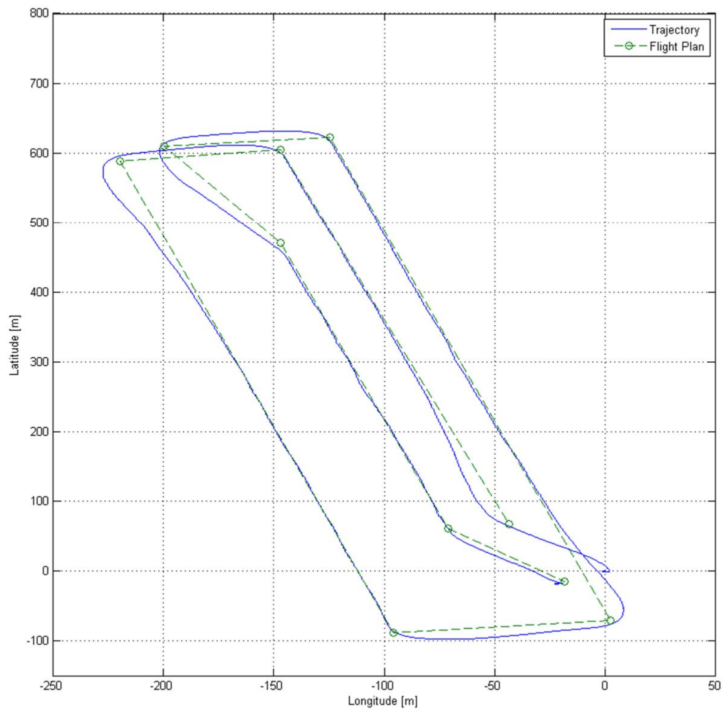


Figure 64: RPA flown trajectory in Flight #1 and RPA flight plan waypoints (Plan view)

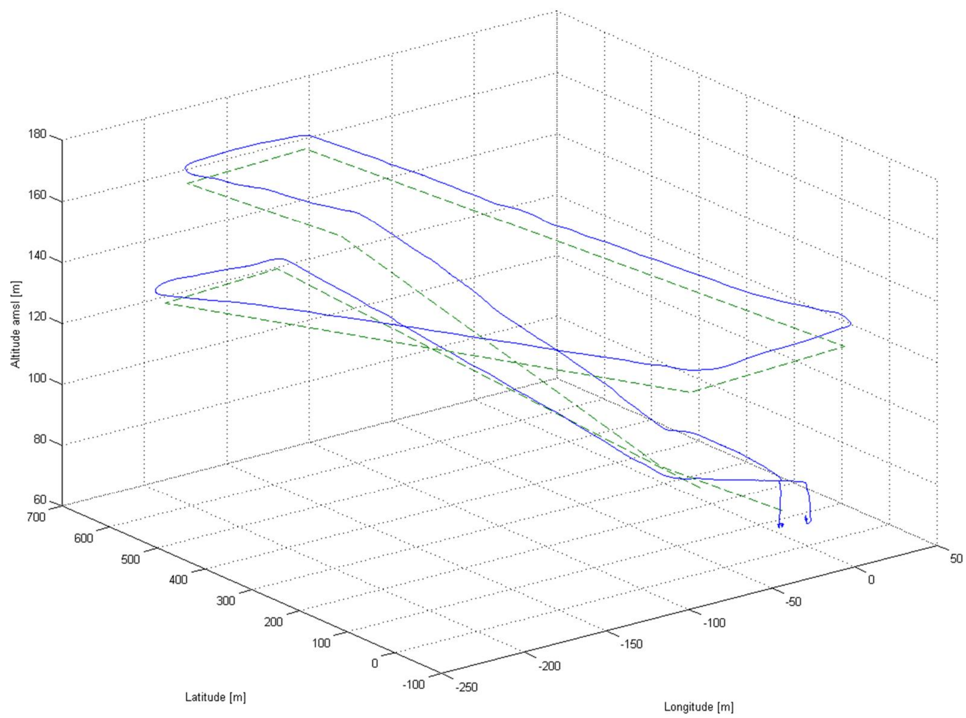


Figure 65: RPA flown trajectory in Flight #1 and RPA flight plan waypoints (3D view)

From the RPAS Pilot and from the ATCOs point of view, the exercise demonstrated that both stakeholders maintained full awareness of the mission while it was executed, that the interaction foreseen via voice communication was successfully performed within the nominal workload for controlling/handling the RPAS as any other vehicle in the airspace.
No deviation from the nominal operational procedures was necessary or recorded.

6.6.3.1.1 Results per KPA

The results in terms of predictability, safety and capacity recorded in this exercise are in line with those reported in 5.3.1.

6.6.3.1.2 Results impacting regulation and standardisation initiatives

The following relevant remarks were collected at the execution of this flight trial:

- the information provided to the supporting actors (ATCOs, Airport operators) prior to an RPAS mission is important for the orchestration and coordination during the flight and should be regulated by operational procedures, as the one generated for INSuRE and agreed prior to the flight trials;
- the RPAS pilots need to have a PPL-like certificate as a minimum;
- the requirements for RPAS pilots flying BLOS has been discussed and should be standardized in Europe and not at National level to favour consistent qualification of the operators/pilots.

6.6.3.1.3 Unexpected Behaviours/Results

No unexpected behaviours/results have been detected during the execution of this exercise. Results are in line with expectations.

6.6.3.1.4 Quality of Demonstration Results

Although the scenario of the flight trials was different from the planned one in terms of location, the exercise results are still valid and with an overall high quality. The controlled airspace is representative of the original scenario and of the objective to be demonstrated.

6.6.3.1.5 Significance of Demonstration Results

The results collected during the flights of this exercise have a good significance from an operational point of view.
Even if the flights have been performed in a limited situation of traffic (no other aircraft in the restricted area but no restriction in the remaining portion of the airport site including the north half of the runway), their results are relevant about the perception of RPAS performance from controllersô perspective in order to monitor and manage the RPAS into controlled airspace.

6.6.4 Conclusions and recommendations

6.6.4.1 Conclusions

The objectives of this exercise were fully reached.
A high level of situational awareness shown by the Controllers has been recorded during the whole execution of this exercise:

- controllers were always aware of the RPA position during the execution of RPA mission;
- controllers were able to communicate with RPA pilot on expected voice frequency;
- RPAS response following a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft.

The workload of controllers was very low in this exercise due to limited traffic in the scenario (i.e. no aircraft other than RPAS is present in the Terminal Area). Therefore:

- mental and perceptual activity to control one RPA was not higher than the one related to a light manned aircraft;
- time pressure due to the rate of pace at which the task elements occurred to control RPA was not higher than the one related to a manned aircraft and the pace was slow;
- very limited work (mentally and physically) to accomplish the level of performance;
- controllers felt secure, gratified, content, relaxed and complacent during the task.

The situational awareness of pilot can be considered very good since:

- pilot was aware of the RPA position always during the execution of RPA mission;
- pilot was able to communicate with ATCO on expected voice frequency;
- RPAS response following to a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft.

The workload of pilot was not too high in this exercise also due to limited need to manoeuvre and to the non-existing additional traffic in the scenario (i.e. no aircraft other than RPAS is present in the Terminal Area). Therefore:

- lower impact on mental and perceptual performance to pilot the RPA compared to a light manned aircraft, since the RPA was manoeuvred from ground and pilot, being on-ground, reported that he could manage the system with more calmness;
- mental and perceptual activity of pilot has been reported to be simple, therefore the risk of forgetting something important was mentioned in the pilot feedback associated with such a relaxed activity;
- physical activity to pilot one RPA was not higher than the one related to a light manned aircraft;
- time pressure due to the rate of pace at which the task elements occurred to control RPA is not higher than the one related to a manned aircraft and the pace was low in this exercise due the simple scenario;
- pilot considered his work (mentally and physically) suitable to accomplish the expected level of performance;
- pilot felt neither relaxed nor stressed during the exercise;

- pilot was enough satisfied of its performance in accomplishing the goals foreseen in this exercise.

For pilot, it was very easy to see the difference between the planned route and the flown route, and the difference is always very small and irrelevant with respect to ATC.
The feeling of pilot on safe integration of RPAs in controlled airspace was good.
Furthermore, pilot felt more secure in controlled airspace than in not-controlled airspace. Coordination offered by controllers give pilot a greater feeling of safe operations.
Therefore, the exercise was performed successfully, from operational and human performance point of view.

6.6.4.2 Recommendations

As general feedback from pilots, three different communication media (cell phone, VHF and UHF radio) can be somewhat confusing if each channel is used at the same time. An integrated multi-frequency voice segment in the UCS should represent a good upgrade reducing the need of using three different appliances to keep communication under control.
During the exercise, due to limited traffic present, it was not a particular problem, but in more congested situation it can represent a real limitation.

The controllers reported a positive feeling on safe integration of RPAs in controlled airspace, derived from this flight trial experience.

6.7 Demonstration Exercise EXE-RPAS.02-007 Report

EXE-RPAS.02-007 is the seventh exercise related to INSuRE project demonstration.

6.7.1 Exercise Scope

EXE-RPAS.02-007 focuses on the operational procedures between RPAS pilot and ATCOs during the contingency situation of data link loss. This exercise is meant to perform a typical photo flight mission over the airport CTR and evaluates the interaction of the RPAS with ATCOs, as per EXE-RPAS.02-006, but in this case considering the non-nominal scenario and verifying the implementation of the appropriate RPAS contingency procedure.

6.7.2 Conduct of Demonstration Exercise EXE-RPAS.02-007

6.7.2.1 Exercise Preparation

The preparatory activities are the same performed for EXE-RPAS.02-006 and described in 6.6.2.1.

6.7.2.2 Data Link loss approach

The managements of Data Link loss events is described, as reported also in the Safety Assessment Document (Ref. [11]), in the following table:

Contingency	Contingency Event	Action
Data link loss	Complete Data-Link loss	The RPAS is pre-programmed to fly to the pre-defined way-points (through the so-called contingency path), if the C2 link between Control Station and RPA is lost. The way-points are defined by the pilot by means of the Control Station. The entire Flight Plan (contingency path included) is agreed with ATS; If the link will not be re-established, the RPAS will follow the contingency path, otherwise the pilot can select from the Control Station the next waypoint; Communication to ATC of the “link loss” procedure engagement
	Partial Data-Link loss: Loss of Ground→On-board channel	See Action related to “Complete Data-Link loss”
	Partial Data-Link loss: Loss of On-board → Ground channel	See Action related to “Complete Data-Link loss”
Loss of Control Station	Complete loss of control station	See Action related to “Complete Data-Link loss”.

Contingency	Contingency Event	Action
	Fail to provide semiautomatic commands to the AV	Switch to automatic mode to land as soon as possible to the nearest available landing spot; Warn ATC about failure.
	Fail to update Flight Plan to the AV	Switch to semi-automatic mode to land as soon as possible to the nearest available landing spot; Warn ATC about failure.
	Fail to provide flight data / mission data to the crew	Switch off C&C Data-link and generate a Link Loss: See Action related to "Complete Data-Link loss".

6.7.2.3 Exercise execution

For the execution of the flight the operational procedure steps for interaction between ATCO and pilot has been:

7) Voice check on TWR frequency; this check is performed half an hour before the foreseen take-off time;
8) TWR provides to free the runaway by the foreseen take-off time;
9) RPA Pilot starts communication with TWR controller five minutes in advance to take-off asking for departure info (this step determines the airspace engagement by the RPAS);
10) RPA Pilot communicate to TWR controller the take-off;
11) Reporting to TWR controller upon completion of RPAS activity for authorization to return to the identified area for landing;
12) Reporting to TWR for final communication after landing.

The RPAS starts the same mission planned for the previous flight but at a certain point during mission the pilot initiate a link loss by disconnecting the UCS from the ground hub. The RPA flies up to the next waypoint and, because the link is not re-established, engages the contingency path and lands in the pre-defined spot.

Mobile phones was used for inter-pilot communication and are still identified as backup way to communicate; VHF radio is the usual operational way to communicate and a UHF radio (430Mhz frequency) is identified as the emergency mean of communication.

All missions executed by RPA have been logged.

6.7.2.4 Deviation from the planned activities

Although the scenario has been changed with respect to the demonstration plan in term of location, the foreseen objectives of the flight trials have been attained.

6.7.3 Exercise Results

6.7.3.1 Summary of Exercise Results

The following picture shows the flown path during the execution of the flight for EXE-RPAS.02-007; evidence is put on the data link loss induction point and the contingency path engaged.

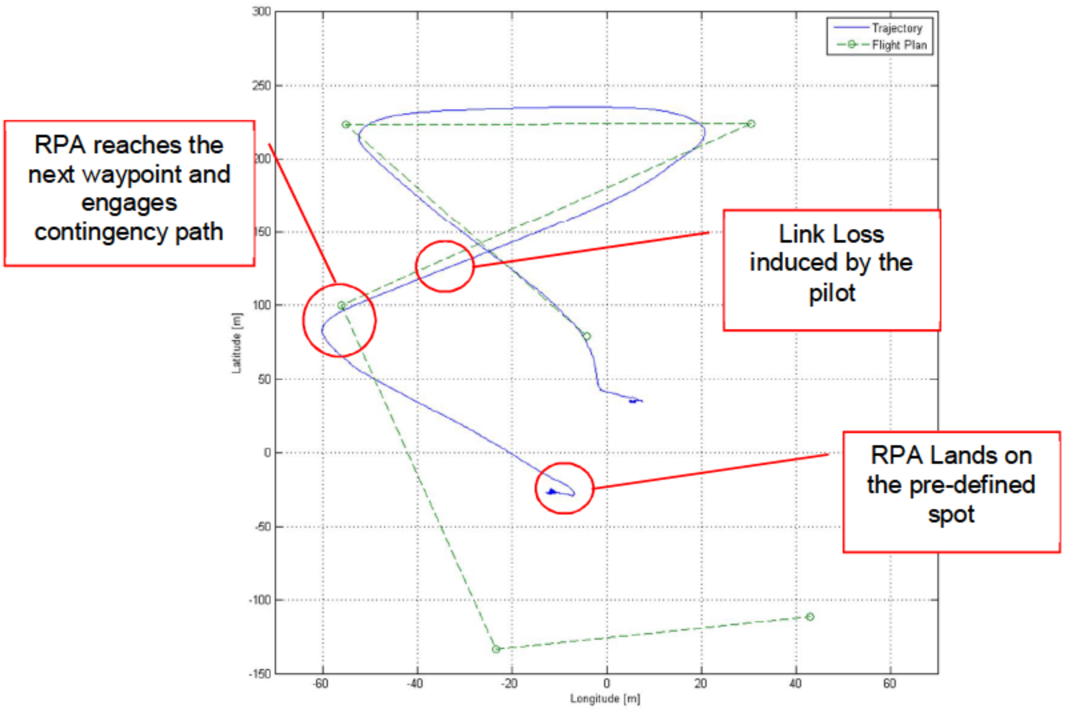


Figure 66: RPA flown trajectory and RPA flight plan waypoints (plan view)

From the RPAS Pilot and from the ATCOs point of view, the exercise demonstrated that both stakeholders maintained full awareness of the mission while it was executed, that the interaction foreseen via voice communication was successfully performed within the nominal workload for controlling/handling the RPAS as any other vehicle in the airspace. No deviation from the nominal operational procedures was necessary or recorded.
During the contingency simulated during flight the RPAS link loss procedure was performed without particular problems and with reaction time and situational awareness satisfactory for both pilot and controllers point of view.
The performance of the RPAS system was the one expected (as per system manual and safety related documentation) in activating the automatic landing procedure in the identified contingency landing spot after the data-link loss.
The exercise has been successfully testing the above operational procedure, which is in general deemed acceptable from both ATCOs and RPAS Pilot.

6.7.3.1.1 Results per KPA

The results in terms of predictability, safety and capacity recorded in this exercise are in line with those reported in 5.3.1.

6.7.3.1.2 Results impacting regulation and standardisation initiatives

The following relevant remarks were collected at the execution of this flight trial:

- the information provided to the supporting actors (ATCOs, Airport operators) prior to an RPAS mission is important for the orchestration and coordination during the flight and should be regulated by operational procedures, as the one generated for INSuRE and agreed prior to the flight trials;
- the contingency response need to be foreseen for each point of the mission where a contingency event can occur – as part of the required safety assessment for RPAS certification and PtF issue the CAAs consider the response to contingency events but, as

per current regulations, there is no standard approach in evaluating the possible response types, in particular when they imply an automatic landing procedure.

6.7.3.1.3 Unexpected Behaviours/Results

No unexpected behaviours/results have been detected during the execution of this exercise. Results are in line with expectations.

6.7.3.1.4 Quality of Demonstration Results

Although the scenario of the flight trials was different from the planned one in terms of location, the exercise results are still valid and with an overall high quality. The controlled airspace is representative of the original scenario and of the objective to be demonstrated.

6.7.3.1.5 Significance of Demonstration Results

The results collected during the flights of this exercise have a high significance from an operational point of view.
Even if the flights have been performed in a limited situation of traffic, their results are relevant about the perception of RPAS performance from controllersôperspective in order to monitor and manage the RPAS into controlled airspace and during the event of a data link loss contingency. As a result of the contingency event execution and its successful handling, the perceived safety of integration and the situational awareness of both pilot and controllers resulted increased.

6.7.4 Conclusions and recommendations

6.7.4.1 Conclusions

The objectives of this exercise were fully reached.
A high level of situational awareness shown by the Controllers has been recorded during the whole execution of this exercise:

- controllers were always aware of the RPA position during the execution of RPA mission;
- controllers were able to communicate with RPA pilot on expected voice frequency;
- RPAS response following a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft.

The workload of controllers was very low in this exercise due to limited traffic in the scenario (i.e. no aircraft other than RPAS is present in the Terminal Area). Therefore:

- mental and perceptual activity to control one RPA was not higher than the one related to a light manned aircraft;
- time pressure due to the rate of pace at which the task elements occurred to control RPA was not higher than the one related to a manned aircraft and the pace was slow;
- very limited work (mentally and physically) to accomplish the level of performance;
- controllers felt secure, gratified, content, relaxed and complacent during the task;

The situational awareness of pilot can be considered very good since:

- pilot was aware of the RPA position always during the execution of RPA mission;
- pilot was able to communicate with ATCO on expected voice frequency;
- RPAS response following to a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft.

The workload of pilot was not too high in this exercise also due to limited need to manoeuvre and to the non-existing additional traffic in the scenario (i.e. no aircraft other than RPAS is present in the Terminal Area). Therefore:

- lower impact on mental and perceptual performance to pilot the RPA compared to a light manned aircraft, since the RPA was manoeuvred from ground and pilot, being on-ground, reported that he could manage the system with more calmness;

- mental and perceptual activity of pilot has been reported to be simple, therefore the risk of forgetting something important was mentioned in the pilot feedback associated with such a relaxed activity;
- physical activity to pilot one RPA was not higher than the one related to a light manned aircraft;
- time pressure due to the rate of pace at which the task elements occurred to control RPA is not higher than the one related to a manned aircraft and the pace was low in this exercise due the simple scenario; even in case of emergency request from controllers, the pressure was limited due to simple operations to accomplish up to landing;
- pilot considered his work (mentally and physically) suitable to accomplish the expected level of performance;
- pilot felt neither relaxed nor stressed during the exercise;
- pilot was enough satisfied of its performance in accomplishing the goals foreseen in this exercise.

For pilot, it was very easy to see the difference between the planned route and the flown route, and the difference is always very small and irrelevant with respect to ATC.
The feeling of pilot on safe integration of RPAs in controlled airspace was good.
Furthermore, pilot felt more secure in controlled airspace than in not-controlled airspace. Coordination offered by controllers give pilot a greater feeling of safe operations.
Therefore, the exercise was performed successfully, from operational and human performance point of view.

6.7.4.2 Recommendations

It is recommended to consider a possible standardization of procedures associated with contingency RPAS operation including:

- The concepts of operation for data-link loss
- The level and type of information shared between RPAS pilot and ATC during the contingency procedures execution
- The method of providing back-up communications in the event of a communication link failure (as already mentioned for exercise EXE-RPAS.02-006).

6.8 Demonstration Exercise EXE-RPAS.02-008 Report

EXE-RPAS.02-008 is the eighth and last exercise related to INSuRE project demonstration.

6.8.1 Exercise Scope

EXE-RPAS.02-008 focuses on the operational procedures between RPAS pilot and ATCOs during the emergency situation in which ATCO requests the RPAS to land in order to free the airspace for an emergency landing of another foreseen arriving flight. This exercise is meant to perform a typical photo flight mission over the airport CTR and evaluates the interaction of the RPAS with ATCOs, as per EXE-RPAS.02-006, but in this case considering the non-nominal scenario and verifying the implementation of the appropriate RPAS emergency landing procedure:

- Emergency procedures: ATC requests immediate landing and to free the runaway as fast as possible for an incoming emergency flight.

6.8.2 Conduct of Demonstration Exercise EXE-RPAS.02-008

6.8.2.1 Exercise Preparation

The preparatory activities are the same performed for EXE-RPAS.02-006 and described in 6.6.2.1.

6.8.2.2 Exercise execution

For the execution of the flight the operational procedure steps for interaction between ATCO and pilot has been:

13) Voice check on TWR frequency; this check is performed half an hour before the foreseen take-off time;
14) TWR provides to free the runaway by the foreseen take-off time;
15) RPA Pilot starts communication with TWR controller five minutes in advance to take-off asking for departure info (this step determines the airspace engagement by the RPAS);
16) RPA Pilot communicate to TWR controller the take-off;
17) Reporting to TWR controller upon completion of RPAS activity for authorization to return to the identified area for landing;
18) Reporting to TWR for final communication after landing.

The RPAS starts the same mission of Flight #1 but at a certain point TWR request an immediate landing and to free the runaway as fast as possible. The pilot engages the semi-automatic flight mode, takes the RPAS to the ground and rapidly shuts off the engine.
The transport trailer, in accordance with airport logistic control, enters the runaway and the RPAS helicopter is loaded and transported outside the runaway area.
The operation time is monitored to better evaluate the actual time from the TWR request to the instant the runaway is free for the inspection.

Mobile phones were used for inter-pilot communication and are still identified as backup way to communicate; VHF radio is the usual operational way to communicate and a UHF radio (430Mhz frequency) is identified as the emergency mean of communication..

All missions executed by RPA have been logged.

6.8.2.3 Deviation from the planned activities

Although the scenario has been changed with respect to the demonstration plan in term of location, the foreseen objectives of the flight trials have been attained.

6.8.3 Exercise Results

6.8.3.1 Summary of Exercise Results

The following picture shows the flown path during the execution of the flight for EXE-RPAS.02-008; evidence is put on the emergency path performed upon request by the TWR; in the picture are evidenced the point where the pilot switched from automatic flight mode and the semi-automatic mode.

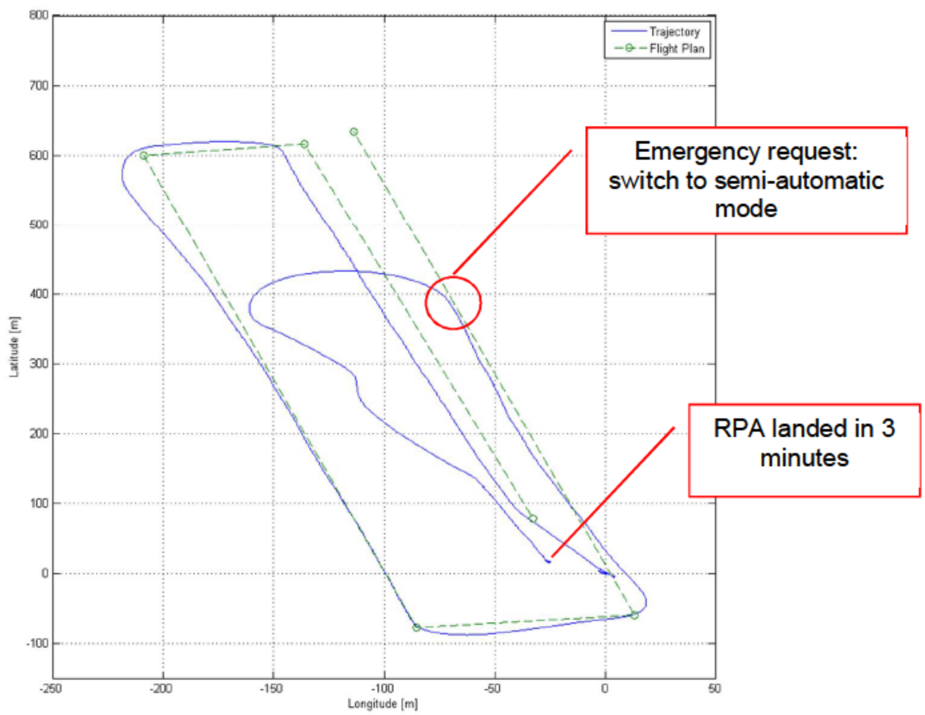


Figure 67: RPA flown trajectory in Flight #2 and RPA flight plan waypoints (Plan view)

From the RPAS Pilot and from the ATCOs point of view, the exercise demonstrated that both stakeholders maintained full awareness of the mission while it was executed, that the interaction foreseen via voice communication was successfully performed within the nominal workload for controlling/handling the RPAS as any other vehicle in the airspace.
No deviation from the nominal operational procedures was necessary or recorded.
The emergency operation, TWR request to free the runaway as fast as possible, was performed without particular problems and with reaction time and situational awareness satisfactory for both pilot and controllers.
The exercise has been successfully testing the above operational procedure, which is in general deemed acceptable from both ATCOs and RPAS Pilot.

6.8.3.1.1 Results per KPA

The results in terms of predictability, safety and capacity recorded in this exercise are in line with those reported in 5.3.1.

6.8.3.1.2 Results impacting regulation and standardisation initiatives

The following relevant remarks were collected at the execution of this flight trial:

- the information provided to the supporting actors (ATCOs, Airport operators) prior to an RPAS mission is important for the orchestration and coordination during the flight and should be regulated by operational procedures, as the one generated for INSuRE and agreed prior to the flight trials;
- the training of the RPAS team and in particular of the pilot in command should include the operational aspects related to the handling of emergency situations guided by operational procedures in place at the site of the mission (corresponding to specific airport procedures for management of emergency on the site, e.g. fire alerts, emergency aircraft landing) and expecting specific response time from the involved parties, in this case the RPAS team.

6.8.3.1.3 Unexpected Behaviours/Results

No unexpected behaviours/results have been detected during the execution of this exercise. Results are in line with expectations.

6.8.3.1.4 Quality of Demonstration Results

Although the scenario of the flight trials was different from the planned one in terms of location, the exercise results are still valid and with an overall high quality. The controlled airspace is representative of the original scenario and of the objective to be demonstrated.

6.8.3.1.5 Significance of Demonstration Results

The results collected during the flight performed for of this exercise have a high significance from an operational point of view.
Even if the flights have been performed in a limited situation of traffic, their results are relevant about the perception of RPAS performance from controllersôperspective in order to monitor and manage the RPAS into controlled airspace. Moreover the handling of an emergency situation increased the perceived safety of integration and the situational awareness of both RPAS pilot and controllers.
The airport supporting personnel involved in the emergency trial also appreciated the opportunity to test the activities related to supporting the RPAS team in freeing the runway as fast as possible, since it is under their responsibility to check and confirm to Tower Control that the runway is available and clean for a landing of another aircraft.

6.8.4 Conclusions and recommendations

6.8.4.1 Conclusions

The objectives of this exercise were fully reached.
A high level of situational awareness shown by the Controllers has been recorded during the whole execution of this exercise:

- controllers were always aware of the RPA position during the execution of RPA mission;
- controllers were able to communicate with RPA pilot on expected voice frequency;
- RPAS response following a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft.

The workload of controllers was very low in this exercise due to limited traffic in the scenario (i.e. no aircraft other than RPAS is present in the Terminal Area). Therefore:

- mental and perceptual activity to control one RPA was not higher than the one related to a light manned aircraft;
- time pressure due to the rate of pace at which the task elements occurred to control RPA was not higher than the one related to a manned aircraft and the pace was slow;
- very limited work (mentally and physically) to accomplish the level of performance;
- controllers felt secure, gratified, content, relaxed and complacent during the task;

The situational awareness of pilot can be considered very good since:

- pilot was aware of the RPA position always during the execution of RPA mission;
- pilot was able to communicate with ATCO on expected voice frequency;

- RPAS response following to a specific ATCO clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft.

The workload of pilot was not too high in this exercise also due to limited need to manoeuvre and to the non-existing additional traffic in the scenario (i.e. no aircraft other than RPAS is present in the Terminal Area). Therefore:

- lower impact on mental and perceptual performance to pilot the RPA compared to a light manned aircraft, since the RPA was manoeuvred from ground and pilot, being on-ground, reported that he could manage the system with more calmness;
- mental and perceptual activity of pilot has been reported to be simple, therefore the risk of forgetting something important was mentioned in the pilot feedback associated with such a relaxed activity;
- physical activity to pilot one RPA was not higher than the one related to a light manned aircraft;
- time pressure due to the rate of pace at which the task elements occurred to control RPA is not higher than the one related to a manned aircraft and the pace was low in this exercise due the simple scenario; even in case of emergency request from controllers, the pressure was limited due to simple operations to accomplish up to landing;
- pilot considered his work (mentally and physically) suitable to accomplish the expected level of performance;
- pilot felt neither relaxed nor stressed during the exercise;
- pilot was enough satisfied of its performance in accomplishing the goals foreseen in this exercise.

For pilot, it was very easy to see the difference between the planned route and the flown route, and the difference is always very small and irrelevant with respect to ATC.
The feeling of pilot on safe integration of RPAs in controlled airspace was good.
Furthermore, pilot felt more secure in controlled airspace than in not-controlled airspace. Coordination offered by controllers give pilot a greater feeling of safe operations.
Therefore, the exercise was performed successfully, from operational and human performance point of view.

6.8.4.2 Recommendations

It is recommended to train the RPAS team and the pilot in command on procedures associated with emergency at the operational site, specifically on:

- Expected reaction time;
- Expected communication and responses between the involved actors;
- The method of providing back-up communications in the event of a communication link failure (as already mentioned for exercise EXE-RPAS.02-006).

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7 Summary of the Communication Activities

The communication activities started directly after the Kick Off Meeting officially declaring with SJU the beginning of the execution phase of the INSuRE project.
The first INSuRE communication message has been published on the consortium partners web sites following the SJU press release on the RPAS projects awarding. The INSuRE first press release, approved and with input by SJU Communication Office before finalization and publishing, is reported in the dedicated paragraph of this section.

In 2014, the main event in which the INSuRE project was presented is the World ATM Congress (WAC), which was held in Madrid on 4-6 March. In this occasion SESAR JU has organized a workshop dedicated to the SESAR Demonstration Projects including the RPAS Demonstration ones and, amongst these also INSuRE. Moreover, at the WAC, IDS had a company stand as exhibitor which gave further opportunities to present the project future activities, systems, plan and objectives to the various stakeholders visiting the stand.

In June 2014, IDS hold the yearly AeroSIG event (location and precise dates are still to be defined), which is a three days meeting to present the IDS ongoing activities and products to the customers throughout the World. A presentation was dedicated to the activities in SESAR and, in particular, to INSuRE and to the ongoing activities related to RPAS systems and their foreseen operational integration in ATM.

SD is member of UVS International and part of EUROCAE Group 93. UVS organizes two annual conferences, in December and in June, of interest for result dissemination (www.uvs-info.com).
SD attended:

- The June conference in 2014, focused on RPAS regulatory issues, operational matters, current & future applications;
- The December conference in 2014, specific for civil operation involving RPAS.

SD was present to the 51st International Paris Air Show at Le Bourget in June 2015. Reference: http://www.paris-air-show.com/.

Furthermore, SD participated to the following conferences:

- ERF2014 (40th European Rotorcraft Forum 2014) on 2-5 September;
- AHS (American Helicopter Society) Forum 71st in 2015 (not yet scheduled but foreseen yearly in May timeframe).

For these events, the INSuRE consortium proposed papers presenting the available project results.

In 2015 during 19th-21st May, there was an International Exhibition of Defence and Security Technologies in Brno call “IDET”.

INSuRE Consortium participated actively to other relevant events (SESAR events as well as ATM and RPAS related conferences/congresses) at the end of 2014 and in 2015.

The INSuRE dissemination and communication activities, always coordinated with SESAR JU, continue beyond the project lifetime to ensure that also the final results, documented in the project final report, are properly presented to the stakeholders.

A summary view of the communication activities is reported in the following table:

Event	Foreseen dates and location	INSuRE Participation	INSuRE PoC	Reference
Press Release	16 October 2013 (INSuRE Project Kick Off Meeting)	Leadership	[redacted]	See consortium partners web sites: https://www.idscorporation.com/ http://www.rlp.cz/ www.sistemidinamici.com
World ATM Congress 2014	4-6 March 2014 (Madrid)	Exhibition		http://www.worldatmcongress.org/
AeroSIG 2014	June 2014	Presenter		See https://www.idscorporation.com/home/events
Remotely Piloted Aircraft Systems Conference	23-26 June 2014 (Brussels)	Presenter		www.rpas-2014.org
AeroSIG 2015	June 2015	Presenter		See https://www.idscorporation.com/home/events
UAVA conference	21 May 2015	Presenter		See http://www.uava.cz/
51st International Paris Air Show	15-21 June 2015, (Le Bourget)	Visitor/ Exhibitor		http://www.paris-air-show.com/
Final INSuRE Communication Event	15 February 2015 (date to be confirmed)	Chairman		SESAR INSuRE Project Schedule

Table 25: INSuRE Communication Activities overview

8 Next Steps

INSuRE initially intended to perform the flights in Brno (Czech Republic). It is not excluded, given all the preparatory simulation work performed and the collaboration in place within the Consortium, to implement in Brno future RPAS demonstration activities in the scope of other programmes or projects, enlarging the objectives and using the INSuRE results as a starting point.
More work is deemed necessary in the following areas:

- Detect and Avoidance capability implementation beyond the usage of the ADS-B implemented and tested in INSuRE;
- Standardization of the operational procedures throughout Europe for the issuing of the PtF for RPAS missions in BLOS;
- Standardization of training requirements for RPAS pilots and operators;
- Standardization of data exchange and data formats for information exchange between ATC systems and RPAS systems.

8.1 Conclusions

As general results of the INSuRE demonstrations, the integration of RPAS in controlled airspace has been proven to be not far from implementation for operational missions, since:

- the situational awareness shown by the Controllers and RPAS pilot during the simulation and flight activities has been high;
- the operational procedures in place for controlling manned flight in the nominal traffic demonstrated to be adequate also for RPAS, given that the RPAS system is equipped with capabilities to provide communication means with ATC and to support awareness of surrounding traffic (RADAR track input and ADS-B for cooperative traffic);
- RPAS response following a specific ATCO (both TWR and TMA) clearance happened within reasonable time range and it could be considered comparable with the response of a manned aircraft;
- workload of pilots and controllers has been calculated and felt comparable to the workload of handling a manned aircraft in the same traffic scenario;
- the communication between RPAS pilot and ATCOs (both TWR and TMA) follows the same rules as the communication for manned operations/clearances, given that also the RPAS pilot is trained on operational voice communication standards;
- during the integration of multiple RPAs controlled by a single pilot, the pilots (two different pilots tested this case) declared that they felt not confident and safe enough in handling the two systems simultaneously; their workload was too high, in particular in the take-off and landing phases, when they had to be aware of the second vehicle position as well as manoeuvring the first. Monitoring and replying to ATC on multiple frequencies and different ATC sectors while controlling two different RPAS increased additionally the already high pilotsôstress level;
- the RPAS contingency procedure as response for a data-link loss was tested successfully during the flight trial;
- the RPAS fast landing as response for an emergency procedure at the operational airport site was tested successfully during the flight trial;
- RPAS pilot felt more secure in controlled airspace than in not-controlled airspace; coordination offered by controllers give pilot a greater feeling of safe operations.

During exercises execution a certain misunderstanding in discussing and describing the type of operations has been recorded, both for pilots and ATCO, concerning the concepts of VFR/IFR vs VLOS/BVLOS; it is the project team opinion that VFR/IFR concepts do not apply to RPAS, where the flight operations are conducted only via UCS. Standardizing and clarifying these concepts, focusing only on the VLOS and BVLOS definitions, could support a common understanding amongst RPAS stakeholders.

A major added value of the SESAR INSuRE demonstration lies in the fact that, being RPAS civil operations a quite new area in ATM, it spawn coordination tables and discussions between the stakeholders (ANSP, RPAS Operator, National CAA, Airport authorities) in order to define and document an operational procedure approved by all parties and to be put in place to support the demonstration. The Letter of Operations, defined and signed by ENAV and Aeroporti di Puglia, for the INSuRE Flight Demo is the first in its kind and will be used as basis for the management of future RPAS activities in the airspace of Taranto/Grottaglie, which has been qualified by the Italian CAA as logistic platform for research and demonstration RPAS activities.

8.2 Recommendations

Together with the relevant CONOPS, the definition of a Letter of Operations is the way used successfully in INSuRE to operationally manage dedicated the RPAS flight trials, containing the procedures for airspace usage, coordination, communication and the references to the applicable documents in case of contingency or emergency situation. This approach, in the opinion of the project team and external stakeholders, is recommended for implementation in future RPAS missions since it could be easily scalable and applied to similar scenarios in Europe.

Recommendations for the implementation of the Detect & Avoidance operations:

- Relying only on ADS-B data can be sufficient in cases where aircrafts are all equipped but additional on-board radar equipment could be used to have higher knowledge of traffic if not all cooperating;
- The RPAS "pilot to pilot" communication (in case of VLOS or E-VLOS operations foreseeing a safety pilot and a pilot in command) can be performed using very shortly the operational frequency for the live trial and defining a list of short messages for communicating with TOWER for info on repetition of activities, without congesting the voice link;
- Detect and Avoidance capability implementation should follow standards yet to be defined.

As general recommendation from pilots, three different communication media (cell phone, VHF and UHF radio) can be somewhat confusing if each channel is used at the same time. An integrated multi-frequency voice segment in the UCS should represent a good upgrade reducing the need of using three different appliances to keep communication under control. During the INSuRE exercises, due to limited traffic present, it was not a particular problem, but in more congested situation it can represent a real limitation.

The suggested integrated voice segment should not rely on a dedicated on-board appliance in order not to increase the already congested EM environment and require additional weight to be carried on-board. This statement is particularly relevant for light RPAS for which additional airborne systems will also drastically reduce payload carrying capabilities. This recommendation implies that ground to ground communication should be assured and standardized (e.g. via SWIM) even if an upgrade of the ATC voice communication systems is most probably required.

CPDLC messages could be used as additional way of implementing ground-ground communication for RPAS operations in order to decongest the voice frequency nominally used.

For future improvement to the Ground Control Station capability of piloting multiple RPAS from one station the following recommendations are deemed to be useful:

- It is important to have some fast way to leave the RPAS in hover disregarding all previous operations. For fast way, pilot means one (and only one) pressure switch.
- The three flight modes (JOY LWSPD, JOY GSPD, JOY IAS) must be activated by three different push buttons, better if replicated on the screen in touchscreen conf. Every single button must activate the corresponding mode without ambiguity and "hover" button must be activated and available in every moment.
- Changing from a RPA to another does not have to provoke change in the UCS configuration. At the moment, if you were in JOY GSPD mode, when switch back you find the RPA cockpit in "HOVER" mode and you have to re-toggle between modes in a pretty complex way.
- It could be truly useful if the OTW screen could be split in two allowing to maintain some situational awareness of the "not controlled" RPAS while controlling the other one.

It is recommended to consider a possible standardization of procedures associated with contingency RPAS operation including:

- The concepts of operation for data-link loss (see implementation details in 6.7.2.2) as well as for the other types of contingencies evaluated in the relevant Safety Documentation;
- The level and type of information shared between RPAS pilot and ATC during the contingency procedures execution.

It is recommended to train the RPAS team and the pilot in command on procedures associated with emergency at the operational site, specifically on:

- Expected reaction time;
- Expected communication and responses between the involved actors;
- The method of providing back-up communications in the event of a communication link failure.

As a requirement proposed for supporting full integration of RPAS in ATZ, also TWR ATCOs should be provided with additional surveillance information integrated in the controller working position, relying on RPAS transponder data (e.g. Mode-S or ADS-B).

Sharing RPAS Flight Plans, in standardized format as done for manned flights, with the operational stakeholders involved (ATC Units as well as Airport authorities where relevant) before the mission execution can support the integration of RPAS in civil traffic scenario (in particular for operations in which the flight level and the type of flight are comparable with those of a manned aircraft) increasing awareness in all parties involved in the operations. During the INSuRE demonstrations the flight plans have been presented at the RPAS pre-flight briefing.

9 References

9.1 Applicable Documents

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

[2] Roadmap for the integration of civil Remotely-Piloted Aircraft systems into the European Aviation System ï Final Report from European RPAS Steering Group and Annexes ï June 2013

[3] Regulation (EC) No 216/2008 (Annex II letter (i): unmanned aircraft with an operating mass no more than 150 kg)

[4] UNI EN ISO 9001:2008 – Quality Management System: Requirements

[5] Technical Proposal in response to call ref. SJU/LC/0087-CFP, RPAS Integration into non-segregated ATM (INSuRE)

[6] Financial Proposal in response to call ref. SJU/LC/0087-CFP, RPAS Integration into non-segregated ATM (INSuRE)

[7] RPAS.02 INSuRE Demonstration Plan, 00.01.01, 28/02/2014

[8] RPAS.02 INSuRE Validation Plan, 00.01.00, 14/11/2014

[9] RPAS.02 INSuRE Simulation Platform Acceptance Test, 00.01.00, 28/11/2014

[10] RPAS.02 INSuRE Simulation Report, 00.01.00, 16/03/2015

[11] RPAS.02 INSuRE Safety Assessment, 00.01.00, 08/05/2015

[12] RPAS.02 INSuRE Final Demonstration Plan, 00.01.00, 08/05/2015

9.2 Reference Documents

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

[1] Demonstration Design

[2] Deployment Scenario Descriptions

[3] Communication Plan

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

[5] ATM Master Plan
https://www.atmmasterplan.eu

[6] Operational Focus Area, Programme Guidance, Edition 03.00.00, date 4.05.2012

[7] SJU Communication Guidelines RPAS 2013 ï final

[8] European Operational Concept Validation Methodology Version 3.0 Vol.1 and Vol.2

[9] SESAR Concept of Operations Step1, 01.00.00

[10] SESAR Concept of Operations Step2, 01.00.00

[11] CS-VLR Certification Specification for Very Light Rotorcraft ï EASA

[12] STANAG 4703 (EDITION 1) Light UAV Systems Airworthiness Requirements (USAR-LIGHT)

[13] EASA A-NPA No 16-2005 - Policy for Unmanned Aerial Vehicle

[14] NPA 2012-10 - Notice of Proposed Amendment (NPA) Transposition of Amendment 43 to Annex 2 to the Chicago Convention on remotely piloted aircraft systems (RPASs) into common rules of the air ï EASA

[15] ENAC ï Regolamento per Mezzi a Pilotaggio Remoto ï Ed.1 published on 16/12/2013

[16] European ATM Architecture (https://www.atmmasterplan.eu/architecture/)

[17] SESAR B.05 D68 Performance Assessment - Step 1 (Cycle 2), 00.01.00, 15/11/2013

[18] Joint Authorities for Rulemaking of Unmanned Systems (JARUS) - Certification Specification for Light Unmanned Rotorcraft Systems (CS-LURS) - JARUS_CS-LURS Version 1.0

[19] SESAR 16.06.05 D26, SESAR Human Performance Reference Material ï Guidance, 00.02.00

Appendix A Communication Material

A.1 INSuRE Kick-Off press release

Rome, Italy - 16th October, 2013 - The Integration into non-segregated ATM (INSuRE) Project Kick Off Meeting, in IDSôs Rome premises on 16th October, marks the ñT0ò point of the projectôs execution phase. The INSuRE Project encompasses a set of validation and demonstration activities addressing the integration of RPAS (Remotely Piloted Air Systems) into non-segregated airspace.

The purpose of INSuRE is to address and demonstrate the:

- Operational management of one rotary wing RPAS, piloted from a fixed station on the ground, evaluating its interaction with other vehicles in a non-segregated airspace;
- Operational aspects in implementing nominal ATCO procedures;
- Safety aspects to allow safe integration in controlled airspaces;
- Human factor aspects addressing both the pilotôs and ATCOôs workload and reactions.

The INSuRE Project is one of nine Integrated RPAS Demonstration projects that have been selected for co-financing by the SESAR Joint Undertaking (SESAR JU), which coordinates the SESAR (Single European Sky ATM Research) programme. SESAR in-flight demonstrations show, on a larger scale, the benefits of the programme in day-to-day operations and build confidence in the SESAR solutions amongst the ATM community.

SESAR Integrated RPAS Demonstrations aim to:

- Demonstrate how to integrate RPAS into non-segregated airspace in a multi-aircraft and manned flight environment, in order to explore the feasibility of integration with the wider aviation community by 2016;
- Focus on concrete results filling the operational and technical gaps identified for RPAS integration into non-segregated airspace;
- Capitalise on the SESAR delivery approach by providing synergies, risk and opportunities, with the overall SESAR programme.

Ingegneria Dei Sistemi S.p.A. (IDS), Air Navigation Services of the Czech Republic (ANS CR) and Sistemi Dinamici S.p.A. (SD) are the members of the INSuRE Consortium which were awarded the co-financing of the INSuRE Project. The agreement was signed between the SESAR JU, which is providing 50% of the funding, and IDS (the consortium lead) on 10th September 2013.

IDS is the consortiumôs coordinator and has been responsible for project management and, on the technical side of the simulation campaign, for validating the approach and providing expertise both at ATM level and at the technical level. IDS made available to the project its validation platform in Pisa, including an aircraft cockpit simulator and an ATC simulator, and the capability to simulate and control the RPAS vehicles in the validation scenario.

RPAS Ground Station

The necessary and crucial role of the ANSP is covered by ANS CR. ANS CR will lead the operational activities at the selected aerodrome (LKTB Brno-Turany) and the dedicated safety analysis. The ANSP is also contributing with licenced and experienced personnel (ATCO as well as ATSEP) together with a team of ANSP experts.

BRNO Airport ï Tower

The RPAS manufacturer and operator is represented by SD, which will coordinate and lead the relevant preparation and execution of the flight campaign in the Czech Republic. In 2012 SD started the ñRUAS-HEROò program for the development and production of a rotary wing RPAS with an MTOM (Maximum Take Off Mass) of less than 150 Kg. The RUAS-HERO will be the RPAS vehicle used in the INSuRE demonstration flights.

RPAS vehicle – RUAS-HERO

About the INSuRE project consortium:

Ingegneria Dei Sistemi S.p.A. (IDS) is an independent engineering and systems technologies company, providing research, innovation and products in the electromagnetic and air navigation fields for both civil and defence applications since 1980.

Air Navigation Services of the Czech Republic (ANS CR), a state-owned enterprise established on January 1st 1995 is the national provider of Air Navigation Services in the airspace of the Czech Republic and at the Prague-Ruzyne, Brno-Turany, Ostrava-Mosnov and Karlovy Vary Airports.

Sistemi Dinamici S.p.A. (SD) was created as a joint venture between IDS and AgustaWestland in January 2006. Sistemi Dinamici's mission is to develop methodologies and innovative solutions in the fields of rotary wing RPAS, rotor aeroelasticity, wind tunnel equipment, helicopter flight mechanics and fly by wire.

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.
For further information, please see http://www.sesarju.eu/news-press/news/steering-safe-integration-of-rpas.

A.2 INSuRE Simulation Platform Acceptance Test

Pisa, Italy - 17th November, 2014 - The INSuRE Simulation Platform Acceptance test was performed successfully in November 2014 at IDS in Pisa. The simulation platform includes the following interoperable systems:

- Tower simulator with two Controller Working Positions
- RPAS simulator with operational Ground Control Station
- Cockpit simulator

A.3 INSuRE Simulation Campaign

Pisa, Italy - 12th - 16th January, 2015 - The integration into non-segregated ATM (INSuRE) project has successfully completed a simulation campaign in Pisa, demonstrating the feasibility of safely integrating remotely piloted aircraft systems (RPAS) into civil airspace. The INSuRE Project is one of nine Integrated RPAS Demonstration Projects that are co-financed by the SESAR Joint Undertaking (SESAR JU) - the public-private partnership that coordinates the research and innovation activities of the SESAR (Single European Sky ATM Research) programme.

On the first day of the campaign, the project held dedicated simulator training sessions, before the exercises got underway. On the last day, a dissemination event took place, bringing together representatives from ENAV who were given the opportunity of observing two exercise runs. The simulation campaign team was composed of two air traffic controllers from ANS CR (Air Navigation Services of the Czech Republic), one light aircraft pilot from Ingegneria Dei Sistemi S.p.A. (IDS), two RPAS pilots - one from SD (Sistemi Dinamici S.p.A.) and one from IDS - two pseudo-pilots, platform experts and the INSuRE project team supporting the simulation evaluation.

The aim of the validation campaign was to assess the actual impact of the introduction of RPAS in the ATM, specifically for the Brno aerodrome (LKTB) scenario in the Czech Republic. The whole set of exercises planned in the validation plan was successfully performed to validate the relevant concept and operations:

- Exercise 1 ï RPAS mission in a defined area
- Exercise 2 ï Departure from LKTB - RPAS and manned light aircraft
- Exercise 3 ï Detection and avoidance - RPAS and manned light aircraft
- Exercise 4 ï Two RPAS in controlled airspace

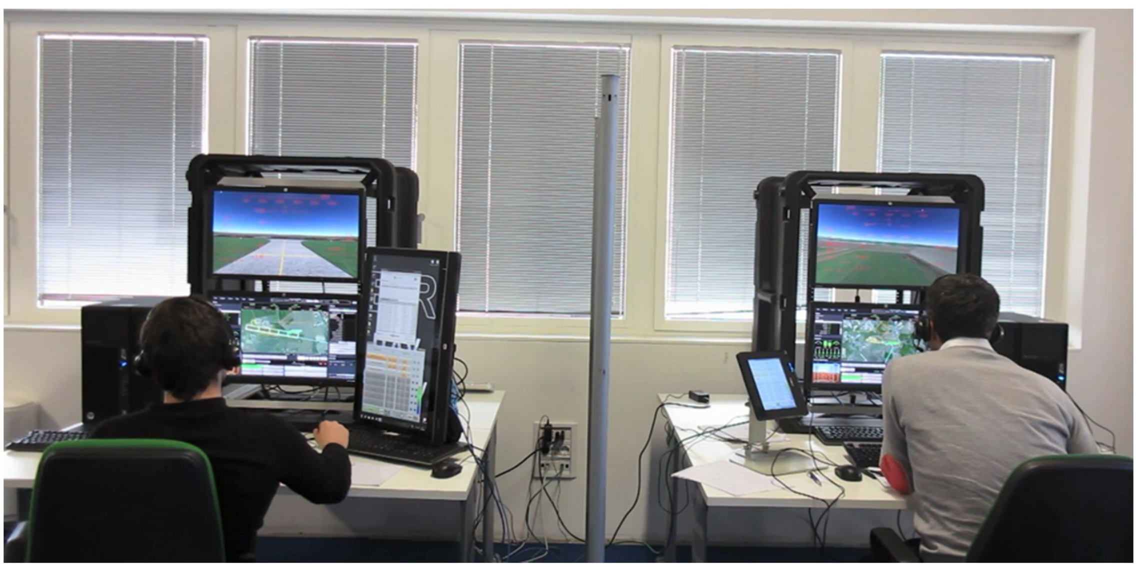
Each exercise involved a certain number of runs to cover different features in the same scenario. The focus was mainly on a subset of runs which are then to be replicated in the flight trial of the subsequent INSuRE flight campaign.

The high level objectives of the simulation exercises were:

- Evaluation of the interaction and co-operation between the RPAS pilot and two air traffic controllers for the integration of RPAS in a non-segregated area;
- Evaluation of a safe integration of RPAS with other manned traffic both during ground and airborne maneuvering;
- Evaluation of the safety level of the collision detection system and of the RPAS behavior when a conflict situation arises;
- Evaluation of the adaptation implemented on the collision detection subsystem for the RPAS simulator to receive ADS-B data as an input;
- Validation, through real-time simulation, of a complex scenario of RPAS integration in civil traffic (including also more than one RPAS and additional manned aircraft traffic).

All simulated exercises, performed in preparation for the flight campaign, were successfully executed from human performance, safety and predictability points of view. A high level of situational awareness shown by controllers was recorded during the whole execution of this campaign. The workload of air traffic controllers was in general low in the exercises due to limited traffic planned in the scenarios. The situational awareness of RPAS pilots during the relevant set of simulation exercises was considered very good and pilot workload was limited.

Tower Simulator



RPAS Ground Stations

ATCOs De-briefing Session

A.4 INSuRE at SESAR Innovation Days 2015

A.5 INSuRE Flight Campaign

Successful Flight Tests for the INSuRE Project

From the 15th to 17th of December a series of RPAS (remotely piloted aircraft system) flight tests were held at Grottaglie Airport in Italy as part of the INSuRE project under the framework and co-financed by the wider European SESAR program (Single European Sky ATM Research), which aims to support the development of technological capabilities and regulations for the simultaneous operation of both manned and unmanned aircraft in controlled airspace.

RPAS – SD-150-HERO

The test session was conducted by IDS (Ingegneria Dei Sistemi) with their project partners SD (Sistemi Dinamici) and ANS CR (Air Navigation Services of the Czech Republic), and took the form of a series of flights of the SD-150 Hero, a rotorcraft RPAS, with a ground based mobile command station developed by SD. The tests demonstrated the aircraft's ability to conduct operational missions and have also enabled the definition and testing of one of the first recognized procedures for the management of these systems in regulated areas.
All the performed activities were successfully completed and the results obtained will enable the quantitative evaluation of the INSuRE project demonstration objectives.

This series of tests have effectively kicked off experimental RPAS activities at Grottaglie Airport in accordance with the directives defined by ENAC (the Italian Civil Aviation Authority) and the European Union for the operational integration of unmanned systems into a single sky. The operational procedures put in place for the INSuRE RPAS activities were defined and agreed amongst all stakeholders: the project partners, Aeroporti di Puglia, ENAV (the Italian ANSP) and ENAC.
IDS and SD will continue experimental RPAS activities, outside of the scope of the INSuRE project, in the new year.

Appendix B Operational Supporting Material

B.1 Letter of Operations

The embedded file is the ñLettera Operazioniò defined by ENAV and Aeroporti di Puglia and agreed by all participants in the INSuRE demonstration flights.

Although in Italian, it represents an example of the agreed operational procedures to be put in place to manage RPAS activities in a specific area/scenario.

OL SAPR 14.pdf

The letter of operations has been based on the identified need of the Project stakeholders (team and external entities involved in the Flight Campaign) to document in one place only the procedures to be followed and the needed associated information in support of the Flight Trials at Grottaglie airport.

The relevant information included are:

- Communication means (phone numbers and operational radio frequencies)
- Demonstration airspaces and governance/responsibilities for the air spaces dedicated to the Project demonstration flights
- Procedures for coordination amongst the stakeholders (IDS, SD, Coordination office of the airport, ENAV, ENAC)
- Operational applicable procedures and reference to the applicable Emergency Plan of the Airport (required to be known by the RPAS Operator and Flight Team).

There is no SESAR Concept requiring the production of such a document but, given the positive feedback in its usage for INSuRE, it is recommended to be prepared for similar RPAS missions involving more than three entities and in areas where the coordination is of very high importance, as it can be for an airport.

B.2 NOTAM

A.O.I.S.

NOTAM PRINT

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X 1W2899/2015      11/12/2015  17:13       IN FORCE
R  A)BRINDISI FIR-GROTTAGLIE AREA 1B(AREA :LIR315)
:  B)2015-12-14 07:00  C)2015-12-18 18:00
   D)14 0700-0800 1130-1400 1730-1800, 15 1230-1400 173
     0-1800, 16 0700-1030 1400-1600, 17 1400-1600, 18 1
     000-1230 AND 1600-1800
   E)RESTRICTED AREA LIR315 ACTIVE DUE TO UNMANNED ACFT SYSTEM FLT TEST
     REF AIP ENR 5.1.2-23
   F)SFC  G)5000FT AMSL
   Q)LIBB/QRRCA/IV/BO  /W /000/050/4030N01724E005

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Appendix C Ground Control Station overview

C.1 Ground Control Station

The Ground Control Station provides the following main functions:

1. Mission Planning
2. Command and Control and onboard payload
3. Mission Data Recording
4. Mission Data Elaboration

Figure 68: Payload Control Station (left side) and Pilot Control Station (right side)

It is equipped with:

- Ruggedized Computer fitted with software for mission planning, platform command and control, real-time visualization of acquired video data and post mission analysis.
- Sun-readable Touchscreen and Joypad.
- Modem, Video Receiver and Antennas.
- GPS Antenna for localization of the Ground Control Station.
- MPG-4 Video Recorder.
- Container and Electric/Mechanical Interface.

A Video server is integrated for the visualization on the LCD panel and its recording in MPG-4 format. The Ground Control Station is equipped with a Video Out connector in order to provide the capability to display the video stream on a second LCD panel. The Mission Management Software provides the capability to rapidly plan the mission profile by an intuitive click-and-drag interface over a digital cartography base. During the mission, the tool provides the management of pre-programmed trajectory waypoints with online modification of the flight parameter and the display of the acquired video. Besides the waypoint navigation, the software tool provides the capability to directly pilot the platform with high level commands (setting of heading, height and speed). At the end of the mission, telemetry data and acquired video are logged and recorded in order to provide elements of the post-mission analysis of the reconnaissance task. The Power Supply circuit provides capability to operate the Ground Control Station both and on normal electric power supply.
The Ground Control Station is designed with a modular approach in order to be operated both in portable mode and installed on light vehicles.

C.2 Pilot Human-Machine Interface (HMI)

According to the presented picture relevant to IDS proprietary SW for controlling the asset, it is available an intuitive HMI, basically constituted by the following functional panels:

1. Interface main ribbon bar, allowing activation of primary block displays (see block n.1 in Fig.1)
2. Payload visualization and control (not shown in Fig.1)
3. System Status and Telemetry parameters (see block n. 2 in Fig.1)
4. Attitude and flight control (see block n. 3 in Fig.1)
5. Mission management (see block n. 4 in Fig.1)
6. Mission planning and in-flight waypoint management (see block n. 5 in Fig.1)
7. Warning panel (see block n. 6 in Fig.1)

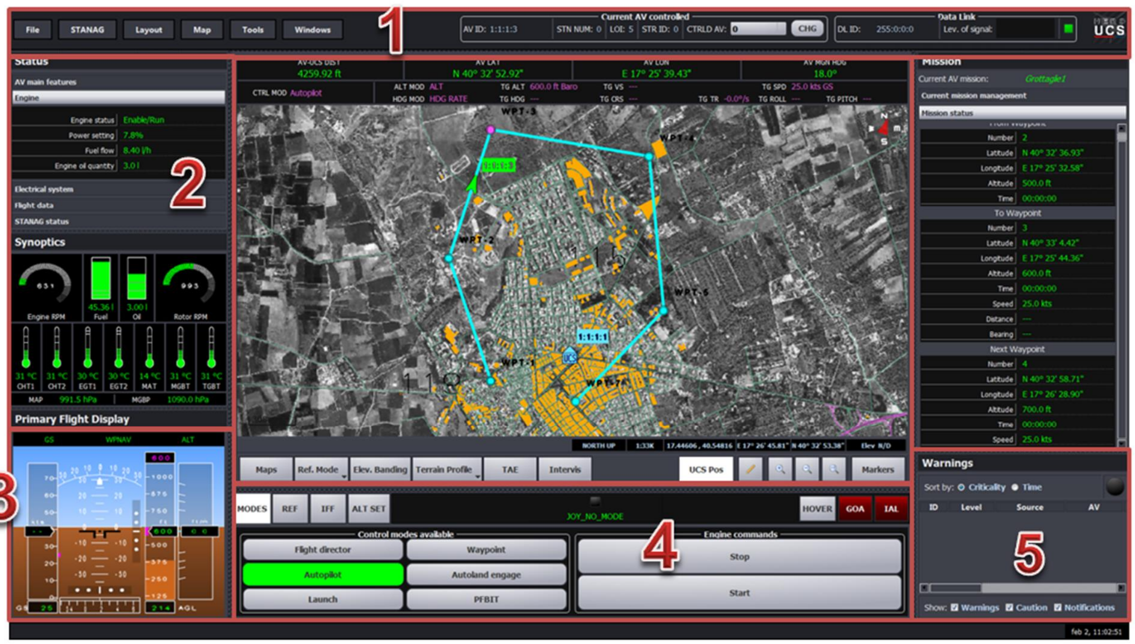

Figure 69: Pilot Human-Machine Interface

As for the payload control station, which is shown as the screens on the left side, IDS implements internally developed imaging-exploitation software, in order to get the maximum capabilities of whichever EO/IR sensor implemented for aerial ISR applications, like:

1. EO/IR Sensor Full Motion Video (FMV)
2. Camera/sensor footprint/point of impact overlaid on the map
3. Point and click gimbal control
4. Recording and playback of video from airborne cameras including support for video metadata
5. Synthetic video overlaid with geo-referenced data and labels.

C.3 Alerts and Warnings

The implementation of Alerts and Warnings has been based on the Eurocontrol TCAS II specifications (version 7.1) and in particular on the Collision Avoidance concepts.

TCAS collision detection logic uses the concept of *tau* (τ) to estimate the time to *closest point of approach* (CPA) between the own aircraft an intruder. The time tau is defined as *range* (r) over *closure rate* where the closure rate is the opposite of the *range rate* ($\dot{r}$):

$$\tau \equiv -\frac{r}{\dot{r}}$$

The time tau and the actual time to CPA coincide only when the aircrafts are on a perfect collision course and not accelerating.

In the vertical dimension, time to co-altitude and vertical separation are used instead of tau and range. Time to co-altitude is called *vertical tau* and is computed as vertical separation divided by vertical closure rate.
The above definition of tau may arise a problem with low range closure rates. TCAS II addresses this problem using a modified definition of tau:

$$\tau_{mod} = -\frac{r^2 - DMOD^2}{r\dot{r}}$$

Modified tau values are identical to the true value of tau at large ranges and range rates but are more conservative for smaller ranges and range rates. It assumes that the current range is greater or equal than DMOD.

Own Altitude (feet)	SL	Tau (Seconds)		DMOD (nmi)		ZTHR (feet) Altitude Threshold		ALIM (feet)
		TA	RA	TA	RA	TA	RA	RA
< 1000 (AGL)	2	20	N/A	0.30	N/A	850	N/A	N/A
1000 - 2350 (AGL)	3	25	15	0.33	0.20	850	600	300
2350 – 5000	4	30	20	0.48	0.35	850	600	300
5000 – 10000	5	40	25	0.75	0.55	850	600	350
10000 – 20000	6	45	30	1.00	0.80	850	600	400
20000 – 42000	7	48	35	1.30	1.10	850	700	600
> 42000	7	48	35	1.30	1.10	1200	800	700

The parameters in the above table have been used for the collision detection algorithms to implement the GCS capability of providing traffic advisories (TAs) and resolution advisories (RAs).
The mathematical models and algorithms developed by IDS are in line with the following paper :
A TCAS-II Resolution Advisory Detection Algorithm———————————————- Cesar Mu~nozy Anthony Narkawicz, James Chamberlain NASA, Langley Research Center, Hampton, VA, 23681, USA.

The Alerts and Warnings implementation for the INSuRE project did not include avoidance manoeuvres information to the pilot, who was responsible to implement the avoidance based upon the applicable rules of the air.

-END OF DOCUMENT-