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INOUI

INNOVATIVE OPERATIONAL UAS INTEGRATION

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D0.7 Final Activity Report

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1 Executive Summary

Unmanned Aircraft Systems (UAS) are becoming increasingly important for civil applications such as aerial photography, agricultural remote sensing and application, pipeline and power line surveillance, fisheries and wildlife monitoring, fire-fighting, weather and climate studies, law enforcement, rescue and recovery missions. The main challenge however, remains the integration of UAS as a new airspace user into the future ATM System.

As part of the European Commission Research Programme FP6, Directorate General for Energy and Transport (DG Tren), the INOUI project (**IN**novative **O**perational **U**AS **I**ntegration) is a response to that challenge. The INOUI consortium consists of seven organisations including UAS Manufacturer, Air Navigation Service Provider, Research Centres and Consultancy Companies from France, Germany and Spain, namely DFS Deutsche Flugsicherung GmbH (DFS), Ingeniería de Sistemas para la Defensa de España, S.A. (Isdefe), Boeing Research & Technology Europe, S.L. (BRT&E), Fundación Instituto de Investigación INNAXIS, Rheinmetall Defence Electronics GmbH (RDE), Office National d’Etudes et Recherches Aérospatiales (Onera).

Discussions and workshops within the INOUI project have confirmed that a wealth of civil and governmental UAS applications exists. All these applications face similar problems and now strive to find common solutions. Additionally, INOUI activities have revealed that military UAS missions face the same problems and challenges as missions of non-military UAS. One of the main issues for all UAS applications is the integration into the future ATM System as a new airspace user. For the time being SESAR – as the driver for the future ATM System - only partially considers UAS in its DoWs.

The project INOUI was proposed and implemented with the intention to complement SESAR with regard to UAS activities. Within this complementing of SESAR the integration of UAS in non-restricted airspace forms the focus of INOUI. Due to necessary alignments at the beginning of the project and due to proposed adaptations and scope enhancements the INOUI contract was prolonged by 5 month, lasting finally from 09/10/2007 to 08/03/2010 (29 month).

At this point in time the basic understanding within the UAS Stakeholder Community, which was confirmed during the both INOUI workshops, October 2008 and March 2009, is that

- UAS are the 3rd group of airspace users
- UAS are already in the skies, albeit either at a very low altitude or in segregated airspace
- UAS usage will significantly increase, especially for civil and governmental purposes

The INOUI objective, as part European R&D community, was to contribute to the solution of UAS integration in the 2020 Air Traffic Management system, especially the SES implementation program SESAR. Related to the different working packages the objectives were as follows:

- Identify the spread of operational concepts for UAV applications and describe the resulting procedures and requirements in the different timeframes up to 2020 (WP1)
- Identify how the UAS can fit into the ATM System of 2020 and what activities have to be taken especially from the UAV point of view (research roadmap) (WP2)
- Identify existing certification requirements and processes and suggest an optimum certification blueprint for human resources and as far as required UAV related technologies (WP3)
- Identify how UAV can benefit from SWIM and what activities have to be taken to achieve the benefit (WP4)
- Identify the safety issues related to UAS and develop high level safety objectives and requirements (WP5)
- Identify the potential airport types for UAV operations and describe the operational impact (WP6)

The UAS Stakeholder Community is fragmented and the challenges are tackled in several working groups. The INOUI project represents a holistic approach to the future UAS integration into the ATM environment 2020+. INOUI is summarizing the existing knowledge, identifying and filling gaps and with that work benefiting the European Roadmap for UAS integration. The results of this coherent approach shall help and accelerate to bring UAS into the air in the earliest possible timeframe.

One of the most important tasks for an optimized work within the INOUI project and for the dissemination of the results were the identification of parties that might be interested in the findings of INOUI, means defining the UAS stakeholder group. The inner cycle of the graph includes the UAS Stakeholder segments; the outer cycle describes the framework for a successful UAS integration in the ATM environment.

The UAS Stakeholder Framework

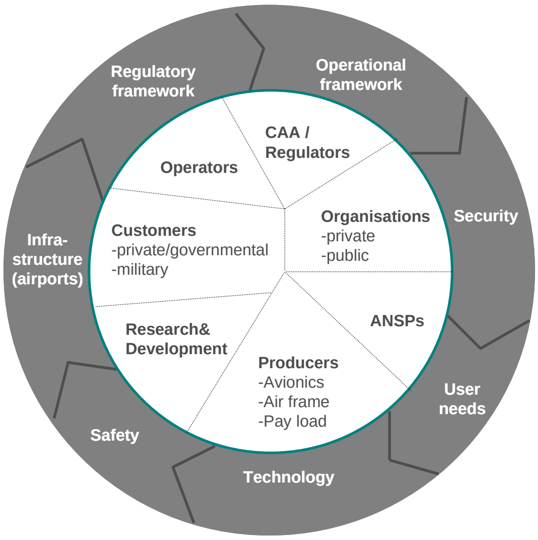

Figure 1 Stakeholder Framework INOUI

Source: INOUI, October 2008

The sources and the beneficiaries of the INOUI work were identified in the 1st working period (9.10.07 – 8.10.2008) of the project. This overview was presented to EUROCONTROL, agreed by SESAR and presented to the UAS Stakeholders (e.g. at the 1st INOUI Stakeholder Workshop October 2008).

Alignment of INOUI with other European UAS activities and projects

	Sources	Beneficiaries
WP1 – UAs Concepts, Procedures and Requirements for 2020	•SESAR Definition Phase: ATM Target Concept, ConOps, Architecture and CNS Technologies •Other UAS related projects and activities as USICO, CAPECON, USEP, Air4All etc., but they are focused on short term integration and current ATM environment	•SESAR Development Phase (i.e. WP B): INOUI will suggest certain technological and procedural requirements/ solutions. Creating reports and dissemination activities will foster the acceptance of UAS within SESAR and pave the way for integration solutions.
WP2 – 2020 Seamless "UAS-Enabled" ATM Enterprise Architecture	•SESAR Definition Phase •Eurocontrol studies •SOFIA / Pegase	•SESAR Development Phase (i.e. WP B)
WP3 – Certification Blue Print for UAS in Europe	•EASA •EUROCAE WG73 •NATO STANAG 4670 DUO •JAA/Eurocontrol UAV Task-force – final report	•EASA •EUROCAE WG73 •Regulatory authorities (Eurocontrol, SESAR) •Industry partners
WP4 – 2020 UAS Common Operation Picture (SWIM enabled) – Activities	•SESAR Definition Phase •SWIM-SUIT	•SESAR Development Phase •Technical and operational interoperability (SESAR "entreprise architecture")
WP5 – Safety Analysis for civil UAS applications	•EASA •ESARR 4 •EUROCAE WG73 •Flight trials & simulations (e.g. WASLA-HALE, VUSIL)	•SESAR Development Phase (i.e. WP 16) •EUROCAE WG 73
WP6 – New Airport concepts for UAS	•Hardly any informations/publications existing •Other UAS activities focus on integration in airspace, not on airport concepts	•SESAR Development Phase

In period 2 the focus was on interchange with the respective other working groups and a close alignment with SESAR. Within SESAR, WP B "Target concept and Architecture Maintenance" was agreed to be the anchor for INOUI, bringing UAS into SESAR. A close cooperation took place between SESAR WPB and the INOUI team.

INOUI Stakeholder Workshops and Dissemination Forum

Important elements of the INOUI project have been two Stakeholder Workshops. These workshops had the task to exchange experience and views between stakeholders for taking their needs and requirements into account in the INOUI project. The first workshop was part of WP1 "UAS ATM Concepts, Procedures and Requirements for 2020" took place from 21 – 23 October, 2008. The second workshop was part of WP6 "New Aerodromes Concepts for UAS" and took place from 10 - 12 March, 2009.

The research results of the project were presented at the INOUI Dissemination Forum in Cologne, Germany, on 1 - 2 December 2009. The forum was open to all interested UAS stakeholders.

- The 85 participants from Europe and USA represented all UAS stakeholder groups: private, governmental and military users, operators, CAA/regulators, research & development institutes, producers, ANSPs and other relevant organisations like EASA, European Defence Agency (EDA), EUROCAE resp. EUROCAE WG73 and JAPCC. According to participants' feedback, they received a concise overview of the work of the INOUI project, the key results and the future challenges.
- As key note speaker the INOUI consortium welcomed Gilles Fartek, European Commission DG TREN; Jukka Justi, Director Armament EDA; Peter Ahlers, DFS and Head of WP B SESAR; and Jules Kneepkens, Rulemaking Director, EASA. The work package leaders of INOUI presented the content and the results of the six work packages and 21 deliverables. The attendees had the opportunity to ask questions and to discuss follow-up topics.
- SESAR defines the common future ATM system in Europe. Although UAS are recognized by SESAR as legitimate airspace user, the topic of UAS was only briefly mentioned in SESAR Definition Phase and the related deliverables. Consequently, the results of the INOUI project feed into upcoming work within the SESAR Development Phase. On behalf of the SJU the work was appreciated by Peter Ahlers, head of SESAR WP B (Target Concept and Architecture): "SESAR needs the expertise gathered in INOUI concerning UAS operations and requirements. We will consider and integrate UAS operations in concepts and system architecture and the results of INOUI will be used to update the CONOPS". "Detailed conceptual descriptions and requirements concerning UAS operations will be developed in operational and technical thread work packages, the material developed by INOUI will be used and considered. SESAR can possibly learn from UAS technology which is already available".

List of INOUI deliverables

The publication of the INOUI deliverables continued over the project period with focus on publications in 2009. In year 1 the deliverables D 1.1, D 1.2 and D 2.1 were submitted to the EC, all other deliverables were submitted in period 2:

D1.1	Definition of the UAS environment
D1.2	Concept of the civil UAS applications
D1.3	First proposal for the integration of UAS
D1.4	Harmonized proposal for the integration of UAS
D2.1	Report on Technology Systems Solutions
D2.2	Assessment of Technology for UAS Integration
D.2.3	Conclusions and Recommendations on New Technological Developments
D3.1	Regulatory Aspects for UAS Operations, Operators and Personnel Qualification
D3.2	UAS certification
D3.3	Regulatory Roadmap for the UAS Integration in the SES

D4.1	Research Report "Elements of the UAS systems within the 2020 SWIM-enabled ATM."
D4.2	Research Report describing the new UAS-related COP actors
D4.3	Research Report describing the Level of Autonomy of UAS in COP
D5.0	Scope of Risks and Qantified Safety Criteria
D5.1	System Description for Safety Analysis
D5.2	Functional Hazard Analysis
D5.3	Towards Safety Requirements for the Integration of UAS
D5.4	Airport Safety Analysis
D5.5	Interpretation of Safety Analysis in the context of SESAR
D6.1	Operational Concept for the UAS in the Airports
D6.2	Technology Watch for the Operation of UAS in the Airports

Publication of INOUI results

All deliverables of the INOUI project, an Executive Summary per work package and the complete documentation of the Stakeholder Workshops and the Dissemination Forum were published on the INOUI webpage (respectively in early 2010 as soon as European Commission approval has been obtained). A comprehensive glossary of UAS terms and terminology used in the project can also be found on the website.

Furthermore a booklet was compiled to provide the UAS stakeholder community an overview of the content and the results of the INOUI project and points the interested reader to the detailed INOUI deliverables. The booklet itself was designed to present the wider public with a broad view on the current problems and the challenges for successful integration of UAS into non-segregated airspace. It is also available for download on the INOUI webpage.

The INOUI project represents a holistic approach to the future UAS integration into the ATM environment of 2020 and beyond. The goal was a stepwise approach to the integration of UAS and the earliest possible use of UAS applications whilst taking different stakeholder needs into account.

The INOUI team likes to thank the stakeholders participating in the INOUI Stakeholder Workshops, feedback rounds and the Dissemination Forum for providing their input and expresses its gratitude to the institutions and organizations supporting the work of the INOUI team in the last two years.

The INOUI deliverables and all other INOUI documents are available for download on the INOUI project webpage http://www.inoui.isdefe.es/INOUI and on the webpage of European Commision, DG MOVE http://ec.europa.eu/transport/air/uas_en.htm.

2 Introduction

Unmanned aircraft are remotely piloted aircraft, meaning that the pilot is not on board the aircraft. An Unmanned Aircraft System (UAS) consists of one or more remotely piloted aircraft, one or more control stations and the command and control links as well as any other system elements.

Today (2010) UAS are mainly used for military missions but a non-military UAS market is emerging. UAS are considered to be beneficial in a growing number of civil and non-military / governmental applications. In general employing UAS is considered useful for dull, dirty or dangerous missions. These are missions putting a human pilot at risk, i.e. natural disaster reconnaissance. Unmanned Aircraft Systems are therefore becoming increasingly important for non-military applications, e.g. aerial photography, pipeline and power line surveillance, fisheries and wildlife monitoring, fire-fighting, weather and climate studies, law enforcement etc. A main challenge however is the integration of UAS into the existing and future ATM System.

The INOUI project is a response to that challenge as part of the European Commission Research Program FP6, Directorate-General for Energy and Transport (DG Tren). INOUI represents a holistic approach to UAS integration. The INOUI team is contributing with the project results into the Single European Sky ATM Research (SESAR) Development Phase, with the goal to enable the earliest possible use of UAS applications in current and future ATM environment.

2.1 Background

"Innovative Operational UAS Integration" (INOUI) is a "Specific Targeted Research Project" supported by the European Commission Directorate General "Transport and Energy" within the 6th Framework Programme in response to Call 4 of the Thematic Priority Aeronautics and Space, Research Area 1.3.1, Innovative air traffic management research, Research Domain 4.g., ATM for new vehicles.

Main objective of the INOUI project was to provide a roadmap to the future of UAS in the context of the ever changing ATM environment. In this respect, INOUI aims at complementing the SESAR activities with regard to the operational concept and the architecture as well as the roadmap for Research and Development activities. In particular INOUI research comprised the following areas:

- Integration of UAS into the future ATM architecture of 2020+ as defined within SESAR (INOUI Work package 01)
- UAS applications, related operational concepts, procedures and requirement and their impact/consequences on the ATM system (INOUI Work package 02)
- Certification and licensing of UAS technology and human resources (INOUI Work package 03)
- Common Operation Picture and integrating UAS into the System-Wide Information Management (SWIM) (INOUI Work package 04)

- Safety analysis of UAS integration in the ATM System (INOUI Workpackage 05)
- Aerodrome concepts and UAS operations – procedures and requirements up to 2020 (INOUI Work package 06)

The INOUI project was initially planned for 2 years. An amendment to the contract included scope enhacements due to meanwhile developments in UAS reseach and ATM environment (SESAR) and a prolongation of the INOUI contract by 5 month. The total project period lasted finally from 9/19/2007 to 8/03/2010.

The work was conducted by a consortium formed of partners from France, Germany and Spain. The INOUI consortium consists of six organisations including a UAS Manufacturer, an Air Navigation Service Provider, Research Centres and Consultancy Companies. More specifically, the following organizations participate:

- DFS Deutsche Flugsicherung GmbH (DFS),
- Ingeniería de Sistemas para la Defensa de España, S.A. (Isdefe),
- Boeing Research & Technology Europe, S.L. (BR&TE),
- Fundación Instituto de Investigación INNAXIS (INNAXIS),
- Rheinmetall Defence Electronics GmbH (RDE),
- The French Aerospace Lab (Office National d'Etudes et Recherches Aérospatiales) (ONERA).

The overall objective of INOUI was to assess different domains of the ATM system of today and 2020 to develop a roadmap how to integrate UAS into the operational concept for the future. This activity will complement the activities of the SESAR definition phase and fill the gaps with regard to the specifications of UAS.

The publication of the INOUI deliverables started mainly in the working period 2. In year 1 the Deliverables D 1.1, D 1.2 and D 2.1 were submitted to the EC plus the management documents. All other 18 deliverables plus additional publications, e.g. UAS Terms & Terminology, were submitted to EC within period 2 and were published subsequently.

All documents are available for download on the INOUI project webpage http://www.inoui.isdefe.es/INOUI.

2.2 Purpose of the Document

The purpose of this document is to report to the European Commission on one hand and on the other hand to inform interested Stakeholders about the INOUI work, i.e. its dedicated deliverables, the scope of work, the methodology of research, the findings, the conclusions and the recommendations. For detailed information the reader is referred to the respective deliverables of the work packages.

2.3 Overview of project objectives

The discussions and workshops within the INOUI project have confirmed again that a wealth of civil and governmental UAS applications exists. All these applications face similar problems and now strive to find common solutions. Additionally, INOUI activities have revealed that military UAS missions face exactly the same problems and challenges as missions of non-military UAS. One of the main issues for all UAS applications is the integration into the future ATM System as a new airspace user. For the time being SESAR – as the driver for the future ATM System - only partially considered UAS in its DoWs.

The project INOUI focused on the integration of UAS in non-restricted airspace. Basic understanding within the UAS Stakeholder Community is that

- UAS are the 3rd group of airspace users
- UAS are already in the skies, albeit either at a very low altitude or in segregated airspace
- UAS usage will significantly increase, especially for civil and governmental purposes

The INOUI objective, as part European R&D community, was to contribute for the solution of UAS integration in the 2020 Air Traffic Management system, especially the SES implementation programme SESAR. Related to the different working packages the objectives were as follows:

- Identify the spread of operational concepts for UAV applications and describe the resulting procedures and requirements in the different timeframes up to 2020
- Identify how the UAS can fit into the ATM System of 2020 and what activities have to be taken especially from the UAV point of view (research roadmap)
- Identify existing certification requirements and processes and suggest an optimum certification blueprint for human resources and as far as required UAV related technologies
- Identify how UAV can benefit from SWIM and what activities have to be taken to achieve the benefit
- Identify the safety issues related to UAS and develop high level safety objectives and requirements
- Identify the potential airport types for UAV operations and describe the operational impact.

3 Work Package 1 « UAS ATM Concepts, Procedures and Requirements for 2020 »

3.1 Scope of Work and Method of Research

Air traffic management (ATM) is a complex matter, but has been common with manned aviation for a long time. Now Unmanned Aircraft Systems (UAS) are starting to participate. In several aspects, they are completely different from their manned counterparts but they have to be operated within a system that has been developed and approved in the course of a century.

Today, Unmanned Aircraft (UA) exist in multiple designs, from micro-light model aircraft to the size of an airliner, and have a large range of capabilities – size, performance, manoeuvrability and endurance. Fixed wing aircraft, rotary wing aircraft, lighter-than-air vehicles and various types of power plant are known. UA vary from fully autonomous flight controls to those requiring more direct pilot inputs, their communication systems range from those capable of global reach to those limited to line of sight. Types of missions are rarely point to point but typically involve some form of patterned flight or tracking activity that may include intermittent short- or long-term orbits.

From an ATM perspective, future UAS operations will pose a unique set of issues and taken together, these variations have the potential to significantly affect air traffic operations and will place additional challenges on an ATM system already under great strain.

The main objective of work package 1 (WP 1) is the definition of the concept, the necessary procedures and requirements for the integration of civil UAS into the air traffic management in the 2020 and beyond timeframe. The fundamentals for this future scenario are set by the SESAR programme.

For the achievement of the objective this INOUI work package, several steps were followed.

- Definition of the ATM environment for the integration of UAS in 2020 according to current and foreseen technologies and concepts as defined by SESAR
- Development of a concept for the integration of UAS into non segregated airspace in 2020
- Development of necessary procedures for the integration of UAS
- Discussion of the procedures and requirements for the integration of UAS

According to these steps WP 1 was set up in 4 sub work packages:

WP 1.1 – Definition of the ATM Environment for UAS in 2020

WP 1.2 – Definition of the Concept

WP 1.3 – Integration of UAS into the Airspace

WP 1.4 – Discussion with relevant Organisations

The objective of **WP 1.1** was the identification of the future Air Traffic Management (ATM) environment expected in the 2020 timeframe which sets the operational scenario for UAS integration. The deliverable of this work package D1.1 “Definition of the Environment for Civil UAS Applications” described the changes from current ATM system to the SESAR driven future ATM system. Key elements of today’s system were depicted as well as those foreseen within the SESAR Concept of Operations. Both ground (ATC related) and airborne (UAS related) perspectives were considered.

The listing and brief description of the different possible UAS applications is the starting point of **WP 1.2**. The most promising commercial UAS applications were analysed and described regarding the content of the application, their potential and the timeframe in which the applications will become operative. All applications, from low altitude surveillance like pipeline monitoring up to high flying applications like relay of mobile telecommunications were considered. The description of the different applications, their specifics and necessary requirements was the aim of deliverable D1.2 “Concept for Civil UAS Applications”.

In **WP 1.3** the integration of the civil UAS applications into the airspace was described. Therefore the different applications found in WP 1.2 and the solutions presented were analysed. The results of related projects were also integrated. At a next step the development of the ground system procedures was established together with ATC controllers. In deliverable 1.3 the various operational procedures with relevance to UAS are described. They were divided into those relevant for managed or unmanaged airspace. Furthermore the different flight phases (pre-flight, starting phase, mission flight, landing phase) were considered. Also those procedures not particularly associated with a certain flight phase, like radiotelephony, handover between control stations etc. were described in detail.

Furthermore technical requirements for the UA side were derived and described, following the same regime in relation to managed-unmanaged airspace and phase of flight.

WP 1.4 was a parallel activity to the other sub WP, namely discussion with relevant organisations and stakeholders in the UAS domain. The objective was twofold, first input to INOUI, second presenting INOUI results for discussion and feedback.

As WP 1 represents the operational thread served as input to other work packages within the INOUI project, reference has to be made to those which used this input and also contributed to topics related to integration of UAS into the future ATM system: Namely WP 2 which deals with the technological perspective of the ATM environment and thus complements the operational view of WP 1, WP 3 which is about certification of UAS and licensing of related personnel, WP 5 with it’s focus on safety analysis and WP 6 where new aerodrome concepts for UAS are described in more detail including operational, procedural and technological issues.

Deliverables of work package

INOUI WP1 consists of four deliverables, each one containing the results of the research made in the tasks mentioned above:

D1.1 "Definition of the environment for civil UAS applications"	Describes the changes from current to the SESAR driven future ATM system; highlights ATM operations and CNS technologies necessary to support the ATM Concept of Operations (ConOps).of SESAR. The consequences of these changes in ATM environment were viewed from a ground and UAS perspective.
D1.2 "Concept for Civil UAS Applications"	Providing a general classification of civil UAS applications and the integration of such applications into the airspace. The different applications were analysed, ranging from low altitude surveillance like pipeline monitoring up to high flying applications like transmission of mobile telecommunications with the focus on low altitude surveillance/observation, cargo flight and station keeping missions.
D1.3 "Proposal for the Integration of UAS"	Description of operational procedures and derived technical requirements. Moreover an executive summary was created with key issues for discussion & feedback by stakeholders.
D1.4 "Harmonised Proposal for the Integration of UAS"	Integrated the feedback on D1.3. The focus of this deliverable was on description of operational procedures with specifics or uniqueness to UAS which need to be taken into account for a seamless integration of UAS.

Methods of research

The research performed within WP2 has been fed by three different sources of information:

- Review of existing documents
  - SESAR Deliverables: D1, D2, D3, D4, D5, D6
  - Simulation trials results (WASLA-HALE II, III; EUROCONTROL)
  - Flight trials results (VUSIL)
  - ICAO docs, AIP Germany and other aviation literature
  - Other UAV/ UAS projects and literature
- INOUI Stakeholder Workshops 1 "Innovative Operational UAS Integration" and 2 "Innovative Concepts for UAS Integration at Aerodromes"

- Feedback on D1.3 – Proposal for UAS Integration
- Workshops with ATCos
- Consultations with other working groups
- INOUI members expertise and knowledge: Isdefe, Rheinmetall Defence Electronics, DFS Deutsche Flugsicherung, Onera and Boeing R&TE
  - ISD with expertise and experience in avionics, ATC systems, ATM structure and concepts.
  - RDE with expertise and experience in avionics systems and UAS.
  - DFS with expertise and experience in ATC systems and air navigation services provision.
  - ONE with expertise and experience in see and avoid issues relative to the integration of UAS studies about the technologies to be used for the integration of UAS.
  - BRTE with expertise and experience in how UAS impose requirements to the information management systems in the ATM architecture as well as how the numerous stakeholders involved in the UAS flight handle the operations.
- Input provided by EASA, Eurocontrol, Eurocae WG73, NATO JAPCC, European Cockpit Association, manufacturers, research institutions

3.2 Findings of the Work Package

It is expected that UAS will shortly become an additional air space user. To successfully access non-segregated air space, UAS should be able to interoperate with the current and future ATM systems. The description of current and future ATM, the description of different concepts and possible civil UAS application, and the definition of procedures and requirements for integrating UAS were subject of work package 1. In the following section the work performed and the key results of the four sub work packages are described.

3.2.1 WP 1.1 – Definition of the ATM Environment for UAS in 2020

The objective of WP 1.1 of the INOUI project was the identification of the future Air Traffic Management (ATM) environment expected in the 2020 timeframe which sets the operational scenario for UAS integration. D1.1 “Definition of the Environment for Civil UAS Applications” described the changes from current ATM system to the SESAR driven future ATM system. Key elements of today’s system were depicted as well as those foreseen within the SESAR Concept of Operations. Both ground (ATC related) and airborne (UAS related) perspectives were considered.

Figure below schematically depicts the European ATM system as considered in SESAR D3. It consists of the three main components ATM Operations, ATM Support and ATM Shared Concepts, each representing functions and information to be managed by the ATM system.

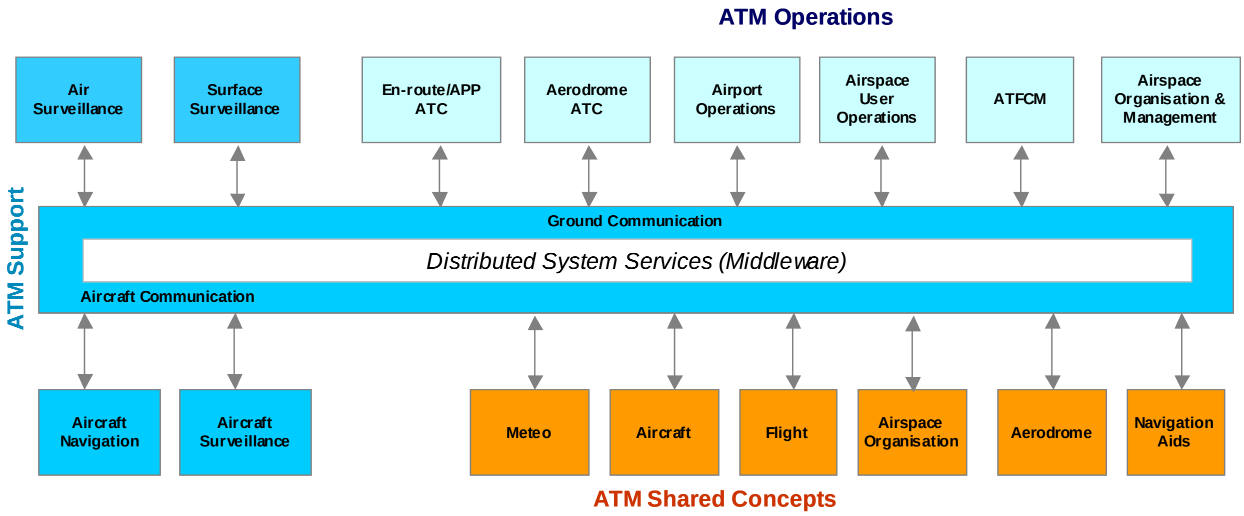

Figure 2 High level European ATM System 2020 logical architecture (SESAR 2007)

ATM Operations contain the core ATC elements and provides direct support for the main actors of the system. The architecture reflects the organisational structure of ATM and covers En-route and Approach ATC, Aerodrome ATC, Airport Operations, Airspace User Operations, Air Traffic Flow and Capacity Management, and Airspace Organisation and Management.

The Air Traffic Control (ATC) task is to provide safe, efficient and orderly flow of air traffic. The service is provided by Air Traffic Controllers working at aerodromes or in Air Traffic Control Centres. Tower control is responsible for all aircraft in the vicinity of an aerodrome and on its manoeuvring area (e.g. runways and taxiways). Approach control is responsible for control of the air traffic in the terminal airspace surrounding an airport/ aerodrome including arriving and departing aircraft. En-route ATC is responsible for the provision of air traffic control to aircraft after departure and before arrival, i.e. those aircraft which are not controlled by approach ATC or aerodrome ATC.

The Air Traffic Flow and Capacity Management (ATFCM) is responsible for the strategic (long term) planning of the air traffic including pre-tactical and tactical activities to match demand and capacity.

The Airspace Organisation and Management establishes airspace structures in order to accommodate the different types of air activity, the volume of traffic and the differing levels of service. The primary objective is to maximise the utilisation of available airspace by dynamic time-sharing and by segregating airspace among various categories of users based on short-term needs and to plan airspace usage in a way that balances the impact on civil air traffic flow and capacity management with military needs.

Airport Operations are related to the ground infrastructure and is aimed at supporting the planning and monitoring of airport resource use (stands, de-icing areas) and services to aircraft operators (stand allocation, passenger handling, luggage handling, and refuelling, catering, towing).

Airspace Users Operations concerns the ATM related aspects of flight operations including Flight Planning, Flight Briefing, Aircraft Management, Fleet Management, Operations Management, and Schedule Management. These kinds of operations have differences in planning horizons from “scheduled well in advance” to “just prior to the flight becoming active”, depending on the nature of the airspace user (e.g. civil commercial, GAT, military).

ATM Support provides the services to support the ATM Operations and covers Communication, Navigation (Aircraft Navigation), Surveillance (Aircraft Surveillance, Air Surveillance and Ground Surveillance). CNS is the key enabler for air traffic control. Because of its importance and foreseen changes in CNS technologies to support the ATM Concept of Operations (ConOps) and ATM architecture for 2020 and beyond as described by the SESAR consortium, they were analysed more deeply within INOUI WP 1.1.

ATM Shared Concepts contains the common services that are used by more than one kind of organisation to access certain information. The shared elements cover Flight, Aircraft, Airspace Organisation, Navigation Aids, Aerodrome and Meteorology. The Aeronautical Information Service Provider is directly linked to the Shared Elements for ensuring consistency and distribution.

The element Flight is related to planning and conducting a flight, i.e basic flight information, flight plan management (creation, deletion and access to the known set of flights), the flight profile and trajectory, and constraints applicable to a flight.

The Aircraft element contains the aircraft characteristics such as aircraft description/ categorisation, its equipment, performance, operating preferences, etc.

The Airspace Organisation contains all specific elements which describe the overall structure of the airspace. Therefore it addresses routes structure and geography, airspace sectorisation and capacity and significant points which all together make up the description of the airspace.

The Navigation elements contain the entities (type, name, location, etc.) of available navigation aids like VOR (VHF Omni-directional Radio range), NDB (Non-Directional Beacon), ILS (Instrument Landing System), etc.

The Aerodrome part describes the aerodrome in a broader sense with type of aerodrome, geographical and structural entities (layout of runways, taxiways and apron), its configuration and operation mode, and infrastructure, etc.

Meteorology Service Providers have the responsibility to forecast, observe, provide and collect enroute and airfield weather forecasts and the corresponding actual weather reports for all parties dealing with flight planning and flight operations.

SESAR ATM Target Concept

The European ATM is expected to change substantially over the next years with the introduction of new concepts, technologies and procedures as defined within the SESAR programme, the European Air Traffic Management (ATM) modernisation programme. Many of these changes will be motivated by increasing demand in the number and diversity of system users, including the addition of UAS. Important changes will be trajectory based operations (e.g. business trajectory and trajectory management), collaborative planning (e.g. Network Operations Plan (NOP) and Collaborative Decision Making (CDM)), information sharing through system wide information management (SWIM), flexible use of airspace, new separation modes supported by ASAS (Airborne Separation Assistance Systems) and ACAS (Airborne Collision Avoidance System) and new communication, navigation & surveillance technologies (CNS). Thus SESAR brings a new dimension to European ATM which has a wide effect on all airspace users including UAS. For a successful integration of UAS into the future ATM it is fundamental that UAS operations are compatible and interoperable with the planned concepts, procedures and technologies.

In the SESAR timeframe CNS technology will undergo significant changes and INOUI deliverable D1.1 highlights the CNS technology necessary to support the ATM Concept of Operations (ConOps) and ATM architecture for 2020 and beyond as described by the SESAR consortium. In its simplest form, the 2020 CNS baseline can be characterised as follows:

- Communication technologies that enable improved voice and data exchanges between service actors within the system, such as those necessary to support the system wide information management (SWIM) functionality and collaborative decision making (CDM) process.
- Navigation technologies that enable precision positioning, timing and guidance of the aircraft to support high performance, efficient 4D trajectory operations in all phases of flight.
- Surveillance technologies that enable precision monitoring of all traffic to assure safe and efficient operations, including enhanced Traffic Situational Awareness and Airborne Separation Assurance Systems (ASAS), as well as technologies enabling weather or obstacles surveillance.

Communication Technologies - Consequences for UAS

- UAS control station should be permanently connected to the ATC frequency in managed airspace and at controlled aerodromes. In the case of fully automatic systems, a deeper analysis should be done in order to clarify how those communications are going to be assured. It must be considered that remotely adjustable voice radio has to be on board an UA if the radio communication with ATC is relayed via the UA.
- Frequency spectrum requirements for the UAS flight operations relevant data links (i.e. command and control, also called C^2 data link) need still to be defined and it is not yet clear which is going to be the band assigned to each of them. To assure the correct protection of the frequencies, it is likely to be the aeronautical band but the scarce

number of frequencies currently available is a problem that must be solved. Furthermore it must be considered that depending on where in the world UAS are in operation, different frequency bands have to be used. Interoperability is therefore not assured currently. It is crucial that the issue of C^2 data link frequencies is on the agenda of the next WRC meeting in 2012.

- Flight operations relevant data links onboard UAS should comply with the minimum RCP (Required Communication Performance) established for a given airspace. Those minimums should be defined in the near term by an authorized regulator and will be associated to different performance parameters like latency, availability, integrity, security, predictability, throughput and coverage, etc.
- SWIM interoperability should be correctly addressed to assure the correct exchange of information between UAS and any other stakeholder. This issue will be analyzed in deep in INOUI WP4.
- UAS flight management system should be able to deal with ATC clearances and restrictions uplinked via data link.
- UAS shall be fitted with advanced functionalities like taxi path or route uplink which will be common use in manned aviation by 2020.

Navigation Technologies - Consequences for UAS

The objective of **navigation** technologies is to provide aircraft positioning and trajectory management in all phases of flight. En-route Navigation is currently provided by a large range of navigation services using conventional terrestrial systems and more recently global navigation satellite systems (GNSS). In accordance with SESAR D3 it is expected that the current ground-based infrastructure will change to a satellite-based one, because of increased navigation performance requirements related to 3D and 4D trajectory management. Dependent on the flight phase (En-route/ terminal navigation, approach & landing, airport surface movement) different technologies apply.

- UAS control stations should be fitted with state of the art avionics systems capable of interoperating with those collaborative equipments already installed in manned aviation. However all this equipment must be capable of being remotely controlled, as there is no pilot in the cockpit who could do this directly. Examples of this are calibrating the altimeter and setting transponder codes.
- To grant UAS access to managed airspace it is fundamental to certify each UAS navigation performance in terms of required navigation performance (RNP), including lateral containment and altitude containment along a segment
- UAS autopilot systems should be at least as reliable and precise as those currently installed in manned aviation.
- UAS should be fitted with Trajectory Management Requirements conformance monitoring to assure an accurate execution of the cleared trajectory and obtain proper alerts in the case of any non-programmed deviation.

Surveillance Technologies - Consequences for UAS

As an integral part of Air Traffic Management (ATM), **surveillance** positional data constitutes the principal means of surveillance of aircraft for the efficient execution of Air Traffic Control. The objective of the surveillance service is to provide a complete picture of the actual traffic situation to ensure a safe separation and an efficient traffic flow. ATM surveillance is the observation of an area or space for the purpose of determining the position and movement of aircraft or vehicles in that area or space to enable Air Traffic Control. Three basic surveillance principles are distinguished: independent non-cooperative, independent cooperative and dependent cooperative surveillance. Currently in most areas of Europe surveillance relies upon radar coverage based Secondary Surveillance radar (SSR) and complemented by Primary Surveillance Radar (PSR).

- UAS should be fitted with systems capable of supporting future self separation concepts like ASAS, otherwise, fully integration of UAS in controlled airspace where separation assurance is being delegated to the pilot will be complicated. Any sense and avoid systems onboard the UAS should also be able to cooperate with those systems onboard manned aircraft to assure a correct situational awareness for all airspace users.
- Existing terrain awareness and avoidance systems should be adapted to their use in UAS. It is still not clear how this is to be achieved but the probability of UAS controlled flight into terrain (CFIT) should remain as low as that for current manned aviation.
- As in the previous point, weather awareness and avoidance systems should be adapted to meet UAS requirements. In the case of fully automatic UAS, response to the system resolutions should be followed automatically without human intervention but maintaining coordination with ATC, to avoid creating any conflict with other traffic.

3.2.2 Conclusions WP1.1

The objective of WP 1.1 of the INOUI project is the identification of the future Air Traffic Management (ATM) environment expected in the 2020 timeframe which sets the operational scenario for UAS integration.

The ATM system is a network of communication, navigation and surveillance systems supporting and enabling the ATM operations to ensure safe, orderly and efficient flight. Driven by the SES programme and SESAR the European ATM is expected to change significantly over the next years with the introduction of new technologies and procedures. Many of these changes will be motivated by increasing demand in the number and diversity of system users, including the addition of UAS.

Based on the available information of SESAR, the Concept of Operations and other inputs the following broad assumptions regarding the future ATM and UAS characteristics were drawn that are establishing the foundation for the future ATM and routine access of UAS into civil airspace.

The future ATM will focus on 4-D trajectories. By using a 4-D flight plan, each flight will navigate at selected latitude, longitude, and altitude (similar to the current system), as well as arriving, with a time tolerance, at a series of 4-D waypoints. 4-D flight plans will reduce uncertainty and increase predictably for both air traffic service users and providers. Although most UAS will be equipped with a GNSS based or other approved navigation system, only the more sophisticated UAS will be able to take advantage of the 4-D option because of the stringent certification requirements for 4-D flight. Those UAS and manned aircraft unable to meet the 4-D criteria will instead file 3-D flight plans. Other non-trajectory defined flight plans will also be allowed for operations where exact routes or altitudes cannot be predetermined.

In the future ATM, a System Wide Information Management (SWIM) will aggregate, integrate, fuse and disseminate tailored information to both air traffic service users (pilots, airlines, military, etc.) and providers (ATC, meteorologist, traffic flow managers). The system will provide common situational awareness if the location and intent of other aircraft is known, facilitate collaboration and link systems and users together for effective decision making. UAS operators will be both consumers and providers of this information.

Communications between pilots of both manned and unmanned aircraft and the ATM system will be increasingly relying on electronic data transfer via data link for routine communications. These exchanges will require the pilots' acknowledgment and approval prior to execution of the air traffic instruction. Depending on the aircraft, these instructions may automatically feed into the flight control systems, whereas in other vehicles, manual control actions will still be required. However it is very likely that voice remains an essential means of communication at least until the 2020 timeframe using standard equipment and frequencies of today. Beyond 2020, and as defined by the SESAR Concept of Operations, voice will remain the primary means of communications only in certain circumstances. The role of voice communications will then essentially be a safety back-up means. Especially in time critical events, data link applications have not proven to be a substitute to voice.

The ATM will strategically adjust ATC sector boundaries to increase flexibility in the provision of air traffic services. The air traffic system will employ this strategy to distribute workload more evenly when demand for services is expected to exceed the sector capacity. These actions will be transparent to the operators of manned and unmanned aircraft.

Alternative separation methods will be provided, with separation responsibility delegated to pilots for limited durations, when and where appropriate. This will mitigate controller workload and improve the efficiency of operations. Also new airborne separation and delegation procedures and corresponding technologies will provide a concept that could allow UAS to safely separate themselves from other aircraft: However, it must be noted in manned aviation the final responsibility for collision avoidance remains with the pilot. In the current situation in uncontrolled airspace and under VFR, where the technical requirements for navigation and surveillance equipment are reduced compared to IFR and controlled airspace the collision avoidance is referred to as “see and avoid” principle. For UAS this principle is not applicable to its full extend but rather referred to as “detect/sense and avoid” principle, which is one of the major challenges for UAS integration.

A certain number of UAS will be operated exclusively by a remote pilot without assistance from any type of automation. But also some UAS operating in the future ATM will possess a range of autonomous capabilities to perform or assist in navigation, system monitoring, and flight control functions.

UAS will have various levels of equipage for interacting with the air traffic system, e.g. transponders (Mode-S, ADS-B) and 4-D navigation system. Equipage levels will be determined by limitations in size, power generation, and payload capacities of the vehicle, in addition to vehicle cost and mission requirements.

Safety and security classifications, approvals and controls will be required for all civil and commercial UAS operations. For example, all UAS will have certified and approved plans for lost communication links and system failures. Data link communications for vehicle control and flight telemetry will be encrypted to safeguard the protection of the data link and the authenticity of the operator.

Taken together, these assumptions indicate that different new technologies and procedures have to be developed and applied within the future ATM system to enable the integration of UAS into the airspace. On the other hand technologies developed for and by the UAS community could also bring benefit to the future ATM and manned aircraft.

3.2.3 WP 1.2 – Definition of the Concept

The civilian applications for UAS are quickly emerging as a large and lucrative new aerospace market. Due to their nature, UAS have the capability to fulfil a number of key civil airspace operations. The most noticeable visible areas where UAS are rapidly gaining momentum are those where it is challenging for a manned aircraft to operate, or where it is prohibitively expensive. In particular, the most common UAS civil operations include dull, long endurance, risky or dangerous missions.

However it must be noted that the ability for UAS to engage in specific operations is closely coupled to regulations and airworthiness certification. Where existing regulations do not permit the use of future civil UAS operations, a regulatory framework needs to be developed to determine which technologies or procedures are essential. In addition, a demonstration at an early stage to show the safe introduction of these future UAS civil operations should be an objective.

The future operations in non-segregated airspace will depend on the development of procedures and technologies that will enable UA to fly in a mix of air traffic (manned and unmanned) with the same (or higher) level of safety as an aircraft controlled by a pilot onboard.

In the INOUI project three different kinds of applications are analysed in detail: Surveillance Observation, Cargo Flight and Station Keeping and there are a number of generic UAS civilian operations which may be considered:

1. **Low altitude surveillance** (below flight level 100) – One of the mostly discussed UAS applications are surveillance tasks, especially surveillance at low altitude. Due to the nature of these very different types of operation, they are defined as follows:

   A. Very low operations

   Very low operations are those which will take place near to the ground level and for this reason below the minimum safety altitudes in European counties, (below 500 ft. AGL). As the air traffic at these altitudes is mostly allowed only for helicopters (doing aerial work or rescue missions), collision avoidance has to be focussed on the collision with ground obstacles and objects (to be observed or inspected). Very low altitude operations have been successfully demonstrated for the following applications:

- Power line inspections
- Crop dusting
- Building inspections (bridges)
- Close area support to local fire brigades
- Arial photography

B. Low altitude operations

The major challenge of these UAS applications is their integration into the airspace structures below flight level 100. Here, where in current airspace E, F and G no separation is provided to VFR traffic, collision avoidance is mostly based only on the "see and avoid" principle. Prior to the integration of such UAS in the managed airspace, the capability for the UAS to substitute the "see and avoid" by a "detect/sense and avoid" must be clearly assessed and a way how to assure the function "collision avoidance" must include available technologies as well as mature procedures. Low altitude operations have been successfully demonstrated for the following applications:

- Pipeline surveillance
- Border control
- Traffic surveillance
- Disaster monitoring

There are numerous further possible applications which were identified, a comprehensive overview can be found in INOUI deliverable D1.2. Thus there is a great market potential for this type of application, be it in the area of civil commercial, governmental or science & research.

2. **Cargo flights** – The second major civil application category will be the unmanned cargo flight.

Three types of civil air cargo system are already in use: local, short haul and long haul operations. It can be anticipated that the situation will remain the same in the years to come. Each of these three systems has its own concept of operation, adapted to the type of cargo to be carried and to the distance to be covered.

For short distances (local operation, typically up to 500 km), most of the cargo that deserves an air support is made of small parcels and mail as larger cargo would be more conveniently transported by rail or road. Examples are humanitarian missions or supplying remote or inaccessible areas.

For medium (short haul operation, typically up to 1,500 km) and large distances (long haul operation, typically up to 15,000 km), the needs in terms of cargo air transportation are more important as rail and road may not be fast enough. Indeed, delivery time is a very important constraint when considering freight transportation. In addition, the probability to cross seas or oceans increases with the distance, and air transportation is much faster and flexible than sea transportation.

Cargo flights are envisaged mainly for freight transportation and the interest for such applications is increasing. In addition, a large part of this traffic is currently (and will continue to be) performed above oceans or uninhabited areas, which may be a prerequisite, at least to start this type of activity, for the operation of unmanned large aircraft on special UAS freight routing and dedicated aerodromes. Thus new concepts are envisioned to supplement current cargo flights, partly on especially dedicated aerodromes and UAS freight routing. A high potential is expected, as freight volume was increasing in the past. Furthermore, new types of operation could emerge in the future, e.g. single pilot cargo operations, where for certain phases of flight the on-board pilot takes responsibility, while in other phases the aircraft is an UA.

Nevertheless, the unmanned aircraft must be integrated into air traffic management. Technical problems, like security of the flight critical data links, automatic flight or communication latencies caused by the data link are currently the major concern regarding this type of operations.

On the other hand, besides the possible financial benefit gained by taking the man out of the cockpit, unmanned cargo flights can become a high priority mission, if the operation itself is found very dangerous for the flight crew. The use of an unmanned system for humanitarian missions, e.g. to transport medical equipment, food etc. to support surviving victims in remote or inaccessible regions, can successfully demonstrate this concept of operation.

3. **Station Keeping** – This type of application refers to the operation of a UA as a geostationary platform at an altitude of around 20 km or more, i.e. within the stratosphere which is situated between about 10 km and 50 km altitude.

Hence station keeping applications including remote sensing and telecommunications could be alternatives to satellites and have considerable advantages in cost and flexibility to them.

Since the primary objective of such applications is to use the UAS for telecommunication purposes, it is especially important for the UA platform to maintain proper position over long periods of time for the successful mission operation. These types of missions are mostly suited to High Altitude Long Endurance (HALE) UA and include beyond line of sight communications capabilities, broad-line wireless access, digital broadcasting (audio/ video), remote sensing, etc. It must be noted that UAS specific operations may vary a lot depending on the complexity of each flight from the above.

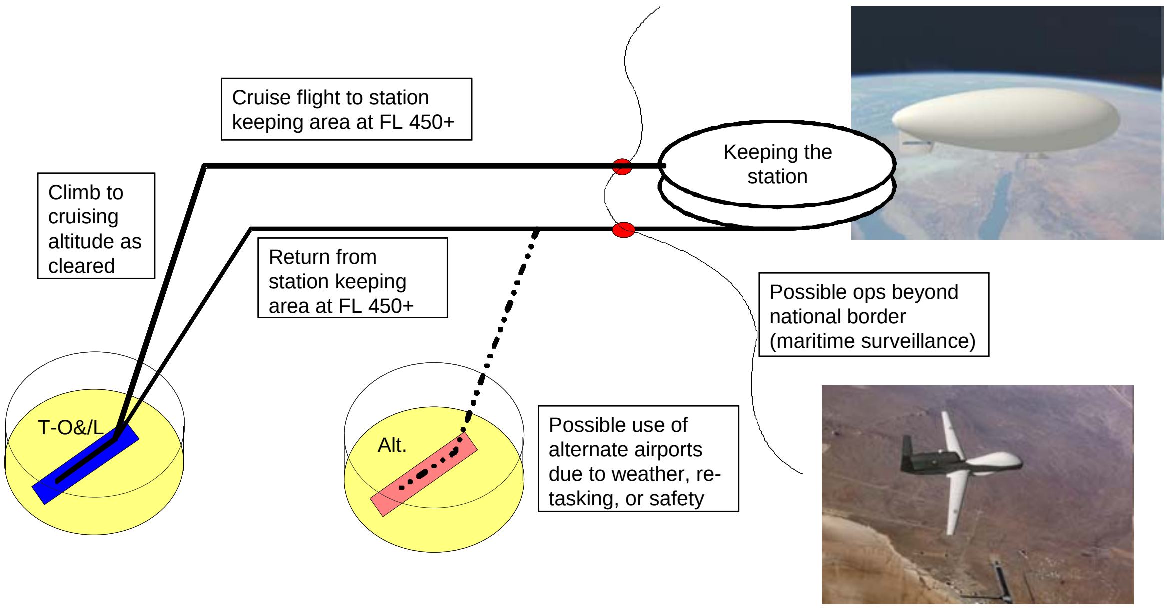

Figure 3 Station Keeping concept for operations

3.2.4 Conclusions WP1.2

The growing UAS field shows that a huge number of clients will be interested in its applications and particular features. Surveillance applications will probably be the most interesting missions and for this reason, a seamless management of every actor involved in the UAS operation has to be considered.

Given the large variety of applications, the industry should develop aircraft fitting them to their objectives and payload. Some surveillance missions will need small size aircraft with a high performance and manoeuvrability, e.g. in police or security missions. Other UA could be bigger with a larger range and endurance to cover vast areas, as is the case of research studies. These issues imply that the very first direct cost for the operator is to choose the right UAS according to the purpose of the operation that is going to be carried out.

It is important to have a clear view of the difference between the concepts of operator, pilot and client. In view of the previous sections they can be defined as follows:

- The operator is the legal entity owner of the UAS
- The pilot is the person being directly responsible for the airborne operation of the UAS.
- The client is the entity buying a service from the operator.

One UAS type of operation possibility is a pilot commanding a UAS as an employee of an operator working for a client. Nevertheless, an operator could also be a pilot. Then the civil liability is a question that needs to be clarified by the authorities. The difficult part to deal with could be the “inboard intelligence” that may remain under the responsibility of the UAS manufacturer, unless established otherwise by the authorities.

As any other aircraft, a UA with appropriate permissions may fly over special use airspace (SUA). Special use airspace consists of airspace of defined dimensions identified by an area on the surface of the earth wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both. These are areas where safety or security concerns exist, such as nuclear power plants, nature reserves, controlled firing areas, etc.

Safety and security issues are inherent to the previous concepts. It is of particular interest that the pilots have a certification or license in order to operate the UAS flight. This certification shall be the result of a process in which the pilot has followed theoretical and practical trainings courses. The UAS shall be certified as well, including the air vehicle, the ground station and the data link. Authorities shall also establish which is the minimum equipment for the operation and should establish which is the mandatory equipment according to the operational needs.

Aeronautical insurances shall be also mandatory, such as hull insurances, dealing with aircraft damages and even more important liabilities insurances (third parties) dealing with people and property on ground and in the air.

In the current and future global air traffic management concept, the strategic flight planning phase will become more important in order to manage all flights efficiently. The special nature of the UAS and its applications implies that the way to manage the flight plan, in the strategic or pre-tactical phase, should be different to the rest of airspace users because there could be short-term or immediate civil missions that must be carried out on short notice, such as border surveillance or fire fighting.

Collaborative and standardized plans between airport operators, UAS operators and ATC services are needed. This collaboration shall have as a result contingency plans that should cover every aspect of the operation, in order to assure that the operation either at an airport or in managed airspace is performed in a safe and secure manner. The development of concepts such as CDM and SWIM and the development of tools for implementing these concepts will be needed in order to achieve a successful collaboration between all the actors involved in UAS operations.

3.2.5 WP 1.3 – Integration of UAS into the Airspace

The integration of civil UAS applications into the airspace was analysed in this WP and necessary procedural and technical requirements were described in the deliverable D 1.3. The purpose of D 1.3 “Proposal for the Integration of UAS into the Civil Airspace” was to describe a general classification of civil UAS applications, like surveillance/observation, cargo flights and station keeping, and their integration into non-segregated airspace. The emphasis in D1.3 is placed on those issues which need either special consideration because of specifics unique to UAS or where adjustments to established operations and procedures of manned aviation are considered as necessary for a smooth integration of UAS into non-segregated airspace. Thus general rules and operational procedures for UAS which have a considerable difference to manned aviation are described, followed by the description of procedures for special cases. The focus is set on a mixed traffic scenario where manned and unmanned aircraft co-exists in non-segregated airspace.

The various operational procedures with relevance to UAS are described, divided into those relevant for managed or unmanaged airspace. Furthermore the different flight phases (pre-flight, starting phase, mission flight, landing phase) were considered. Also those procedures not particularly associated with a certain flight phase, like radiotelephony, handover between control stations etc. were described in detail. The described procedures are based on current knowledge (e.g. ICAO documents and Aeronautical Information Publication - AIP), theoretical considerations like project documents, results from first examination of procedural issues in simulated operational environment to assess potential impacts, or verification of concepts in practical flight trials. Feedback and discussions' results from the two INOUI stakeholder workshops conducted so far have also been considered and incorporated into the document.

Basic Principles for the Integration of UAS

Although the integration of UAS in the future ATM environment shall happen without a significant impact on the current users of the airspace it is likely to have an effect on a number of stakeholders in the ATM system. Therefore the operations of UAS itself have to comply with the existing and future regulations and procedures of manned aviation as feasible. A general concept of UAS integration is that UAS shall pose no greater risk than manned aviation. UAS and their operations shall show equivalence to manned aircraft operations as much as possible. Following the principle of equivalence, equivalent operations and behaviour must lead to equivalent rights for UAS. They have some unique characteristics which require adaptation to existing procedures or additional ones. Basically, the established operational procedures for manned aviation, as well as new ones developed within SESAR, will also be applied to UAS and will be only adjusted where required.

In summary, the principles for UAS integration are:

- UAS are legitimate airspace users. Legitimate means that UAS are certified and have obtained operational approval. UAS have equal rights but the same rules and operational procedures apply. Thus, besides certification and flight crew licensing issues currently discussed, UAS have to fulfil certain operational procedures which have been established in manned aviation for a long time.
- The integration of UAS into the future ATM environment shall occur without a significant negative impact on the established manned aviation, in an evolving context driven by SESAR innovations.
- Guiding principle: integration must not compromise existing aviation safety levels or increase risk to third parties in the air or on the ground – UAS shall pose no greater risk than manned aviation
- UAS receive equal and fair treatment by ATC, though different if necessary. A prerequisite is that UAS must be transparent to ATC and other airspace users, meaning that intentions and behaviour of UAS should be clear and predictable and will have to comply with ATC instructions. In the opinion of ATC controllers using today's procedures and technical equipment UA shall behave as manned aircraft.
- the operation of UAS itself has to comply with the existing and future regulations and procedures of manned aviation as feasible

- UAS will also have to comply with the capability requirements applicable to the airspace within which they intend to operate
- existing “rules” that are fundamental to safe operations should not be changed (right-of-way rules, existing procedures, radio telephony, etc.) or only if required (e.g. phraseology, emergency procedures)
- Basically the established operational procedures as well as those (to be) developed within SESAR available for manned aviation will be applied to UAS and adjusted only where required.
- Existing rules need initially to be interpreted with some flexibility but inevitable or necessary changes of procedures shall mirror those applicable to manned aviation as much as possible
- UAS operations have to consider all relevant SESAR results like all other users and shall be compatible with the SESAR concepts (e.g. UAS should be able to comply with 4D Trajectory Management processes).
- UAS have to self separate as other a/c (“self separation” is referring to the ability to detect and avoid other traffic. In the context of SESAR CONOPS this is even related to the (temporary) delegation of separation from ATC to pilot under certain circumstances or for defined segments of the flight. Technological enablers: ASAS (Airborne Separation Assistance System), ADS-B (Automatic Dependent Surveillance – Broadcast). As a backup ‘safety net’ ACAS (Airborne Collision Avoidance System) is used.
- UAS (i.e. the ground control station by ground lines and the UA via mobile data link) should become one more user category of SWIM, without the need to create a digital network only for UAS purposes.

Besides ATM procedures, technical and operational requirements need to be taken into account for the future integration of UAS. Operational procedures and derived technical requirements for UAS are described and first solutions proposed in deliverable D 1.3.

The various operational procedures with relevance to UAS are described, divided into those relevant for managed or unmanaged airspace. Furthermore the different flight phases (pre-flight, starting phase, mission flight, landing phase) were considered. Also those procedures not particularly associated with a certain flight phase, like radiotelephony, handover between control stations etc. were described in detail. The described procedures are based on current knowledge, e.g. ICAO documents and Aeronautical Information Publication – AIP. Theoretical considerations like project documents, results from first examination of procedural issues in simulated operational environment to assess potential impacts, or verification of concepts in practical flight trials were also taken into account. In addition consultations of ATC controllers provided valuable input to procedural issues. Feedback and discussions’ results from the two INOUI stakeholder workshops conducted so far have also been considered and incorporated into deliverable D 1.3.

Many standard procedures have specifics to UAS, which need to be regarded. Therefore the choice is either to adapt UAS operations or to adapt procedures, while considering the basic principles above.

Furthermore there are several challenges to be considered:

- Communication with ATC (managed airspace) and with other airspace users (unmanaged airspace), including necessary infrastructure and architecture, will remain a special challenge given the continuing need for an immediate response to ATC instructions. Techniques to ensure robust communications, under all conditions will require special attention and potentially special procedures.
- Loss of C^2 data link which is a unique UAS issue.
- Sense/detect & avoid issues which constitute the main barrier for the integration of UAS. This refers not only to technical concerns but moreover to procedural aspects in respect to existing right-of-way rules.
- General and specific contingency and emergency procedures need also to be developed and harmonised, including loss of radio telephony communication, flight critical system failures, loss of sense/detect and avoid capabilities, etc.

The basic principles and proposals and recommendations for the above stated challenges were compiled into an executive summary which was sent out to UAS stakeholders and relevant organisations for discussion and to achieve a consensus. This activity was part of WP 1.4, described in the next section.

Another topic in deliverable D 1.3 was the definition of technical and operational requirements for civil UAS applications which were derived from the procedures or developed independently. These requirements are related to the phases of flight and whether the mission is conducted in either managed or unmanaged airspace. Particularities of surveillance/ observation missions, cargo flights and station keeping are also taken into account. In total there were more than 100 requirements defined for managed airspace and 55 for unmanaged airspace. For details please refer to D 1.3, which is available on the INOUI web page (http://www.inoui.isdefe.es).

3.2.6 WP 1.4 – Discussion with relevant Organisations

The goal of this WP was to exchange and discuss with UAS stakeholders relevant issues for the integration of UAS, aiming to gain input for and harmonise the integration proposal. The input of the Stakeholder community is of the utmost importance for INOUI to ensure their valuable input, to validate the work done up to now and to get further input for future activities.

Several steps were performed to do so. In October 2008 the first INOUI stakeholder workshop "*UAS ATM Concepts, Procedures and Requirements for 2020*" was held for three days. There the initial results from INOUI project focusing on the operational concept and requirements were presented and discussed. Besides key note speeches and presentations by different stakeholders, like regulatory bodies, manufacturers, and users several working sessions were conducted, where the operational concepts and related operational requirements under the view of specific topics were discussed:

I. Challenges for the integration of civil UAS into future SESAR ATM Environment
II. User Needs
III. Use of UAS technology for Manned Aviation

IV. Regulatory issues

The objectives of the working sessions were discussion of the operational concepts and the operational requirements developed within INOUI and thus to obtain feedback, comments and input from stakeholders to develop final requirements for the integration of the UAS and furthermore to discuss the challenges, solutions and necessary steps for the integration of UAS into the ATM System 2020+.

The second workshop was part of WP 6 *"New Aerodromes Concepts for UAS"* and took place from 10-12 March, 2009. The last day of the workshop was devoted to follow up the issues of 1st INOUI workshop and included presentations about ICAO UAS Study Group, SESAR and the JARUS initiative. The lead of WP1 discussed with the participants statements regarding the future operational concepts. Issues like communication, loss of data link, sense/detect and avoid among others were discussed and potential operational and procedural solutions were highlighted. But still disagreements exist in details which need to be resolved. For this reason other stakeholders will be given the opportunity to comment on the operational concepts developed in INOUI.

Therefore the main issues for a successful integration were compiled in an executive summary of D1.3. As several discussions within the UAS community showed, there is neither a mutual understanding on various terms and definitions nor a complete consensus on certain operational procedures. But both issues are relevant for the work of regulators, for the operational approval of UAS and finally for the acceptance by other airspace users. While initiative has started at ICAO UASSG to develop a common definition of the UAS related terms and in the medium term, ICAO is expected to amend a significant number of their Annexes in order to accommodate UAS operations, development of operational procedures still remains unclear in several aspects. The focus of the executive summary of D1.3 was therefore on those key issues which need to achieve a common agreement and thus it was sent to representatives of the stakeholder community who were asked to comment the given proposals, make amendments where necessary and complement missing topics.

This way the INOUI consortium wanted to gather the inputs from all relevant UAS stakeholders and related organisations. Comments were received from representatives of EASA (European Aviation Safety Agency), EUROCONTROL, WG 73, Military (JAPCC), aviation equipment manufacturers, and the European Cockpit Association, each from their own perspective, thus complementing the proposals and views of the INOUI consortium. The valuable feedback was then almost fully incorporated into this deliverable 1.4 "Harmonised Proposal for the Integration of UAS". While in D1.3 the most relevant ATM procedures were described and analysed, the focus of D1.4 is set on the operational procedures which seem to be critical when integrating UAS into non-segregated airspace.

The D1.4 report describes those ATM related procedural issues specifically applicable to UAS. The focus was on procedures relevant to UAS or which have a particularity associated with UAS. The proposed solutions and recommendations were derived from D1.3, were first proposals were developed and technical as well as procedural requirements were created.

The results from the stakeholders' feedback were reprocessed and proposals and recommendations developed. To obtain a comprehensive overview they were aggregated in different separate tables related to phase of flight and whether relevant for managed or unmanaged airspace. The issue of concerned is named, followed by a description of the topic and its relevance for UAS. Then necessary steps including a proposed solution are described. Finally reference is given whether and how this solution needs validation.

To give an overview about the issues assessed the following table depicts the high level results of relevant procedures or critical issues in managed and unmanaged airspace related to phase of flight. Please note that several facets may be considered under one procedure or issue, so the total number of relevant aspects are higher than the numbers in the table might imply.

Table 1 Summary of procedures and issues assessed

Issues and Procedures assessed - per flight phase –		
	Airspace	
	Managed	**Unmanaged**
Flight Phase		
Pre-flight	4	3
Starting	4	6
En-route	3	3
Landing	5	5
Issues and Procedures assessed - in general, not particular to a flight phase –		
Communication with ATC/ ATS	13	
Setting transponder	5	
Transparency to ATC	2	
Loss of command and control data link	8	
Sense/detect and avoid	14	
Emergencies	6	

The description of common established procedures and their specifics and necessary considerations related to UAS operations shall serve as information for the wider UAS stakeholder community. Moreover, the goal is to raise awareness that not only certification and licensing issues are crucial for UAS integration but UAS also have to fulfil certain rules and operational procedures, before they will become legitimate airspace users.

Though the proposed (new) procedures and recommendations are non-binding, they shall serve as inputs for UAS related organisations to gain a common understanding and to advocate the required final agreement on the different operational, procedural and technical solutions to integrate UAS into the future ATM environment.

3.3 Summary and Conclusions

The aim of this executive summary is to inform the UAS stakeholders about the work carried out in INOUI work package 1 – UAS ATM Concepts, Procedures and Requirements for 2020 and provide an overview of the content of the different sub work packages, the deliverables created and the key results of this WP:

Due to the fact that there will be a considerable growth in the use of UAS, not only for military purposes but increasingly for civil and governmental applications, it is expected that the market potential for manufacturers and for operators is high during the SESAR Development Phase. There is no doubt within the ATM Community that UAS will become another routine airspace user. However, future UAS operations will pose a unique set of issues which all have the potential to significantly affect air traffic operations and will place additional challenges on an ATM system already under great strain, although the ATM system of the future will be better equipped to manage the additional complexity related to the rise of UASs.

The European ATM is expected to change substantially over the next years with the introduction of new concepts, technologies and procedures as defined within the SESAR programme. Accordingly it is crucial that the framework of SESAR developments are considered and respected to enable appropriate access for UAS to non-segregated airspace. UAS Systems will adjust to and benefit from the rules, regulations, procedures, standards, and systems developed within SESAR like all other users. Therefore UAS stakeholders have to consider all relevant SESAR results, either already existing or yet to be developed within the SESAR Joint Undertaking. UAS operations will have to be compatible with the SESAR concepts (e.g. 4D precision trajectories) and have to participate in SWIM like other users. Finally, UAS will have to have self separation capability similar to that of other a/c. Self separation is referring to the ability to detect and avoid other traffic and to perform spacing and sequencing functions. In the context of SESAR CONOPS this is even related to the (temporary) delegation of separation from ATC to the pilot under certain circumstances or for defined segments of the flight. Technological enablers are ACAS (Airborne Collision Avoidance System), ASAS (Airborne Separation Assistance System) and ADS-B (Automatic Dependent Surveillance – Broadcast).

Thus there are more hurdles to clear besides certification and licensing issues currently being discussed to obtain operational approval and to become “legitimate” airspace users. This includes that UA and UAS have to comply with existing rules and operational procedures which are established in manned aviation for a long time. However, there are procedures which might evolve through introduction of the SESAR ATM Concept of Operations or through technological advances foreseen by SESAR are not yet fully defined and are subject to the currently ongoing SESAR development phase within the SESAR Joint Undertaking (SJU). Then there are specifics of UAS that may require new procedures or adaptation of existing ones

SESAR brings a new dimension to European ATM which has a wide effect on all airspace users including UAS. The main characteristics of the SESAR concept were highlighted in this document, e.g. trajectory-based operations, where business trajectories are expressed in all 4 Dimensions (position and time) and flown with much higher precision than today, reducing uncertainty and allowing an increased reliance on airborne and ground based automation. Many UAS in their present state of development are already capable of 4D trajectories, as this capability is fundamental to their mission planning and execution.

The SESAR Concept of Operations (CONOPS) for 2020 fully recognises UAS in general. It expects increasing numbers of UAS, starting with military missions and extending to many types of civilian tasks, with UA ranging from very light to heavy. However the current version of the future ATM Concept of Operations (CONOPS) document makes only limited reference to UAV/UAS considerations and offers little detail about operation of UAS in an SESAR ATM environment.

The basic assumption for UAS being integrated into non-segregated airspace is that the provision of an Air Traffic Service (ATS) to UAS must be transparent to ATC and other airspace users. Controllers for example should not be expected to do anything different than they would for other aircraft under their control nor should they have to apply different rules or work to different criteria and UAS need to have equipment and capabilities applicable to the airspace within which they intend to operate.

The integration of UAS in the ATM future environment shall occur without a significant impact on the current users of the airspace. The operations of UAS have to comply with the existing and future regulations and procedures of manned aviation where feasible. A general concept of UAS integration is that UAS shall pose no greater risk than manned aviation. Consequently, UAS and their operations shall show equivalence to manned aircraft to the highest degree. UAS are only accepted as another class of airspace user that, subject to conformance with appropriate regulations, are allowed to operate in non-segregated airspace when neither restricting, hazarding or otherwise inconveniencing existing airspace users.

The guiding principle is that integration of UAS into non-segregated airspace must be accomplished without compromising existing aviation safety levels or increasing risk to third parties in the air or on the ground. In addition, existing “rules” that are fundamental to safe operations should not be changed (right-of-way rules, existing procedures, radio telephony, etc.) or only if required (e.g. phraseology, emergency procedures). Inevitable changes of procedures or rules shall mirror those applicable to manned aviation as much as possible.

Considering input from different sources, e.g. project reports, ICAO and SESAR documents and input from the 1st INOUI Stakeholder workshop first proposals and recommendations were developed and published in INOUI deliverable D 1.3 "First Proposal for UAS Integration". To gain feedback on key issues from the UAS stakeholder community an executive summary of this document was created for discussion, commenting, complementing and amending where necessary. This feedback was reprocessed and integrated.

Proposals for operational procedures were given, related to the phases of flight and whether the mission is conducted in either managed or unmanaged airspace. Particularities of surveillance/observation missions, cargo flights and station keeping were also taken into account. Though the proposed (new) procedures are non-binding, they shall serve as inputs for UAS related organisations to gain a common understanding and to advocate the required final agreement on the different operational, procedural and technical solutions to integrate UAS into the future ATM environment. Among the key issues are

- Communication with ATC
- Loss of Radio communication
- Loss of Data link
- Detect/Sense & Avoid
- Transparency to other actors/airspace users
- Failure/Emergency procedures

Some of the proposed procedures are related to manned aviation and have been established for a long time. A guiding principle is that UAS operations shall be able to comply with established procedures, however many standard procedures have specifics to UAS and the choice is either to adapt UAS or adapt established procedures. Therefore UAS operators and manufacturers have to carefully analyse the standard procedures and find ways to adapt to them, as presumably changing procedures on a national or even international level will be even more challenging.

Furthermore procedural and technological solutions have to be defined concerning how to deal with all situations, whether under normal or abnormal operating conditions. Therefore validation is required for procedures to specify details and prove solutions to be feasible. Also technological enablers need validation, among them are communication architecture with ATC, automatic landing in adverse weather conditions (CAT II/III), UA movements on aerodromes, emergency recovery capabilities and the ever so prominent sense/detect & avoid issue related to other aircraft, terrain and weather, and to perform spacing and sequencing functions. Validation of procedures and technologies can be achieved through flight trials, simulations or a combination of both.

Finally, it is noteworthy that manned aviation could benefit from developments in UAS related technologies and capabilities. Due to their mission profiles most UAS already apply precision 4D trajectories and experience may be shared. Developments in sense/detect and avoid systems should also be addressed within SESAR as a significant contribution to safety. Improvements in avionics are also expected, as many UAS require small, lightweight and power-saving equipment, which could be very interesting for general aviation, gliders, ultra-lights etc.

For further information on INOUI please visit INOUI-Homepage where all INOUI deliverables and other documents are available for download: http://www.inoui.isdefe.es/INOUI.

3.4 User of the results

The main objective of WP1 was the definition of concepts, necessary procedures and requirements for the integration of UAS into the ATM in the timeframe of 2020 and beyond. The results of the work performed are beneficial for those stakeholders in the UAS community who are involved in the process of integrating (civil) UAS into non-segregated airspace. Among them are the following:

- SESAR, because within the high level deliverables D1 through D6 the issue UAS was treated rudimentarily only. More specifically the below mentioned work packages could be recipients.
    - SESAR WP B (Target Concept & Architecture Maintenance)
    - SESAR WPE (Long-term and Innovative Research Programme)
    - SESAR WP 4 (En-Route Operations)
    - SESAR WP 5 (TMA Operations)
    - SESAR WP 6 (Airport Operations)
    - SESAR WP 12 (Airport)
- UAS Manufacturers, because an overview of the expected changes in ATM is given, concepts were developed and described and finally, critical issues for the integration of UAS were analysed and proposals for procedures and requirements were evolved.
- Regulators, because there are some open questions remaining while new ones came up, which need consensual solutions. The WP1 results could serve as input to such process.
- ANSP, because integration and interoperability would be facilitated if procedures are compatible between different ANSP. The given proposals and recommendations in WP1 could promote the discussion and development of similar procedures.

4 Work Package 2 « UAS-enabled ATM Architecture »

4.1 Scope of Work and Method of Research

Subject of the work package

Evaluation of existing and future systems and technologies that are intended to be applied on the ground and in the air to enable the ATM 2020 paradigm and to assess their impact on UAS and individual aircraft operation.

This work can be split into the following specific targets:

- Assess systems and technologies (existing world-wide) for enabling the ATM 2020 and UAS operation.
- Determine technological gaps and weaknesses for the integration of the UAS into the ATM 2020 and beyond.
- Assess the potential solutions to improve the integration of UAS into the ATM 2020 and beyond.

Work package deliverables

INOUI WP2 consists of three deliverables, each one containing the results of the research made in the tasks mentioned above:

D2.1 Technology Watch	Addresses the characteristics of the technologies foreseen to support the ATM operation in 2020 and beyond.
D 2.2 Assessment of the Technology for UAS Integration	Matches the ground and airborne technologies addressed in D2.1 and determine the gaps and weaknesses of such technologies to cope with the operational concept needs.
D2.3 Conclusions and Recommendations for Technological Developments	Proposes and assesses possible solutions that would suppose an area of investigation for the future, to fill in the gaps and to cope with the ATM 2020 operational concept

Methods of research

The research performed within WP2 has been fed from three different sources of information:

- Review of existing documents:
  - SESAR Deliverables: D1, D2, D3, D4, D5, D6
    - UAS literature: EUROCAE WG73, ASTM F38, RTCA SC203, JAA/Eurocontrol UAV Task Force, etc
    - Manned aviation literature
    - INOUI documents: D1.1, D1.2, D1.3, D4.1
    - Other related projects documents: SOFIA, SWIM-SUIT, CASCADE, etc.
- Inputs from Session III "Use of UAS Technologies for Manned Aviation", INOUI First Stakeholder Workshop 21-23 October 2008
- INOUI members expertise and knowledge: Isdefe, Rheinmetall Defense Electronics, DFS Deutsche Flugsicherung, Onera and Boeing R&TE
  - ISD with expertise and experience in avionics, ATC systems, ATM structure and concepts.
  - RDE with expertise and experience in avionics systems and UAS.
  - DFS with expertise and experience in ATC systems and air navigation services provision.
  - ONE with expertise and experience in see and avoid issues relative to the integration of UAS studies about the technologies to be used for the integration of UAS.
  - BRTE with expertise and experience in how UAS impose requirements to the information management systems in the ATM architecture as well as how the numerous stakeholders involved in the UAS flight handle the operations.

In order to achieve INOUI WP2 objectives a step by step approach has been followed:

1) First a technology watch on current and foreseen technologies both from the UAS and ATM standpoints was performed because UAS developers are looking at the current ATM when designing their systems in order to achieve the interoperability as much as possible. Then SESAR driven changes in the ATM system in 2020 and the foreseen technology under development have also to be considered when integrating UAS in the future. Therefore during the first step carried out in WP2, an identification and assessment of the current and foreseen technologies has benperformed. SESAR foreseen technologies are considered in detail as any UAS technology development has to be compliant with SESAR foreseen technologies.
2) The integration of UAS in non-segregated airspace does not only rely on technologies but also on operational concepts and the related procedures and vice versa. Thus a cross check of the technologies identified in the first step and

the operational and technical requirements derived in INOUI D1.3 “Proposal for Integration of UAS into the civil airspace” for the three applications analysed in INOUI was carried out during the second step of WP2. The objective of this cross check is to identify the technological gaps both from the UAS and ATM perspective which may jeopardise the integration of UAS into the non-segregated airspace. It is also important to mention that not only specific UAS technologies have been considered when looking for gaps but also manned aviation technologies, as both manned and unmanned aviation communities can benefit from each other to fulfil their respective gaps.

3) Finally the third step of WP2 proposed recommendations and solutions in order to fulfil the gaps identified in the previous step. It also proposed ideas for further research and development in the field of UAS in order to allow a seamless integration of UAS in the SESAR environment.

It has to be noted that each step described above corresponds to each WP 2 sub-work package, namely:

WP2.1 Technology Watch

WP2.2 Assessment of the Technology for UAS Integration

WP2.3 Conclusions and Recommendations for Technological Developments

4.2 Findings of the Work Package

4.2.1 Technology Watch

The future ATM for the timeframe of 2020 and beyond is quiet different from the one in use nowadays. Important changes will be trajectory based operations, collaborative planning, information sharing through system wide information management (SWIM), dynamic airspace management and new communication, navigation & surveillance technologies (CNS). For succeeding in the integration of UAS into the future ATM it is fundamental that technologies developed for UAS operation are compatible and interoperable with those for ATM operation.

The focus of WP 2.1 was on technologies related to communication, navigation and surveillance as these are the backbone and key enablers of ATM and being of highest relevance for integrating UAS. Additionally support tools for air traffic controllers were analysed. A distinction was made between technologies currently in use and those which are foreseen in the SESAR timeframe.

In parallel, existing technologies or those currently being developed for the UAS operation were also assessed which are key enablers for the operation of UAS in the 2020 ATM environment:

- communication, navigation and surveillance (CNS),
- flight management system (FMS),
- flight control system (FCS),
- data links,

- detect & avoid systems,
- data fusion systems,
- auto-landing systems, etc.

Specific UAS technologies as defined by different UAS organisations, other UAS projects and different UAS stakeholders and non-specific UAS technologies, i.e. technologies coming from manned aviation, which may be used by UAS, were also assessed.

Most of the key enablers identified for the integration of UAS in managed airspace have also been identified by SESAR as key enablers for the future ATM system. As in the course of SESAR large investments are necessary on behalf of ANSPs, it is rather unlikely that they will further invest in technologies that are solely beneficial for one additional group of airspace users. Compatibility and interoperability of current and future technologies among all airspace users is therefore crucial to the successful integration of UAS.

From a technological view UAS should carry similar functionality for flight, navigation and communication to that required for manned aircraft. The necessary technology is partly available, yet need to be fitted to the requirements specific to UA (e.g. available payload, size and energy) and UAS altogether. Still one of the main challenges remains the “sense/detect and avoid” problem.

4.2.2 UAS technologies

From the point of view of the UAS technologies, there are three areas of technology which are crucial for the operation of UAS in the 2020 ATM environment. These areas are Communication, Navigation and Surveillance.

4.2.2.1 Communication

There are three types of UAS communications:

- between UAS and control station;
- between UAS and UAS or other aircraft including other UAS, and
- between control station and ATC

The two first types of communication are currently performed by using data links. These data links are the same as used for manned aviation.

These communication means can be performed in two ways depending upon the distance and the obstacles that are between the air vehicle and the control station. If the distance is not very large and there are no obstacles the communication is performed via Radio Line of Sight (RLOS). In case the distance is very large or there are obstacles between the air vehicle and the control station, then communication is performed via Beyond Radio Line of Sight (BRLOS), which implies the use of satellites to relay communication.

Communications between the control station and ATC are currently performed via voice.

It is foreseen that in the future 2020 ATM environment all communications will be performed via improved and secure data links as stated by SESAR. Thus UAS product manufacturers will have to adapt the data links foreseen by SESAR in the field of manned aviation to the field of unmanned aviation.

4.2.2.2 Navigation

UAS navigation technologies are currently based on those used in manned aircraft but adapted, when feasible, to unmanned aircraft. The types of navigation technologies used are based upon the type of navigation performed, i.e.:

- inertial navigation;
- satellite navigation, and;
- radio navigation using ground aids.

These types of navigation are performed by different systems either on-board the UA or on the control station.

The primary equipment in charge of navigation on board the UA is the flight management system or FMS. A typical FMS is composed of the following components:

- Flight Control System (FCS): FCS is responsible for keeping the UAS within its flight envelope by maintaining appropriate vertical speed, airspeed, roll angle, pitch rate, yaw rate, roll rate and sideslip. Nowadays most of the FCSs developed for UAS perform also the autopilot and pilot control functions.
- Guidance and Navigation System (GNS): This system provides the FCS with the necessary data in order to perform its functions properly. This system can be used on:
  - radio navigation, based on ground aids, such as NDB, VOR, DME or ILS;
  - inertial navigation, which use a computer and motion sensors to continuously track the position, orientation and velocity of the vehicle without the need for external references, and;
  - satellite navigation, based on the signals broadcasted from three or more satellites and used by the UA to calculate its position.

In the control station other systems used for navigation are needed. These systems are used to provide the UA pilot with references of how the UA is flying. These references are data such as altitude, airspeed, pitch, yaw, roll and other data, such as warnings.

Current basic control instruments, providing data to the crew, are incorporated in a Primary Flight Display (PFD) both for manned aviation, i.e. in the cockpit, and for unmanned aviation. As in certain control stations, there are less strict requirements for weight, size and power consumption of the instruments, the information package provided to the UA crew may comprise more information as on-board an aircraft.

Moreover, other instruments which are not specifically used for command and control the UA are used. These systems inform the UA crew about the status of the UA and its equipments, e.g.:

- Status airspeed, sideslip, engine temperature, acceleration
- Lack of fuel or batteries
- Flight time duration

- Data link monitoring (range, signal strength, operational status, etc.)

However, an unmanned aircraft needs a higher degree of automation than manned aircraft since there is no pilot on board. This issue is currently being addressed and it is foreseen that in the future there will be technologies allowing the UAS to re-plan its flight plan automatically in case a conflict suddenly appears. Some of these technologies are currently in the phase of definition and development, i.e. the Flight Reconfiguration Function addressed by the SOFIA project co-funded by the EC under the 6th Framework Programme.

4.2.2.3 Surveillance

UAS surveillance technologies are an important issue, and maybe one of the most critical as there is no pilot on board, and therefore the direct ability of the UA pilot to "see and avoid" is lost. [1]

According to ICAO Annex 2, UAS have to comply with the right of way rule (UAS addressed in Article 8 of the Convention on International Civil Aviation). Automatic surveillance technology for UAS is still in its specification and research stages. However surveillance should not only rely on technologies but also on procedures. This is of special relevance in managed airspace where ATC is the predetermined separator. The hierarchy for the application of separation provision and collision avoidance can be depicted as follows:

1. ATC – Separation provision from other IFR flights + traffic advisory to VFR flights if requested or possible.
2. Pilot in command – Separation provision from other VFR flights + Collision avoidance to IFR and VFR flights.
3. Automatic operation – Collision Avoidance.

Research and development for sense/detect and avoid and situational awareness will be one of the main issues that UAS developers will deal with in order to allow the integration of UAS in the non-segregated airspace.

In absence of reliable sense/detect and avoid system, surveillance could be currently achieved if the UAS pilot at the control station receives surveillance data from the UA and from ATC via data link (e.g CPDLC) or voice. This would require cooperative transponders on board the aircraft. Then UAS trajectory can be modified to avoid potential conflicts with other airspace users. However, in addition detect and avoid systems must be able to identify weather hazards, terrain and obstacles.

4.2.3 ATM Technologies

Currently from the ATM point of view, the general opinion is that UAS shall be treated the same way as manned aircraft. Consequently the responsible organisations of Air Navigation Service Providers (ANSP) are not likely to invest in technologies which would be

[1] See also INOUI Executive Summary of WP4 and Deliverables D4.2 and D4.3

beneficial only for one category of airspace users. As in the course of SESAR large investments are necessary on behalf of ANSPs, it is rather unlikely that they will further invest in technologies that are solely beneficial for one additional group of airspace users.

ATM technologies supporting UAS operations also rely in three key technological areas: Communication, Navigation and Surveillance. UAS producers as well as UAS operators have to take into account the respective requirements for UAS product development and operational procedures.

4.2.3.1 Communication

The aeronautical communication infrastructure from the ATM point of view is traditionally divided into two parts, the air-to-ground and ground-to-ground infrastructure.

The following are the communication technologies which need to be fully implemented by 2020 for the operation of UAS, to meet the SESAR ATM Target Concept (SESAR D3) :

- Ground-ground
  - o IP based ground-ground communications network supporting all the ATM applications and SWIM services, together with VoIP for ground segments, including VoIP for the ground segment of the air-ground voice link.
- Voice
  - o 8.33KHz channel spacing is the standard for voice communications.
  - o SATCOM (Satellite Voice and Data Communications) voice for oceanic and remote areas.
- Air-Ground data link
  - o VDL2/ATN
- Airport
  - o A new airport data-link to support surface communication, using a derivation of the IEEE 802.16.

4.2.3.2 Navigation

The objective of navigation technologies is to provide aircraft positioning and trajectory management in all phases of flight.

The following are the navigation technologies which need to be fully implemented by 2020 for the operation of UAS, to meet the SESAR ATM Target Concept (SESAR D3) :

- Primary aircraft positioning means will be satellite based for all flight phases.
- Positioning is expected to rely on a minimum of two dual frequency satellite constellations (Galileo, GPS L1/L5 and potentially other constellations, assuming interoperability) and augmentation as required:

  - Aircraft based augmentation (ABAS) such as INS and multiple GNSS processing receiver,

- Satellite based augmentation (SBAS) such as EGNOS in Europe and WAAS in USA

- Terrestrial navigation infrastructure based on DME is maintained to provide a backup for en route and TMA.
- Enhanced on-board trajectory management systems and ATS flight processing systems to support the trajectory concept.

4.2.3.3 Surveillance

As an integral part of Air Traffic Management (ATM), surveillance positional data constitutes the principal means of surveillance of aircraft for the efficient execution of Air Traffic Control. The objective of the surveillance service is to provide a complete picture of the actual traffic situation to ensure a safe separation and an efficient traffic flow. ATM surveillance is the observation of an area or space for the purpose of determining the position and movement of aircraft or vehicles in that area or space to enable Air Traffic Control.

The following are the surveillance technologies which need to be fully implemented by 2020 for the operation of UAS, to meet the SESAR ATM Target Concept (SESAR D3) :

- For the airspace, cooperative surveillance will be the norm, complemented as required by independent non-cooperative surveillance to satisfy safety and security requirements. For the airport both cooperative and independent non-cooperative surveillance systems will be necessary.
  - Primary surveillance radar (PSR) will provide independent non-cooperative surveillance.
  - Since aircraft will have the necessary mode S and ADS-B equipage, the choice of cooperative surveillance technology (Mode S, ADS-B, MLAT) remains flexible, with the service provider determining the best solution for their particular operating environment, based on cost and performance.
  - Surface movement radar (SMR) will provide the independent non-cooperative airport surveillance.
- ADS-B IN/OUT is provided by 1090 ES.
- With a mandate of ADS-B ES 1090 out, TIS-B will not be needed in the transition to support ASAS applications.
- Satellite based ADS-C (ADS-Contract) for oceanic and remote areas (Note: The basic concept of this ADS application is that the ground system will set up a contract with the aircraft such that the aircraft will automatically provide information obtained from its own on-board sensors, and pass this information to the ground system).

Beyond 2020 SESAR is expecting that PSR is replaced by less costly independent non-cooperative surveillance technology and that the 1090 ES system supporting ADS-B in/out is improved and complemented with an additional high performance data link.

4.2.4 Technology Assessment

A technology assessment for a seamless integration of UAS in the non-segregated airspace in the SESAR framework needs to cover not only specific technologies related to the UAS itself, but also to the environment in which it flies i.e. the ATM environment.

The technology assessment performed in INOUI WP2.2 also received important input from the first INOUI Stakeholder Workshop held in Palma de Mallorca Spain on the 21st-23rd October 2008. One of the conclusions of this workshop related to technology assessment was that technologies already in use in manned aviation (or foreseen to be used in the 2020+ framework) are subject to be adapted to the UAS world and vice versa. This conclusion was also in line with a statement made in SESAR D3, which explicitly mentions that:

"Specific technologies needed for UAS to ensure a transparent operation similar to a manned aircraft (e.g. dedicated high integrity UAV/operator[2] command and control data links) fall outside SESAR. It is however conceivable that some technologies that will be developed in the coming years by and for the UAS community will find their way to manned aircraft as well as we know of the requirements of advanced business aviation where sense and avoid technologies are sought for in the not too far future"

With these two important results in mind, together with the technology watch performed in INOUI WP2.1, the process of identifying gaps in technologies which may enable a seamless integration of UAS into non segregated airspace in the SESAR framework was performed. The starting point of this assessment was the list of operational and technical requirements for the integration of UAS in the non-segregated airspace developed in INOUI WP1.3 according to the proposed INOUI concept, both from the ATM and UAS standpoints.

The list of operational and technical requirements was performed on a "flight phase - basis", meaning that each step of a flight as it is currently performed, from pre-flight preparations until landing and reaching parking position, was assessed and its application to UAS operations analysed. This gave the INOUI team a clear view on what is necessary to carry out operations in non-segregated airspace. The detailed list of more than 120 requirements applicable for fixed wing and rotary wing UA can be found in INOUI deliverables D1.3 and, assessed from a technological viewpoint, in D2.2.

4.2.4.1 Technology Gaps and Weaknesses

In order to ease the work and identify the gaps, a systems engineering approach was followed, i.e. a description of the technology needed for each operational and technical requirement was performed. Based on these technology requirements, the technologies identified in the technology watch performed in WP2.1 were cross-checked in order to find whether a gap exists or not.

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[2] "Operator" should be replaced by "Pilot" considering the Eurocae Terminology

The following list of gaps identified is extracted from INOUI D2.2:

1. Sense/detect and avoid technology for direct detection/sensing in order to provide separation between traffic and resolution of potential collisions in the air or on ground (aerodrome surface) still under development.
2. In the future context of SESAR there will be a SWIM (System Wide Information Management) infrastructure. SWIM is still in its definition phase and the technologies that aircraft should be equipped with to participate in the SWIM environment are not yet defined. UAS will be an integral part of the development activities and will have to integrate into the SWIM environment. Consequently, in the timeframe 2020+ this technology is not considered a gap.

   The UAS use of 4D trajectories has to be aligned with SESAR requirements.
3. Flight Management system (FMS) is a technology being constantly improved. Current FMS have capabilities that will allow UAS to fly into the current non-segregated airspace. It is expected that by the 2020+ timeframe FMS will have even more capabilities than today, such as 4D trajectory management which is one of the main aspects addressed by SESAR. However, the developments of these systems are focused on manned aircraft, especially for big aircraft, and in recent times also for general aviation aircraft but not for UAS yet. Therefore there is a gap in the adaptation of Flight Management Systems to UAS, especially in terms of size, weight, power consumption and capabilities.
4. Flight Reconfiguration Function systems enabling a more automatic UAS behaviour are currently being studied in research projects and it is expected that this technology will be available for the 2020+ timeframe according to the ACARE Strategic Research Agenda (Advisory Council for Aeronautics Research in Europe). Therefore this system will be ready for implementation. However, once more, this technology has been developed for manned aviation and an adaptation to UAS, as it needs to happen with Flight Management Systems, is necessary.
5. “Action Plan 17 Future Communication Study” performed by the FAA (Federal Aviation Administration) and EUROCONTROL resulted in a roadmap for the implementation of data link technologies. It was concluded that data link technology for air-ground communications, satellite communications and airport communications will be available for manned aircraft in 2020. However,
   a. Air-air communications, e.g. ADS-B, via data link will not be available
   b. This technology is not being specifically developed for UAS. This is not a gap by itself for UAS as they will use the same technology as manned aircraft. Nevertheless not using the same technology as manned aircraft will provoke problems of compatibility between different airspace users.
6. ACAS technologies have been used in manned aviation for several years and their use is widespread across the world (e.g. TCAS). However, this equipment was designed for manned aviation only and the size and weight may preclude employment in UAS except for larger ones. Therefore, an adaptation of ACAS equipment is necessary based upon specific UAS system requirements, which may depend upon

the type of UAS application to be performed and specific requirements of the airspace in which the UA will fly.

7. Similar as ACAS, terrain detection equipment has been used in manned aviation for years. For the same reason as ACAS, an adaptation of the equipment is necessary based on specific UAS system requirements, which may depend upon the type of UAS application to be performed and specific requirements of the airspace in which the UA will fly.
8. Situational Awareness of UA pilots is of special relevance as the pilot is not on-board the UA. In manned aviation the development of Cockpit Displays of Traffic Information (CDTI) and Advanced Human Machine Interfaces is already in progress. However, these developments are focused on pilots on-board the aircraft. The adaptation of these systems for the UAS control station on the ground is necessary to enhance the situational awareness of UA pilots.
9. Radio frequency spectrum availability is limited.

4.2.5 Technology Developments and Solutions

It is clear that UAS shall not only rely on technology for flying in non-segregated airspace:

- Procedures shall be developed
- Regulations shall be put in place

INOUI has developed a concept of operations to integrate UAS in non-segregated airspace including procedures in WP1 and WP3 which have assessed how regulations should be adapted to enable such integration.

However, it should not be forgotten that technologies remain an important driver for the integration of UAS. In the following sections the technological developments needed to achieve a safe UAS integration are addressed.

4.2.5.1 Developments for a safe integration - Data Exchange

A secure and certified advanced data link and a next generation of GNSS for primary means of navigation to support data exchange and improved CNS applications, in particular sense/detect and avoid capabilities need to be developed for UAS in order to comply with a safe integration.

In order to comply with one of the SESAR cornerstones, UAS need the capability to share information across a common information management system (SWIM) and comply with its interoperability requirements.

One important issue that needs to be addressed is the total bandwidth required to support (European) UAS operations:

- Radio frequency spectrum is in limited supply and in many areas is already heavily used. Therefore, solving the challenge of finding suitable spectrum for the operation of UAS is an important and necessary step for the growth of the UAS industry.
- At international level the allocation of spectrum is the responsibility of the International Telecommunication Union (ITU). For major spectrum decisions, national representatives of all countries meet approximately every four years at the World Radio Communication Conferences (WRC) to agree on new or revised spectrum allocations and associated procedures to use them.
- The ITU WRC07 (held in October/November 2007) decided to put on the agenda of ITU WRC-12 the spectrum requirements for UAS Operation.
- Bandwidth and frequencies for UAS are one of the major international issues for the next WRC to be held in 2012, and beyond.

In the field of frequency allocation for UAS, the European Defence Agency (EDA) launched in 2009 the so called SIGAT project ("Study on Military Spectrum Requirements for the Insertion into the General Air Traffic for the UAS").

4.2.5.2 Developments for a safe integration – Communications with ATC

As identified by INOUI WP1 as well as by the “Joint JAA / EUROCONTROL Initiative on UAVs”, UAS should comply with the principle of transparency, by which an ATC controller must not be expected to do anything different using radio telephony or landlines (such as such as metal wire or optical fibre) than he would do for other aircraft under his control. He should not apply different rules or work to different criteria either.

This principle of transparency also means that UAS need to be able to meet the equipment requirements applicable to the class of airspace they are intending to fly.

4.2.5.3 Developments for a safe Integration – Navigation

One of the key elements of the future SESAR environment is the Business Trajectory (BT). This trajectory is always associated with all the data needed to describe the flight. In particular, air traffic service units need to know the capabilities of the aircraft concerned to enable them to select the most appropriate and efficient trajectory management methods (including the separation methods). UAS as any other airspace users will have to comply with the concept of business trajectories in order to allow their integration into the non-segregated airspace.

It is clear that UAS as any other airspace users will have to comply with the concept of business trajectories in order to allow their integration into the non-segregated airspace.

4.2.5.4 Developments for a safe integration – Surveillance

Probably the main gap currently jeopardizing the safe integration of UAS into the non-segregated airspace from the surveillance point of view is the lack of surveillance capabilities on-board the UAS to replace the human capability of “see and avoid” in manned aviation.

Several different technologies might be used to solve the lack of sense / detect and avoid capability:

- Possible use of cooperative sensors employing transponder methods
- Possible use of ADS-B technologies
- Possible use of non-cooperative sensors such as:
    - Passive ones, e.g. optical camera recording the reflected light or acoustic sensors perceiving the target by passively listening
    - Active ones, e.g. radar which emits an electronic pulse and determine range and bearing by the sensor and timing in response
- Possible use of multiple sensors (sensor fusion)

An important step forward in this field is expected by the MIDCAS (Mid Air Collision Avoidance System) project, which has recently started. The objective of this 50 million Euro technology demonstrator under the umbrella of EDA is to support the development of the critical Sense & Avoid Technology, to demonstrate the baseline of solutions for the Unmanned Aircraft Systems Mid-air Collision Avoidance function which is acceptable by the manned aviation community and is compatible with UAS operations in non-segregated airspace by 2015. The project also addresses in an iterative approach which requirements and standards can progress in parallel with solutions development.

Another important aspect in the UAS surveillance area is to pay adequate attention to weather, terrain and obstacles.

Therefore, it is conclusion of the INOUI work as well as common understanding within the Stakeholder Community that one of the main aspects to be addressed is the development of a certification framework for sense/detect and avoid technology for civil and governmental UAS.

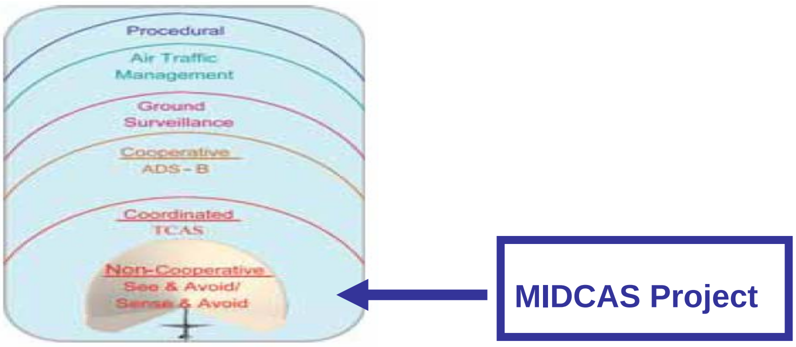


Figure 4 Safety mechanisms for civil aviation (Source: SESAR)

4.3 Conclusions and Recommendations

Based on the research within INOUI WP2 the following conclusions and recommendations were derived:

- Most of the technology needed is available for manned aircraft and for unmanned aircraft systems but there is a need for compatibility and interoperability.
- Research and technology development needs to be harmonised in cooperation with the final UAS users as it will benefit the whole aviation community.
- Technologies coming from manned aviation are subject to be adapted to the UAS world and vice versa.
- CNS technologies offer opportunities but also challenges.
- Different UAS applications may need different technologies.
- Dialogue between standardisation and regulatory bodies and UAS technology developers is required to address systems specifics and to reach consensus on the certification procedures for each system.

Key issue remains the need for compatibility and interoperability of current and future technologies among all air space users.

4.4 User of the results

As mentioned above, SESAR D3 explicitly states:

"Specific technologies needed for UAS to ensure a transparent operation similar to a manned aircraft (e.g. dedicated high integrity UAV/operator[3] command and control data links) fall outside SESAR. It is however conceivable that some technologies that will be developed in the coming years by and for the UAS community will find their way to manned aircraft as well as we know of the requirements of advanced business aviation where sense and avoid technologies are sought for in the not too far future"

From this statement and from the work performed by the INOUI team two conclusions can be drawn:

1. UAS community is not the only one who can benefit from INOUI results.
2. SESAR and manned aviation community in general can benefit as well.

Beneficiaries of the results of INOUI work package 2 more detailed:

[3] "Operator" should now be replaced by "Pilot" considering the Eurocae Terminology

- SESAR, i.e.
    - SESAR WP B Target Concept
    - SESAR WPE R&D Long Term
    - SESAR WP4 En Route Operations
    - SESAR WP5 TMA Operations
- UAS Manufacturers
- Manned Aircraft Manufacturers
- Airborne Systems Manufacturers
- Personal Air Transport Community, such as general aviation, business aviation and in general personal air transport community as defined by EPATS project.

5 Work Package 3 « Certification Blue Print for UAS in Europe »

5.1 Scope of Work and Method of Research

Subject of the work package

The scope of INOUI WP3 is to assess the certification and qualification issues related to UAS to enable their routine operation within the next 20 years and to review and, to a certain extent, analyse the current regulatory framework in which UAS will be employed. The framework affects the operation and manufacturing of UAS in several ways, namely:

- The regulations that have to be taken into account for their operations.
- The processes that have to be followed in order to obtain an airworthiness certification for any UAS.
- The requirements, education and training that UAS personnel, especially pilots and other crew and maintenance staff, have to comply with.

The existing laws and standards are analysed in the present work package, covering a range from ICAO to European or even national rules. When applicability is not only relevant to unmanned aircraft, changes in manned aviation regulation are proposed to set up the future regulation accommodating UAS.

Deliverables of work package

INOUI WP3 consists of three deliverables, each one showing different aspects of the results of this work package. These deliverables are:

D3.1 Regulatory Aspects for UAS Operations, Operators and Personnel Qualification	This document assesses the regulatory issues related to the operational aspects of the UAS: Regulation of UAS Operations and Operators, UAS Personnel Qualification and related ATM Issues.
D3.2 UAS Certification	This document provides an analysis of the current regulation in relation with airworthiness principles and environmental certification for UAS.
D3.3 Regulatory Roadmap for UAS Integration in the SES	This document is outlining the course for introduction of a regulatory framework enabling UAS integration. It highlights the current status of regulatory and standardisation initiatives and derives a list of topics to be addressed.

Methods of research

The research undertaken in this work package has followed, as a methodology, the examination of mainly eight different documentary sources of information, namely:

- EUROCAE WG-73 SG2
- RTCA SC 203
- SESAR D3 The ATM Target Concept
- CAA JARUS initiative
- EASA documentation
- EDA documentation
- EUROCONTROL initiatives
- JAPCC, military UAS operation

Some of the INOUI partners are also members of the aforementioned groups, what guarantees that a correct flow of information has been achieved.

In addition to these pre-existing sources, the INOUI project held two Stakeholder Workshops that allowed for a wider collection of data. Especially the 1st INOUI Stakeholder Workshop, held 21 – 23 October 2008 addressed the issues of regulation and certification within a dedicated working session.

The INOUI team participants in these tasks are Isdefe, DFS, Boeing, ONERA, RDE:

- ISD with expertise and experience in UAS regulation of operation.
- RDE with expertise and experience in UAS certification and personnel qualification and regulation of operation.
- DFS with expertise and experience in UAS regulation of operation and ATM issues.
- ONE with expertise and experience in UAS concept definition, airworthiness analysis, certification and operation regulations, and UAS pilot human machine interface (HMI).
- BRTE with expertise and experience in UAS certification.

In order to achieve INOUI WP3 objectives a stepwise approach has been followed:

4) First, the regulatory issues related to the operational aspects of the UAS were described, namely: Regulation of UAS Operations and Operators, UAS Personnel Qualification, ATM Issues and Aerodrome Issues. International and national aviation regulations and ongoing activities in the area of UAS were analysed for the previous topics. They were listed and assessed, and conclusions were derived at the end of the assessment.
5) Secondly, an analysis of the current regulation in relation with airworthiness and certification of UAS was performed. This included the unmanned aircraft (UA) itself (airframe, software and hardware) as well as the control station (CS) and the

necessary algorithms development framework (autonomy versus automation, as an example). It has been designed to enable the reader to get a comprehensive view about the overall ongoing UAS rulemaking process. The various actions carried out in the USA and in Europe about the UAS airworthiness issues were described, underlining the existing communalities and differences between manned and unmanned aviation. The analysis also encompassed the environmental certification of the UAS in terms of noise and emissions.

6) Third, an assessment of the existing roadmaps was performed to contribute to the integration of the UAS by highlighting the current status and current developments conducted or investigated by working teams on standardization and regulation of the UAS and their operation. In more detail, following works were processed:

- Defining scenarios for the UAS integration into the future ATM system. These scenarios are depending on the evolution of technologies, on the rulemaking process celerity, the possibility for industry to design and bring to market affordable systems complying with regulations and on triggering events such as the framework set by SESAR.
- Setting up possible chronologies between the present time and the mid term future, considering various scenarios.
- Creating a list of actions that are needed to build up the regulatory framework to enable the integration of the UAS into the future ATM system. This list was based on current roadmaps.
- Proposing and assessing required activities to solve the gaps and inconsistencies identified.

As a result, D3.3 provides guidance on the issues, gaps and obstacles that will need to be overcome from a regulatory perspective before full acceptance of UAS operations in the SESAR environment can occur. The duration of this acceptance process will be closely linked to the attention, motivation and resources the entire aerospace communities commit with UAS.

It has to be noted that each step above described match to each WP 3 sub-work package, namely:

WP3.1 Regulatory Aspects for UAS Operations, Operators and Personnel Qualification

WP3.2 UAS Certification

WP3.3 Regulatory Roadmap for UAS Integration in the SES

5.2 Findings of the Work Package

5.2.1 Baselines for the work

5.2.1.1 Assessment of environment and assumptions

A general rule to be respected in the regulation and certification of UAS is that they cannot worsen the current safety levels for aviation. Therefore all aspects related to unmanned aircraft systems must adhere to this constraint. As can be seen below, the different modes of operation, laws and certification processes are affected by the basic safety principle that UAS shall have no adverse effect on ATM safety.

Summarising, the base lines for the work of WP 3 were:

- High demand for UAS operations existing
    - Civil, State and military users
    - Wide spectrum of potential missions waiting for the rules and standards that will be used to design the needed types of UAS (from small vehicles to large High Altitude Long Endurance systems, fixed wing and rotary wing aircraft…),
- UAS have to be operated with the same level of safety as manned aircraft
    - UAS airworthiness
    - UAS operational procedures
    - Crew selection, education, training and licensing
- UAS certification being built is based on manned aviation rules
- There exist UAS peculiarities, compared to manned aviation, i.e.
    - Risk of total loss of C2 data link due to operation
    - Sense and avoid
    - Dedicated handling of emergencies, e.g. forced landing
    - Crew fatigue, incapacitation, permissible flight time
    - Pilot situational awareness
- New paradigm upcoming in case of unmanned aviation: In the UAS case the focus has shifted from loss of the aircraft to fatalities to third parties on the ground, due to the fact that there is no human on board of the UA.

Furthermore, the developments in the field of regulation of UAS (including operation) of several bodies working at national and international levels were considered accordingly, e.g. EUROCAE WG 73, JARUS, FAA and the Military.

5.2.1.2 Modes of Operation

Facilitating the analysis of the different topics the INOUI project followed the approach of clustering. The UAS operations are generally classified into several different "modes of operations". Moreover, the UAS themselves have also been classified according to their maximum take-off mass. The reason for the latter classification is due to the fact that EASA is in charge of UAS having a UA of more than 150 kg while smaller UAS are in the remit of national authorities.

Regarding the operational classification, the issues to be addressed are the relative location of the pilot to the aircraft (line of sight or not) and the type of airspace to be used.

The resulting modes of operation are quite numerous due to the combination of 7 classes of airspace, 2 flight regimes (IFR and VFR) and 3 line of sight situations. In order to simplify the analysis, the INOUI team made a selection of modes of operation based on those modes being used in other working groups..

- Visual Line of Sight (VLOS) operation of small UAS (under 150kg) in visual line of sight as illustrated in **Fehler! Verweisquelle konnte nicht gefunden werden.**.
- Radio Line of Sight (RLOS) operations as illustrated in Figure 6 , including the different classes:
    - IFR, class A to C airspace, excluding non-segregated aerodromes.
    - VFR and IFR, class A to G airspace, excluding non-segregated aerodromes.
    - VFR and IFR, class A to G airspace, including non-segregated aerodromes.
- Beyond Radio Line of Sight (BRLOS) operations, including the different classes:
    - IFR, class A to C airspace, excluding non-segregated aerodromes.
    - VFR and IFR, class A to G airspace, excluding non–segregated aerodromes.
    - VFR and IFR, class A to G airspace, including non–segregated aerodromes.

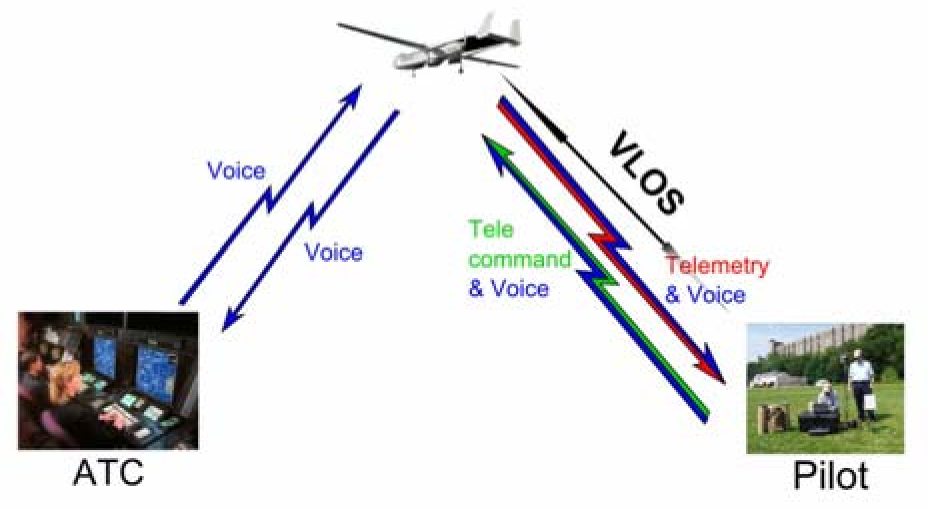


Figure 5 UAS mission enabling visual contact operations with possible ATC-pilot communications relayed through the UA

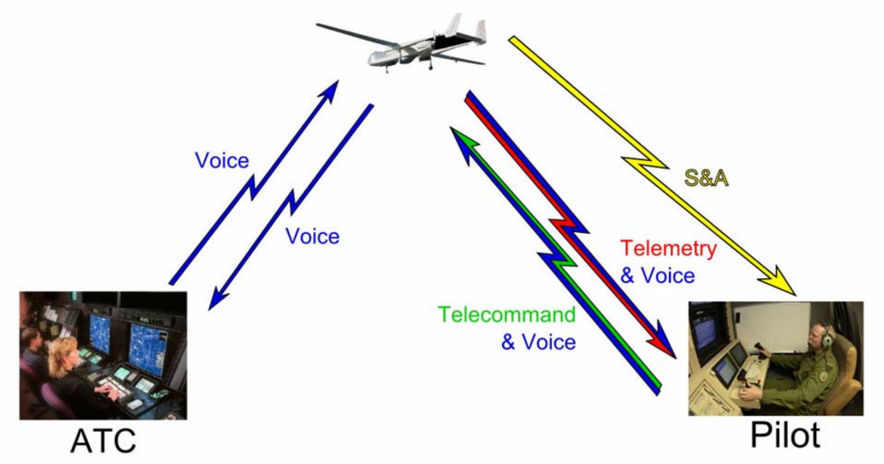


Figure 6 UAS mission enabling LOS data link operations

Regarding the function to be performed either by the ATC or by the UA pilot according to the flight regime and the class of airspace that is used, the complexity of the situation is illustrated in **Fehler! Verweisquelle konnte nicht gefunden werden.**;

Types of flight / Airspace classes	A	B	C	D	E	F	G
IFR/IFR separation	ATC	ATC	ATC	ATC	ATC	UAS_{ATC}	UAS_{ATC}
IFR/VFR separation	X	ATC	ATC	UAS_{ATC}	UAS_{ATC} / UAS	UAS	UAS
VFR/VFR separation	X	ATC	UAS_{ATC}	UAS_{ATC}	UAS_{ATC} / UAS	UAS	UAS
ALL collision avoidance	UAS	UAS	UAS	UAS	UAS	UAS	UAS

X : Separation not to be performed (no VFR in class A), but exceptions possible

ATC **Function provided by ATC**

UAS_{ATC} **Function provided by UAS with traffic information from ATC**

UAS **Function provided by UAS on his own**

Figure 7 Complexity of the UA modes of operation

5.2.2 Regulatory Aspects for UAS Operations, Operators and Personnel Qualification

The regulatory issues related to the operational aspects of the UAS are assessed in the D3.1 “Regulatory Aspects for UAS Operations, Operators, and Personnel Qualification”. A long list of relevant certification initiatives (European and international) already under development or to be launched in the near future has been analysed. In the regulatory frameworks that have been reviewed there is room for many issues such as those related to communications. Airports have also been studied, showing the problems related to them: on the one hand, UAS have to adapt to the existing infrastructure despite the fact that they are not fitted for them; on the other hand, future regulation may allow for the construction of aerodromes and heliports fully devoted to unmanned systems. Finally, the licences for pilots and personnel have been analysed, along with gaps in the current regulations and the training that operators might have to undergo.

Currently there is no single European agency to lead efforts on the integration of UAS, which is producing a large dispersion of efforts, so that parallel studies are carried out on behalf of the body that promotes them, or national solutions are carried out. Both conclusions will not be consistent until the criteria and solutions provided by the various working groups are unified.

In the near future there will be a proliferation of UAS certification initiatives all over the world. UAS applications are ready to be performed whereas Unmanned Aircraft Systems are not cleared to be used due to a lack of a regulatory framework. UAS users, currently mainly military but increasing civil participation in the future, are pushing hard to get their systems fully operational with a routine access to the airspace. A clear position is therefore needed from the numerous agencies involved, coordinating the UAS certification and regulation with the SESAR development.

The integration of UAS in non-segregated airspace must deal with the resolution of major challenges. The following are the main conclusions identified in D3.1:

- Implementation of existing rules of the air with the same level of safety as manned aircraft, which implies providing a technological solution able to the overcome the fact that no crew is on board with emphasis on the ability of observation and maintenance of secure communications.
- Lack of qualified personnel to execute the maintenance tasks represents a hazard to the UAS operations and may worsen the public perception of these kinds of systems. Regarding this issue, modification of current standards would ease the achievement of the certification of these systems and would improve the general public trust in them, avoiding to be perceived as risky.
- Responsibility of the pilot in command to inspect the aircraft prior to the beginning of the flight. However, in the UAS operation, the pilot may be located far away from the aircraft and then be unable to inspect the aerial platform. Therefore some change to the regulations should be studied.
- The regulations should allow an unmanned aircraft to be operated successively by several pilots, e.g., for those large endurance surveillance missions or transoceanic cargo flights. This situation already occurs in the manned aviation when a change in the flight crew happens during the transatlantic flights.

- Regarding ATM and aerodrome operations, there are clear differences between manned and unmanned aircraft and systems. However UAS operations will be based on current aerodromes, so they will have to adapt to the current infrastructure. But there exist the possibility to design new aerodromes fully devoted to UAS.
- The regulation demands the pilot in command to demonstrate three takeoffs and landings of the specific UAS in the previous 90 days. Once again the use of pilots in remote locations poses a problem, since the commander may not be able to supervise the physical state of the airframe after the operations. Moreover, a great deal of UAS launches and recoveries (launching pads, parachutes) have nothing to do with manned aircraft and they require the pilot to know little about them, apart from being able to determine when to start the manoeuvre. To solve this problem, most countries allow the use of simulator based training missions instead of changing regulations.
- The European approach cannot be regarded as the only solution. The initiatives from other countries should also be studied and that means, of course, to take a careful look at the situation in the USA. Several common points, as well as friction areas, occur between the United States of America and its European counterpart.
- Unlike EASA, the USA regulator has no clear position on the weight limit that might force a pilot to hold a proper certificate. This may lead to a situation in which a licensed pilot from the USA may not be able to fly in the European airspace. Global operations would be impaired, so it is suggested to find a way to harmonize the weight requirements.

5.2.3 UAS Certification

The regulatory issues related to the certification of the UAS are assessed in the D3.2 “UAS Certification”. The certification of the unmanned aviation is being built on the considerable knowledge gained for manned aviation all along the first century of aviation, from the early 20th century to present time. Either manned or unmanned, an aircraft is still a flying machine that must have a high probability to be able to keep flying, despite technical problems, and to limit any interference with other airspace users and to the population that live under its flight path. As a consequence, the certification issues of unmanned and manned aviation have much communality. Nowadays, there is a proliferation of UAS certification initiatives all over the world, mainly in the USA (RTCA SC 203) and in Europe (EUROCAE WG73 and CAAs / JARUS). UAS applications are ready to be performed whereas Unmanned Aircraft Systems are not cleared to be used due to a lack of a regulatory framework. UAS potential users, that are currently mainly military, are pushing hard to get their systems fully operational, with a routine access to the airspace.

The certification of UAS must deal with the resolution of major challenges. The following are the main conclusions identified in D3.2:

- Due to the absence at this stage of a dedicated UAS Certification Specification, the establishment of a detailed UAS Type Certification Basis is likely to be a case by case joint effort between the Certifying authority and the Applicant, with due consideration of the envisaged UAS configuration and mode of operation."
- There are a number of issues that may be handled in a generic manner, such as UAS System Safety Objectives and Criteria, EASA (manned) Certification Specification tailoring and Special Conditions / Interpretive Materials / Acceptance Means of Compliance dealing with specific UAS features required.

- However, the definition of agreed UAS safety objectives and criteria are yet to be established in detail. Moreover, a particularity of UAS is that the interrelation between airworthiness and operational approval aspects is high; hence there is a need for an increased coordination between relevant concerned bodies. This issue makes the overall regulation definition process more complex.
- Regarding the UAS airworthiness issues, due to the absence of people onboard the aircraft, safety objectives consider obviously fatalities to third parties on the ground more severe than the loss of a UA, this is a new paradigm that deserves a particular attention. The full process to get a UAS fully certified is anticipated to be long as an agreement on acceptable safety levels has to be reached. UAS manufacturers and regulatory bodies have to find the right balance between safety levels and costs.
- Regarding the noise and emission issues, although they can be considered as very similar to manned aviation, the environmental impact of the use of UAS for long endurance missions has to be analysed. It is anticipated that technologies will progress. This will just ease the compliance to established requirements and, most probably, allow a higher level of performance aiming at decreasing the emissions levels of both manned and unmanned aviation.

5.2.4 Roadmap for the Regulatory and Certification Frameworks

To road towards active and applicable regulatory and certification frameworks for the UAS operation has been crowded in the last few years. Whereas nearly no action was undertaken at the time the INOUI project was submitted to the European Commission, nowadays multinational groups of people (estimations give a figure of more than 200 people currently working on this issue in SC203, WG73 and JARUS) are now fully committed to make possible a routine use of UAS in the near future. This new trend is good news for providing progress and the implementation of technologies needed to reach a satisfactory safety level soon.

The INOUI deliverable D3.3 “Regulatory Roadmap for UAS Integration in the SES” shows that the work that has to be performed by those various groups is huge, but is already well advanced. This deliverable has evolved the works done in D3.1 and D3.2 to propose a clear picture of the current status of the regulatory and certification frameworks for the UAS operation. The INOUI consortium members do not challenge the actors of these official bodies, but integrate with the holistic approach of INOUI into their efforts. This way of collaborative working allows the INOUI Consortium an independent and outside processing of information and generating a holistic view over all activities of these official bodies. The thoughts and results of INOUI are provided and used as independent input and help to align for the activities of the different working groups, targeting to enable the decision-makers to have a simpler and more clear view of the activities and needs in the UAS arena.

A summary of all actions listed in the document D3.3 is presented below. The actions were grouped under three topics:

- UAS Airworthiness Certification Principles,,
- Regulations for Personnel Qualification, and
- Regulations for Air Operations and Operators.

5.2.4.1 Actions for UAS Airworthiness Certification

The following table introduces the actions to be carried out to set the UAS Airworthiness Certification framework.

The actions appear in the fourth column of the table. Every action is coded with a two digits code, the “A” letter (standing for Airworthiness) followed by a serial number (A1-17). Every action corresponds to a generic topic enunciated in the second column of the table and described in the third column.

ID	Topic	Description	Action
A1	Command and Control (C2) link safety and security	Regulations with regards he safety and security of UAS command and control data links	Define how this hazard will be mitigated and standards created
A2	UAS Certification	Process to prove that the UAS is airworthy	Select relevant manned aircraft CS
A3			Customize CS
A4			Submit customized CS to EASA
A5	Sense and Avoid Systems	System able to provide the pilot with relevant information to separate from and avoid collision with other airspace users	Create MASPS
A6			Certify Sense and Avoid System
A7	Environmental Certification	Gas and noise emissions	Define framework for the Environmental Certification of UAS (gas and noise emissions)
A8	Collision avoidance	Aircraft shall not be operated in a negligent or reckless manner so as to endanger life or property of others. Such danger may be collisions of aircraft with the surface (and people and property thereon) or with another aircraft	Determine UAS requirements to avoid unexpected collisions with the surface. When necessary procedural requirements may be needed such as the determination of a threshold population density. Technological means may also help as in manned aviation (TAWS)
A9			Determine UAS requirements to avoid unexpected collisions with another aircraft. When necessary procedural requirements may be needed such as separation minima between UA and aircraft. Technological means may also help as in manned aviation (TCAS, FLARM or specific Sense and Avoid Technologies)
A10	Recorders	Necessity of flight data recorders and cockpit voice recorders for UAS	Determine whether FDR and CVR are needed for UAS (depending on the type of UA and application). Equipment on board the UA may increase weight. Equipment on the control station may be more feasible

ID	Topic	Description	Action
A11			Determine the preservation times of data or voice (if needed) recorded
A12	Low Visibility Operations	Requirements for low visibility operations for UAS	Determine the type of low visibility operations based on the level of autonomy of the UA (as in CAT I/II/III approaches for manned aircraft)
A13			Determine criteria in terms of ceiling, visibility and approach equipment for the different types of UAS
A14	Equipment	Equipment needed to fly	Determine the equipment needed to fly depending on the type of UA, application, type of operation (VLOS, BLOS), airspace (communication with ATC)
A15			Determine whether specific equipment requirements (and procedures) may be required for take-off, landing and emergency
A16	Signals	Use of signals by UAS used for indication specific issues to manned aircraft	Determine whether the use of signals by UAS is still applicable or not.
A17			Determine whether a UA observer as part of the flight crew is useful for operations on ground, transmitting signals status to the UA pilot

5.2.4.2 Actions for Regulations for Personnel Qualification

The following table introduces the actions to be carried out to set the Regulations for Personnel Qualification framework.

The actions appear in the fourth column of the table. Every action is coded with a two digit code, the letter “C” (standing for Crew) followed by a serial number (C1-18). Every action corresponds to a generic topic given in the second column of the table and described in the third column.

ID	Topic	Description	Action
C1	Medical Fitness	UAS Crew members require a medical certificate.	Determine level of medical certification

ID	Topic	Description	Action
C2	Licenses and Ratings	UA pilots require a license	Determine for whom a license in a UAS is essential (e.g. operational and technical activities, checking functions)
C3		Distinction between commercial and non-commercial licenses for UA pilots	Determine whether this distinction should be made based upon UAS applications (e.g. when a UA is operated for remuneration a commercial pilot license should be considered, otherwise an equivalent of a PPL should be considered)
C4		Distinction between single pilot and multi-pilot licenses for UA pilots	Determine whether multi-pilot licenses are needed for UAS applications
C5		UA pilot ratings	Determine the number and scope of ratings depending on the type of operations (VLOS or BLOS), level of autonomy, type of take-off, landing.
C6		Validity of licenses and ratings	Determine requirements and procedures for the validity, revalidation and renewal of UA pilot licenses and ratings
C7		Issue of UA pilot licenses	Determine whether the license should be issued by the Authority or be part of the Operator Approval
C8	Synthetic Flight Instruction	Use of synthetic flight trainers for training of UA crew members	Determine requirements for the UA crew members related to training in synthetic flight training. Simulators may be insufficient to train the entire crew (e.g. launch and recovery system)
C9			Determine requirements for these simulators
C10	Age	Age restrictions to UA crew	Determine minimum age for UA crew based on the type of UA and legal responsibilities
C11			Determine maximum age for UA crew based on medical issues, operational proficiency check and recurring training
C12	Experience	Experience required for UA pilot licenses and ratings	Determine which experience is needed for obtaining a pilot license and ratings (e.g. number of take-offs and landings, number of hours in a simulator)

ID	Topic	Description	Action
C13	Training	Flight Instruction and flight test required for UA crew	Determine which training level is necessary depending on the function to be performed and the kind of license required
C14	Theoretical knowledge, skill and examination	Theoretical knowledge required from the UA crew	Determine specific issues required. When necessary issues should be tailored from manned aircraft requirements (e.g. air law, aircraft general knowledge, flight performance and training, meteorology, navigation, etc.)
C15	Crew Composition	UAS may have different crew members for the different flight phases, and crew members may perform other functions than piloting	Determine who comprises the UA crew based upon the application to be performed
C16			Determine whether maintenance personnel is part of the UA crew (as failures in the control station may occur during a flight and may require quick actions by the maintenance personnel)
C17	Responsibilities and Handover	Responsibilities of the UA pilot	Determine whether it is feasible and safe to control more than one UA by a single UA pilot
C18			Determine handover of responsibilities and control during a UA flight

5.2.4.3 Actions for Regulations for Air Operations and Operators

The following table introduces the actions to be carried out to set the Regulations for Air Operations and Operators framework.

The actions appear in the fourth column of the table. Every action is coded with a two digit code, the letter “O” (standing for Operation) followed by a serial number (O1-6). Every action corresponds to a generic topic given in the second column of the table and described in the third column.

ID	Topic	Description	Action
O1	Performance	Performance classes of a UAS	Determine the set of operating criteria for the different types of UA, operations, applications and airspace

O2			Determine the performance requirements for UAS with unconventional ways for take-off and landing: launch-assisted, rocket-assisted, arresting gear cables of arresting nets
O3			Determine operational procedures when the equipment does not perform as designed (e.g. aborted launches when the rocket does not work or landings when the arresting gear does not work)
O4	Operational procedures	Emergency management	Loss of link due to flight path (lower altitude than expected, terrain mask, out of transmission range)
O5			Forced landing
O6			Forced crash

5.2.4.4 UAS Roadmap Actions

As a consequent next step the tasks to be developed for the regulation of the UAS and their operations within the different groups of UAS and mission types where assessed according to the foreseen level of difficulty and according to the current status of work. The development status of each task in the current situation, and the corresponding working group, is given per cell. [4]

The table also identifies which tasks are currently covered for which missions and how the other missions could benefit from these advances. The table also marks tasks which are not required to be performed with a “not applicable”- status (N/A).

Each mode of operation (VLOS, RLOS and BLOS) was split into the types of operation according to the type of airspace where the UAS operates. For every type of operation, two columns provide the information regarding the status of the tasks, whereby the colour coding indicates the complexity in accomplishing the task: green for “*already solved*”, orange indicates “*to be solved in the short term*” and red for “*highly difficult tasks requiring significant effort to be solved*”. The first column shows whether the task has been solved and its level of complexity, if not, indicating whether it is expected to be solved in the short or medium term; the second column gives the organisation performing the task and the level of complexity expected.

The table legend is as follows:

[4] References used in generating this table are the current regulations on operations, maintenance and licensing (esp. JAR-OPS, JAR-FCL, JAR-145/147 and 66, ICAO Annexes 1, 2, 6, 10, 11 and 18).

Foreseen Difficulty Level	
Issue solved	
Issue solvable in the short term	
Issue needing significant work	

Status of Work	
Regulator / industry are dealing with the issue	
Issue not currently analysed - no anticipated difficulties	
Issue not currently addressed - anticipated difficulties	

ID	Modes of operation						
	VLOS, UA< 150 kg	RLOS operations of UA above 150kg			BRLOS operations of UA above 150kg		
	VLOS operations of small UA (under 150 kg)	IFR, class A to C airspace, excluding non-segregated aerodromes	VFR and IFR, class A to G airspace, excluding non-segregated aerodromes	VFR and IFR, class A to G airspace, including non-segregated aerodromes	IFR, class A to C airspace, excluding non-segregated aerodromes	VFR and IFR, class A to G airspace, excluding non-segregated aerodromes	VFR and IFR, class A to G airspace, including non-segregated aerodromes
A1	Airworthiness	Airworthiness + ops					
A2	No manned aircraft CS for small UA	EASA policy	EASA policy	EASA policy	EASA policy	EASA policy	EASA policy
A3							
A4							
A5	N/A	WG73					
A6	N/A	Industry					
A7	N/A	Industry					
A8	N/A	WG73			WG73		
A9	N/A	WG73			WG73		
A10	N/A						
A11	N/A						
A12	N/A						
A13	N/A						
A14							
A15							
A16	N/A						
A17							
C1	JARUS	JARUS	JARUS	JARUS			
C2	JARUS	JARUS	JARUS	JARUS			
C3	JARUS	JARUS	JARUS	JARUS			
C4	JARUS	JARUS	JARUS	JARUS			
C5	JARUS	JARUS	JARUS	JARUS			
C6	JARUS	JARUS	JARUS	JARUS			
C7	JARUS	JARUS	JARUS	JARUS			
C8	N/A						
C9	N/A						
C10							
C11							
C12							
C13							
C14							
C15							
C16							
C17							
C18							
O1							
O2	N/A						
O3							
O4							
O5							
O6							

5.3 Conclusions and Recommendations

By the years 2008 / 2009, there was a proliferation of UAS certification initiatives all over the world. UAS applications are defined and thus ready to be performed while Unmanned Aircraft Systems are not cleared to be used due to the lack of a regulatory framework and respective technological gaps. In parallel the potential users of UAS are pushing hard to get their systems fully operational with a routine access to the airspace, performing the envisaged missions and benefiting their business with this innovative technology and its opportunities. The increase of interest in UAS by civil operators (both private and institutional) as a consequence of the obvious high potential of these systems, as demonstrated in their current operation in military missions, is remarkable.

The research and assessment performed and documented during the INOUI project shows that the work to be completed is huge. Various groups have already started and progressed in some of the actions. INOUI has focused its efforts at processing the information generated by the different working groups and to assess their results with the aim to provide the Stakeholder Community with an overall view of the current work on regulation of UAS and their operations. Consequently, INOUI WP3.2 and WP3.3 are based on the work available from EUROCAE WG73, EASA, EUROCONTROL, EDA and JARUS.

The recent publication of the EASA policy (E.Y013-01 Policy Statement - Airworthiness Certification of Unmanned Aircraft Systems (UAS), 25/08/2009) establishes general principles for type-certification (including environmental protection) of an Unmanned Aircraft System (UAS). This is a big step forward as it provides a framework to aid the acceptance and standardisation of UAS certification procedures. This policy serves as a reference and a starting point to coordinate the efforts of the different groups working on this topic.

UAS integration will also benefit from the coordination of activities within the EU and the FAA (NextGen) and the military activities towards a successful integration of the UAS.

Regarding airworthiness a new paradigm deserves particular attention: In the UAS case the focus has shifted from loss of the aircraft to fatalities to third parties on the ground, due to the fact that there is no human on board of the UA. Appropriate safety criteria involving population density, kinetic energy etc. have to be developed. The full process to get a UAS fully certified is anticipated to be long, as an agreement on acceptable safety levels has to be reached[5].

A particularity of UAS is that the interrelation between airworthiness and operational approval aspects is high. This is mainly due to the fact that the pilot keeps control of the aircraft through a data link that can technically fail (airworthiness) and can become inoperative during the flight, e.g. because of distance, weather or to terrain masking problems. Hence, there is a need for increased coordination between relevant concerned bodies. This makes the overall regulation definition process more complex.

[5] The interested reader is referred to the INOUI documents of work package 5, Safety Analysis of Civil UAS Operation.

With respect to the noise and emission issues, although they can be considered as very similar to manned aviation, the actual environmental impact of the use of UAS has to be assessed in conjunction with their specific operation modes. UAS will be regulated based on the same standards and regulations as manned aircraft, taking into account they may be used for long duration and/or repetitively over particular locations.

The road to go until UAS can be formerly approved in the airspace appears to be not easy and still challenging. Namely the next topics will require further, longer lasting work:

- UAS System Safety objectives and criteria
- Theoretical knowledge, skills and examination requirements for UAS operators and personnel, i.e. for pilots, maintenance crew, etc.
- Potential legal responsibilities sharing between pilot acting in real time and UA designer that created and validated the automated UA behaviour;
- Handover issues when using multiple control station for a single UA.

Similarly, there are other topics that are expected to be solved in a shorter time, but will also demand hard work from the experts involved, as is the case for:

- Synthetic flight instruction (use of simulators).
- Experience, since the holder of the licence may be required to show a previous experience and perhaps even with manned vehicles.
- Training
- Crew composition and role.
- Signals, from the UAS to manned aircraft.

Fortunately, there are some topics that can be solved in the short term and that are currently being developed by the working groups mentioned previously. Solving these topics will make the solution of more complex tasks easier and will enable and facilitate the operation of UAS in a stepwise approach. The topics expected to be solved short term are:

- Environmental certification, both noise and gas emissions.
- Medical fitness requirements for the pilots and controllers.
- Licence and ratings. Types of pilots and controllers may be needed and not all of them may be required to possess the same knowledge or skills.
- Age restrictions for personnel, similar to those for manned aviation personnel.
- Separation provision and collision avoidance, not considering automated means.
- Recorders.

Concluding, general target within the UAS Stakeholder Community is to integrate UAS stepwise until 2020. The sequence to implement the different modes of UAS operations depends on how the system designs are able to comply with regulations in order to meet the required safety objectives. Although such regulations are not available yet, the momentum built up over the last two years, has to be maintained and, if possible, increased as several long term issues have only been addressed lately. In addition, a lot remains to be done in the short and medium term. Regulators and decision makers must bear in mind that once the regulations are available, the UAS community will need time to adapt their products and services to the regulations. Hence, no immediate integration of the UAS will be obtained at the time the regulations are ready.

5.4 User of the results

The most obvious user of the INOUI results is the UAS community at large. This community can be defined as the people that act in the design, the manufacture, the regulation and the use of UAS. A preliminary list of those people is as follows:

- SESAR WPE Long Term
- SESAR WPB Target Concept
- UAS manufacturers
- Avionics manufacturers
- EASA
- EUROCAE WG-73
- All potential UAS users who are eager to know how far they are from being able to routinely use UAS

6 Work Package 4 « 2020 UAS Common Operation Picture – SWIM enabled »

6.1 Scope of Work and Method of Research

Subject of the work package

Assure the successful integration of the UAS in the non-segregated airspace by the definition of the required interfaces to allow the information exchange between the UAS and any other ATM system through the System Wide Information Management System (SWIM).

This work can be split into the following specific targets:

- Agree and document the concept for the 2020 Common Operating Picture (COP) that will enable seamless UAS operations in Europe.
- Determine all the functions that will allow UAS systems to operate seamlessly in the 2020 SWIM-enabled ATM and as a transparent and integrated data source.
- Define the links between the SWIM-enabled ATM system and UAS systems, specifying the information required by the UAS and the information that these systems share with the SWIM-enabled ATM system. To identify the UAS links between the ATM system and each of the UAS subsystems (ground and air based).
- Study the impact of the different levels of automation of the UAS on the SWIM-enable ATM and if there is any further requirement derived from the fully automated operations.

Deliverables of work package

INOUI WP4 consists of three deliverables, each one containing the results of the research made in the tasks mentioned above:

D4.1 UAS within the 2020 ATM SWIM-enabled system	• System requirements and which are the most probable interfaces with the SWIM system. • Analysis of the information published and subscribed by the UAS
D4.2 New UAS-related common operating picture actors	• Which are the new actors to be introduced in the ATM system by the UAS • Preliminary analysis of the initial security and communication protocols requirements for the UAS SWIM integration

D4.3 Operations depending on the level of automation and autonomy	• UAS Level of Autonomy and their impact as users of SWIM

Methods of research

The research performed within WP4 has been fed by different sources of information:

1. Inputs from other INOUI work packages, particularly WP1 and WP2
2. Coordination with other European Commission projects, particularly with SWIM-SUIT
3. Research in the state of the art on future networked systems
4. Extensive literature review
5. Participation and coordination with industry groups: RTCA SC-203 and EUROCAE WG-73
6. INOUI members expertise and knowledge: Boeing R&TE, ISDEFE, Rheinmetall Defense Electronics, DFS Deutsche Flugsicherung and INNAXIS
    - o BRTE with expertise and experience in how UAS impose requirements to the information management systems in the ATM architecture as well as how the numerous stakeholders involved in the UAS flight handle the operations.
    - o ISD with expertise and experience in avionics, ATC systems, ATM structure and concepts.
    - o RDE with expertise and experience in avionics systems and UAS.
    - o DFS with expertise and experience in ATC systems and air navigation services provision.
    - o INX with expertise and experience in solving systemic complex problems, meaning the interaction between multiple autonomous agents using a diversity of organizational forms in time and space.

In order to achieve INOUI WP4 objectives a stepwise approach has been followed:

1. *WP 4.1 UAS within the 2020 ATM SWIM-enabled system*

   The project considered the 2020 ATM system scenario as the ATM environment into which UAS will be integrated. The research intended to clearly define which UAS configuration will fulfill the system requirements and which the most probable interfaces with the SWIM system are. Also, a first analysis of the information published and subscribed by the UAS has been carried out.

2. *WP 4.2 New UAS-related common operating picture actors*

This work package analyzed and addressed which are the new actors to be introduced in the ATM system by the UAS and how each of those will interface with the system. Also, there was an analysis made of the initial security and communication protocols requirements for the UAS SWIM integration.

Also, we did some research on how the flight critical systems such as “sense / detect and avoid” and “Self Separation assurance” will take advantage of accessing the data provided by SWIM To optimize their operation.

3. *WP 4.3 Operations depending on the level of automation and autonomy*

Based on the research within WP 4.1 and WP4.2 three main topics around the UAS Level of Automation and Autonomy were finally analyzed: Their impact as users of SWIM, their operation in an automated aerial traffic scenario, and a final overview of decision support tools from a human centered automation perspective.

6.2 Findings of the Work Package

The UAS will shortly become an extensive user of the air space. To successfully access the non segregated air space, the UAS should be able to interoperate with the current and future ATM systems. The System Wide Information Management (SWIM) will be the backbone of the future ATM data exchange system. Therefore to assure a correct degree of interoperability between SWIM and the UAS is a must in order to successfully achieve the planned integration.

As the UAS is composed by several subsystems (ground and air based), each of those having different information requirements, it can’t be considered as a unique entity exchanging information with other ATM systems. This one must be considered the main difference between the UAS and any other air space user. Therefore the data exchange process for a UAS should be defined, assigning different roles and responsibilities to each of the UAS subsystems as well as defining which are the information required (consumed) by each of them. This is especially true when talking about safety critical systems where the information provided/ received to/from the SWIM system is required to avoid and incident (e.g. onboard autonomous sense and avoid systems).

The INOUI WP4 was intended to explore how this UAS-SWIM interaction could be done and analyze the implications of such interaction.

6.2.1 UAS within the 2020 ATM SWIM-enabled system (D4.1)

To set the scenario, the D4.1 has defined the main configuration elements around an Unmanned Aerial System (UAS), including the air vehicle (UA), the control Station (CS) and its payload. Reference to interoperability standards, such us the NATO STANAG 4586, have been considered for a seamless approach to interoperability issues. The role of UAS in the future SWIM system was defined, thus establishing preliminary requirements on the UAS interoperability with future network systems. The preliminary definition of the type of information required by UAS to fly inside managed airspace is also considered. Finally, the document presents a complex example of an operating scenario, such as swarming operations.

Configuration of UAS

As defined by NATO standardization agency, UA system can be divided into five high level elements, the air vehicle element, the payload, the datalink, the control station and the launch and recovery element. Section 2 of the D4.1 was aimed to analyze and describe each of those elements to allow the reader to understand the complexity associated to the UAS operations in a SWIM enabled environment.

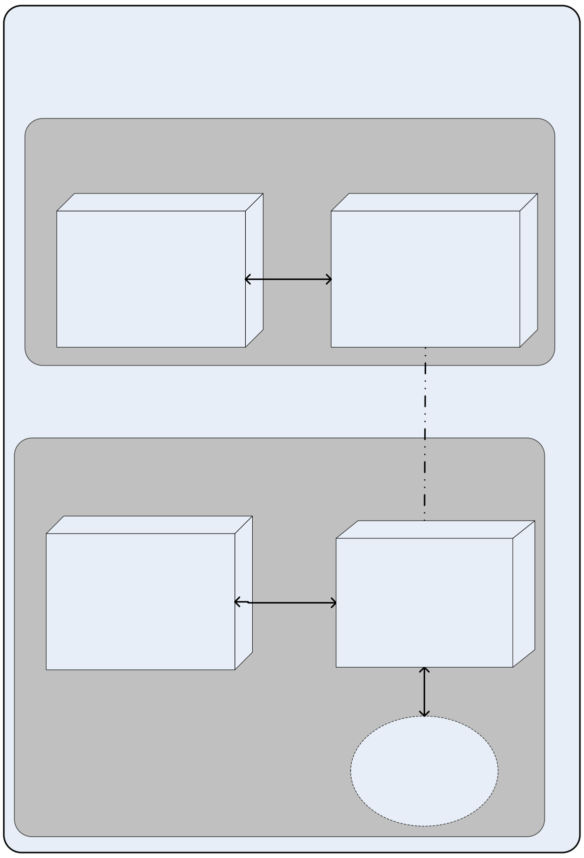


Figure 8 UA System Elements

The unmanned aircraft is been divided in four main categories:

- Navigation systems, describing the expected systems to be found onboard a UA to successfully operate in non segregated airspace.

- Datalink communications, which deals with all those issues associated to the different datalink types and their particular requirements.
- Lighting system, describing the lighting requirements associated to the UA.
- Power plants, as those are a main component for the UAS certification it is important to understand the current power plants available in the market and the future trends.

The control station analysis has been focused on three main topics:

- Interoperability, it is important to assure the interoperability of different control stations with different UA in order to assure and standardization that will allow an easier integration in the SWIM environment, as well as to increase the operational level of safety (back-up options).
- CS key capabilities, where the main requirements for the control station are described.
- Datalink communications, one of the main topics to be addressed in this document, as all of the data to be exchanged between the UA and the CS will be done using different datalinks. Therefore it is important to explore the different requirements and provide different options to fulfil them.
    - Study on the connectivity and interoperability between various CS
    - Datalink encryption standards for critical applications
    - Datalink back-up requirements

Ground and air segments interconnection with ATM systems by SWIM

The UAS are the first airspace users maintaining simultaneously more than one interface with the ATM systems. Both the unmanned aircraft and the control station will interact in some degree with the ATM systems, therefore coherence in those interactions should be assured.

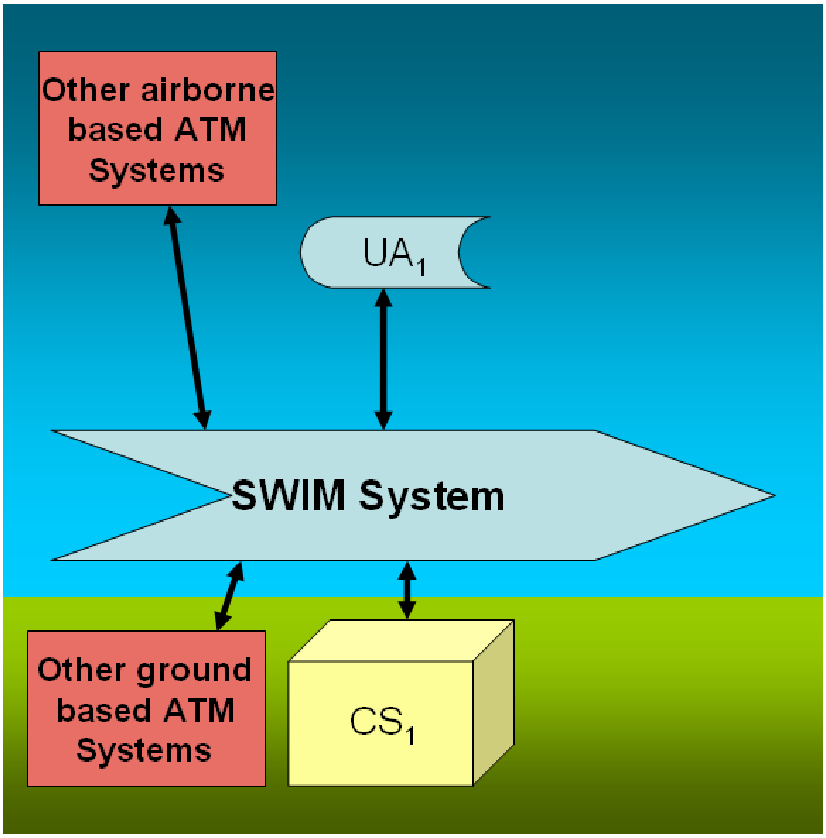


Figure 9 UAS subsystems will interact independently with the ATM system

To do so it is important to define the correct technologies to allow a secure and coherent data exchange between the UAS and the other systems trough SWIM: D4.1 explored how the unmanned systems will impact on the SWIM middleware and which are the more effective technologies to deal will the identified challenges.

It is generally accepted that the main benefit of implementing SWIM is the capacity to deliver the ATM information to the right place at the right time, allowing the airspace users and service providers to make informed and timely decisions. SWIM will also provide reusable interfaces that new applications can use to easily access data produced by existing applications, significantly reducing the cost and cycle time to conceptualize, create and integrate new applications.

Along the D4.1 and extensive analysis is been done to identify which are the data requirements for the UAS from two different perspectives:

1. The type of information required by the UAS which will be provided to it using the SWIM link
2. The type of information that the UAS will be able to offer to other stakeholders by publishing it in SWIM.

The main results are briefly presented in the following tables:

• UAS offered SWIM services	
Publication of the Reference Business Trajectory	As defined by SESAR, the first published RBT which is the on board latest SBT re-computation using updated fuel, passengers, weather and freight load figures. It occurs approximately 15 minutes prior to Estimated Off-Block Time (EOBT)
Update of the Reference Business Trajectory	Update of the RBT may be initiated automatically by the on board systems or by human intervention if required
Revision of the Reference Business Trajectory	The trajectory may be revised either when the flight crew supported by airborne automation determines that a constraint cannot be met, or when either the airspace user, flight crew or ATMSP decide that a new RBT is required to include new or revised constraints
Airborne Weather Data Exchange	Weather data captured by on board systems that may be shared with the ground systems and other aircraft
Airborne Surveillance Data Exchange	Surveillance data captured by on board systems that may be shared with the ground systems and other aircraft

Table 2 UAS offered SWIM services

• UAS requested SWIM services	
Access to Meteorological Data	Access the meteorological data domain to acquire aerodrome weather, area weather and meteorological hazard data
Access to Aeronautical Data	During all ATM phases the aeronautical data domain will be accessed to acquire aircraft, airspace, aerodrome, navigation aids, terrain and obstacle data.
Agreement on the Reference Business Trajectory	The first published reference business trajectory should be agreed with the system to assure compliance with the future flight planning system

Agreement on the Revision of the Reference Business Trajectory	The trajectory may be revised either when the flight crew supported by airborne automation determines that a constraint cannot be met, or when either the airspace user, flight crew or ATMSP decide that a new RBT is required to include new or revised constraints. Any revision should be agreed with all other involved stakeholders prior to its execution.

Table 3 UAS offered and requested SWIM services

Conclusions

The novel ideas and concepts presented the reader in D4.1 must be carefully considered when establishing a common understanding for the role of UAS in the future ATM system - a system that will enable, and be capable of UAS interoperability in a common operating scenario, supported by a network centric environment, such us the European System Wide Information Management (SWIM).

Although the scope of D4.1 was at a research level, it nevertheless highlights a number of potential areas of focus when considering the integration of UAS in a network centric environment. This analysis should provide relevant stakeholders a first step for developing their UAS integration strategy and be capable of interoperating with other ATM systems, avoiding references to other unmanned flying objects such as radio frequency aircrafts. The example of Swarming Applications included in the document helps to better understand the complexity of UAS interoperability in a network centric environment, and shall raise some awareness among the industry key players.

6.2.2 New UAS-related common operating picture actors (D4.2)

As it has been analyzed along the INOUI document D4.1, the UAS potentially constitute a fundamental actor from two different perspectives: as airspace users and as providers of ATM air side related data.

Based on the work been done on the D4.1, the INOUI D4.2 continue the analysis of the interaction of each UAS component with SWIM but following a more technological perspective..The main topics and findings of the document can be summarised as follows:

- The UA and the control station will be independent customers of the ATM system, and will require working with a certain degree of interoperability. Traditional aerial vehicles normally maintain just air-to-ground communications, but this is no longer a valid paradigm. UAS are the first airspace users with two different components (Ground Control Station and Air vehicle) both interacting with the ATM system. Therefore the impact of the new communication channels used in the global ATM system were described.
- Concluding what information will UAS components subscribe to, and describing what information will the UAS components publish in SWIM. Special attention was

paid to the data required by two critical systems: Sense / detect and avoid and ACAS respectively Self Separation.

- Description of possible communication protocols enabling the possibility to maintain common communication between multiple partners allowing the system to participate in the on-line trajectory negotiation. Special attention was paid to the following topics:

    - Future concepts such as P2P concepts.
    - Satellite links using both geostationary and satellite constellation channels
    - Point to multipoint networks which represents the preferred topology for indoor operations

- Security protocols were analysed that will allow safe communications between the UAS components and the ATM systems, helping to minimize the jamming risk and other communication security aspects. Particularly, the work was focused on:

    - Crypto-security: The component of communications security that results from the provision of technically sound cryptosystems and their proper use.
    - Emission security: Protection resulting from all measures taken to deny unauthorized persons information of value which might be derived from intercept and analysis of compromising emanations from crypto-equipment, AIS and telecomm systems.
    - Physical: The component of communications security that results from all physical measures necessary to safeguard classified equipment, material and documents from access thereto or observation thereof by unauthorized persons.
    - Transmission: The component of communications security that results from the applications of measures designed to protect transmissions from interception and exploitation by means other than cryptanalysis.

It is important to bear in mind that the SWIM systems is an ongoing initiative not yet deployed as an operational system, therefore current situation represents a unique opportunity to influence the development of such system and assure that UAS are fully integrated along the development phases.

The expected growth in the number of civil / governmental UAS operations in the mid-term offers a number of challenges to the SWIM system, but also a number of advantages. The main challenge will be the SWIM interoperability assurance of a growing number of unmanned systems as nowadays there is no standard protocols regarding the data handle by UAS. However, the UAS also represent a number of opportunities, among those can be highlighted the possibility of using the UAS as flying nodes of the SWIM network, providing more flexibility to the system without incurring in the high costs associated to terrestrial and satellite relay networks.

Also has to be highlighted the importance of data flows between UAS and other ATM systems in the development of new critical systems like sense / detect and avoid and self separation. The particularities associated to the unmanned aviation requires the use of safe and high integrity datalinks allowing proper flows of data between each component of the UAS and the rest of the ATM systems, particularly if, as said before, critical systems are involved. The INOUI work in this area leaded to the proposal of particular architectures for D/S&A and self separation that allows the UAS to take advantage of the information provides by SWIM. The following figures depict which are those architectures for each system.

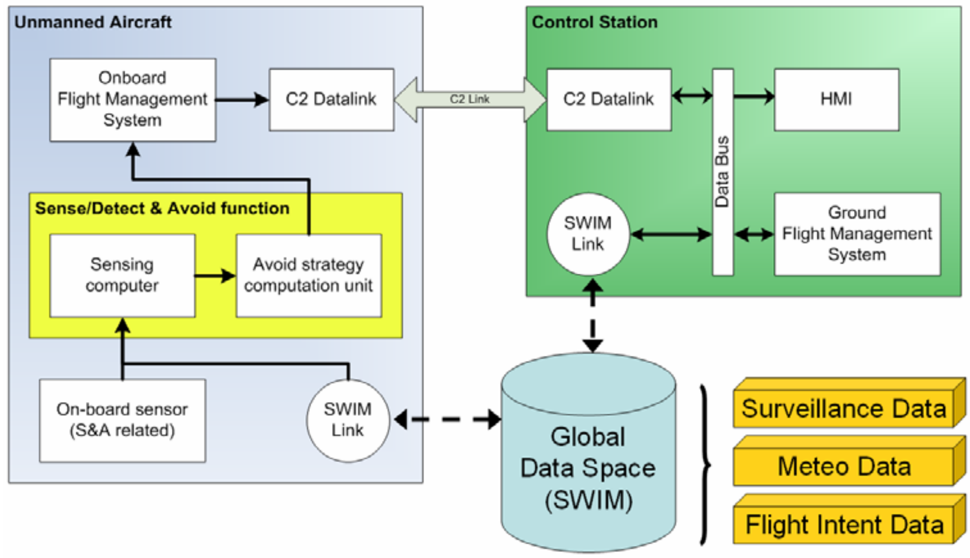


Figure 10 INOUI identified SWIM enabled architecture for collision avoidance

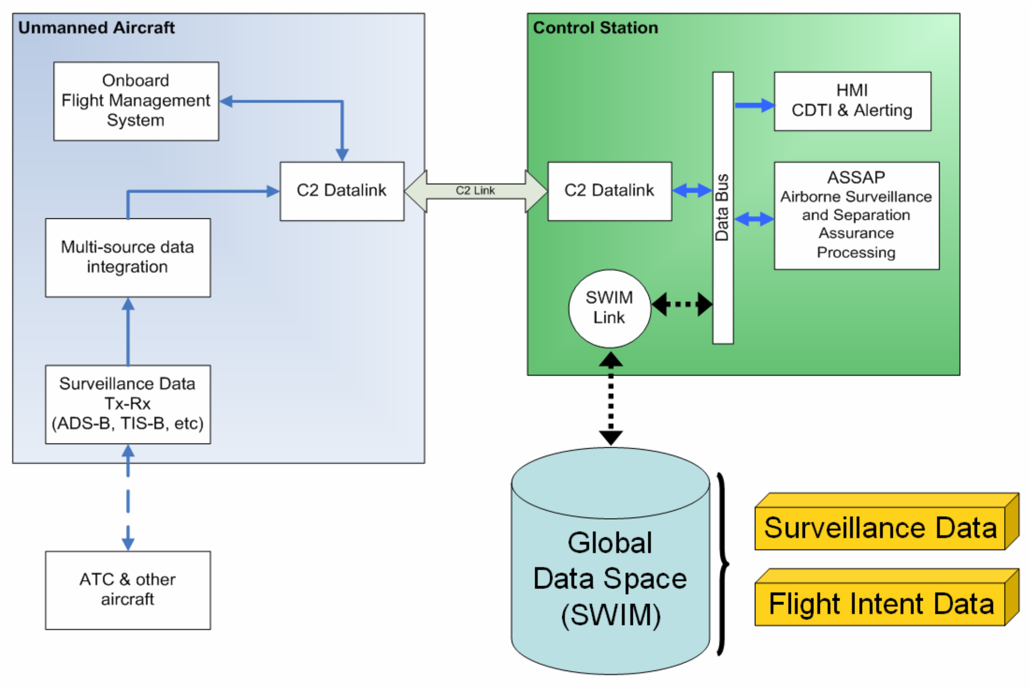


Figure 11 INOUI identified SWIM enabled architecture for self separation

Other important topic to be taken into account and not addressed explicitly within this work package is the spectrum requirements associated to the proposed operations. Communications described along the document involves a considerable amount of data and will require a bandwidth according to it. [6] As the aeronautical spectrum is currently heavily overloaded and is not foreseen a change on this, the importance of the different initiatives currently running all over the world to follow up this issue as key point on the 2012 world radio conference agenda has to be highlighted.

Finally, should be noted the growing importance of those aspects associated to data security. Secure datalinks are required to maintain the required level of safety in UAS operations and assure its completely seamless integration in non-segregated airspace. Appendix 1 in the document D4.2 provides therefore the interested reader with a brief technical approach to a number of current investigations around this issue.

6.2.3 Operations depending on the level of automation and autonomy (D4.3)

To complete the WP 4 study around the integration of UAS in a Common Operation Picture, the objective of D4.3 was to focus on the impact of UAS operations on the overall ATM system depending on the degree of autonomy associated to the UA flight. The range of operations considered included automatic operations supervised by humans to the fully autonomous flights without human direct supervision, if permitted by new regulations.

[6] The reader is also referred to INOUI work package 2, Executive Summary of WP2 and D2.1, D2.2, D2.3

Three main topics for discussion around the UAS Level of Autonomy were discussed: their impact as users of SWIM, their operation in an automated aerial traffic scenario, and a final overview of decision support tools from a human centred automation perspective, in the unmanned aircraft systems domain.

The main objective was to present novel ideas to successfully overcome the challenge of integrating UAS in the 2020+ airspace environment. Furthermore, one of the pillars behind the INOUI work is that UAS will become, in the near future, frequent air space users. As such, the UAS interoperability with the future flexible ATM, so-called System Wide Information Management, must be a priority in order to aim for the maximum the safety and seamless integration of UAS into the airspace.

To successfully achieve this goal, the UAS stakeholders must work together into some of the issues and ideas raised within this research study. INOUI recognises the importance and potential impact of UAS regulatory aspects; however the ideas presented in this study are technology related aiming to provide seamless ATM interoperability supported by a next generation data link communication channel.

Overall, it can be said that UAS will come to be part of the common operating picture presented by SESAR and supported by the future SWIM ATM environment. To successfully achieve this goal, the UAS stakeholders must work together into some of the issues and ideas raised within this research study. INOUI recognises the importance and potential impact of UAS regulatory aspects; however the ideas presented in the D4.3 document are technology related aiming to provide seamless ATM interoperability supported by a next generation data link communication channel.

6.3 Conclusions and Recommendations

To summarize, a number of key messages and novel ideas can be drawn from the research work conducted under WP4 and in particular this final document. The following can be summarized as:

- The two different UAS components (Control Station and Air vehicle) are strongly dependent functionally and will both need interacting with the SWIM ATM system. However the two components may be independent customers of the SWIM ATM system, bearing in mind they will require working with a certain degree of interoperability.
- Traditional aerial vehicles normally maintain just air-to-ground communications, but this is no longer a valid paradigm. Therefore it is important to analyze the impact of the new communication channels used in the global ATM system. As an example, communication protocols enabling the communication between multiple partners are required to allow the system to participate in near real time trajectory negotiation. Future communication concepts such as peer-to-peer are being considered as an option.
- SWIM may be a key enabler for UAS integration in terms of safety and reliability. As an example, in some critical cases where there may be a loss of link between

the Air vehicle and the Control Station, SWIM could even provide a possible backup link between the two.

- SWIM will be the backbone of the future ATM system, so it is important to assure UAS interoperability in the SWIM environment if we want to succeed in its integration in the non segregated airspace.
- UAS are the first airspace users with several direct interfaces to the ATM system, each with different data requirements. Initially, main actors will be the unmanned aircraft (maybe more if swarming applications) and the control station (one or more), each of those exchanging information at the same time with the same systems, but carrying out just one flight.
- Early adoption of data standards will facilitate the future UAS integration in non segregated air space as it will speed up the process to adapt the UAS operations to the future SESAR concept of operation.
- SWIM may play an important role to perform in future flight critical functions such as Sense & Avoid. Most of these functionalities are already defined, but INOUI findings lead to a situation in which it can be said that adding the SWIM component to the solution will help to optimize the process and enhance the system reliability.

6.4 User of the results

It is not the intention of this section to point out who must be interested in the work been done in the INOUI WP4, but it worth the opportunity to highlight the necessity to assure the future collaboration of two main stakeholders groups to assure the future integration of the UAS in non segregated airspace, namely: the **SESAR development team** and the **UAS industry groups.**

To assure the successful integration of the UAS in a SWIM enabled environment it is mandatory to assure the proper coordination between the UAS requirements and the SESAR developments in other to assure that everybody take on board each other requirements.

SESAR developers must take into account those requirements associated to the UAS operations, particularly all those related to the data models being used by the UAS.

On the other hand, the UAS manufacturers should be aware of the SESAR developments and assure that future developments of UAS systems will be in accordance to the standards currently agreed y the industry in the framework of SESAR.

It is suggested from the INOUI WP4 work that at least the following relationships should be established between the industry and the SESAR

- SESAR WP13 – Network information management system, to identify and include the relevant information from/ for the UAS in the data models
- SESAR WP9 – aircraft systems, to assure that the industry is designing future systems accordingly to the requirements defined in this work package
- SESAR WP8 – Information Management, industry should adopt the data standards defined by SESAR, but also should establish a fruitful dialogue with the SESAR developers to assure that the UAS data requirements are taken into account.
- SESAR WP14 – SWIM Technical Architecture, industry should design the future UAS systems accordingly to the SWIM approach in other to avoid future incompatibilities

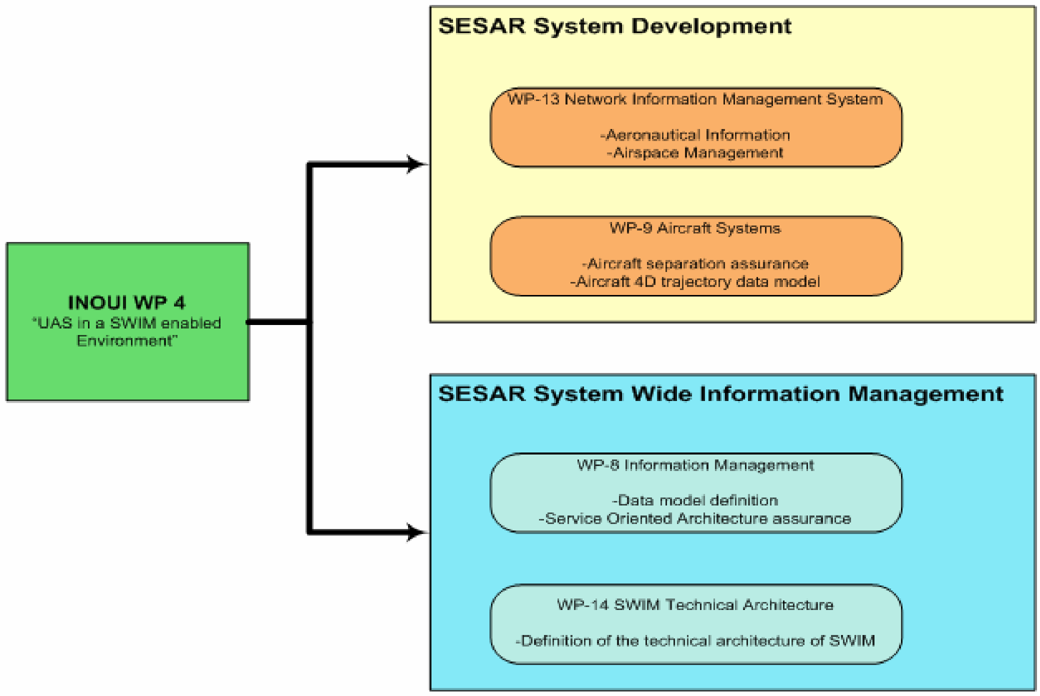


Figure 12 Suggested relationships between INOUI WP4 and SESAR WPs

7 Work Package 5 « Safety Analysis of Civil UAS Operations »

7.1 Scope of Work and Method of Research

Subject of the Work Package

Work package 05 performs the first steps of a safety analysis for integration of UAS in non-segregated airspace. The safety analysis is performed according to the Eurocontrol Safety Regulatory Requirement [ESARR 4] entitled "Risk Assessment and Mitigation in ATM". Although the ultimate goal is to analyse the integration of UAS in the ATM system of 2020, which will be shaped according to SESAR, the work package proceeds in stages. To start with, the first steps of a safety analysis are performed for the context of the present/ near future ATM system. This corresponds to the following tasks:

- WP5.1 Describe scenarios to integrate UAS in present airspace;
- WP5.2 Identify hazards and derive Safety Objectives; and
- WP5.3 Analyse hazards and derive Safety Requirements.

At the start of INOUI, it has been identified that ESARR 4 does not provide the appropriate scope of risks and corresponding safety criteria for the integration of UAS: ESARR 4 concerns changes of the ATM system (which may be induced by the integration of UAS, but which does not enclose all aspects of the integration) and risks with direct contribution of ATM (which does not cover risk contributed by UAS itself). For that reason, the first task of Work package 05 has been inserted:

- WP5.0 Identify and develop safety criteria for integration of UAS.

This task proposes safety criteria for the integration of UAS in the ATM System of 2020. Hence, for instance the traffic increase expected between now and 2020, as well as the corresponding safety ambitions of SESAR are taken into account.

The results of the above four tasks, together with the expected developments regarding ATM and UAS, have been used to obtain a first look on the safety aspects of the integration of UAS in the ATM context of 2020:

- WP5.5 Interpret results in context of SESAR/2020.

All of the above tasks are concerned with integration of UAS in non-segregated airspace, from which the airports have been excluded. A special task has been dedicated to support the development of the operation of UAS at non-segregated/ civil airports undertaken in Work package 06:

- WP5.4 Provide safety feedback for integrating UAS at aerodromes.

Deliverables of Work Package 05

The deliverables of Work package 05 correspond to the aforementioned tasks; an overview is given in the table below.

Overview of Work package 05 deliverables with contents

Deliverable	Contents
D5.0 Scope of Risks & Quantified Safety Criteria	The literature is researched for candidate safety criteria for the integration of UAS. Those criteria providing the most suitable starting point are tailored further to yield a proposal for safety criteria for the integration of UAS in non-segregated airspace. The proposed criteria treat UAS no differently from manned aircraft, they concentrate on risk that the integration poses to other aircraft and exclude risk to people on the ground.
D5.1 System Description for Safety Analysis	This document defines the subject of the safety analysis steps performed in tasks WP5.2 and WP5.3 by describing two scenarios to integrate UAS: ▪ In the first scenario, a high-performance UAS is considered, with performance comparable to that of commercial air transport aircraft and which flies under Instrument Flight Rules in airspace of class C, where it is separated from all other traffic; and ▪ In the second scenario, a UAS with performance comparable to or even less than that of general aviation is considered, still flying under IFR, but in a context in which all aircraft have a transponder, but not all not traffic is controlled by ATC. Sense/detect and avoid is assumed for none of the scenarios.
D5.2 Functional Hazard Analysis	For this deliverable, a Functional Hazard Analysis according to the methodology of ESARR 4 is performed. In particular, the results of the follow tasks have been documented: ▪ Identify hazards related to the integration of UAS; ▪ Structure hazards according to causality; ▪ Classify the hazards' effects according to severity; ▪ Develop decision trees to estimate the conditional probability of effects given occurrence of hazards; and ▪ Derive the maximum acceptable frequencies of the hazards, i.e. the Safety Objectives.
D5.3 Towards Safety Requirements for the Integration of UAS	This document provides ideas for Safety Requirements – what needs to be done to achieve the Safety Objectives? These ideas have been generated and justified in a series of workshops into which the results of various relevant studies have been fed.
D5.4 Aerodrome safety analysis	In order to support the development of a concept for integrating UAS at aerodromes performed in Work package 06, this document has provided safety feedback early in the development process based on the application of the crucial steps in a safety analysis and involving judgements by operational experts.
D5.5 Interpretation of safety analysis results in the context of SESAR	This document sheds light on safety aspects regarding the integration of UAS in non-segregated airspace in the SESAR context of 2020, based on safety analysis results for integration of UAS in the present/near future ATM system, and the relevant changes expected up to 2020.

Methods of Research

Various methods and ways of working have been applied in the course of Work package 05:

- The starting point for the methodology of the safety analysis has been the Eurocontrol Safety Regulatory Requirement [ESARR 4] for Risk Assessment and Mitigation in ATM. This concerns in particular the systematic description [INOUI D5.1] of the integration of UAS in terms of human, procedural and equipment elements, and the environment of operations, as well as the identification of hazards and derivation of Safety Objectives in [INOUI D5.2];
- In almost all tasks of Work package 05, extensive use has been made of expert judgement, normally in the context of workshops involving experts regarding ATM operations (i.e. air traffic controllers), manned and unmanned aircraft operations, safety assessment, as well as general expertise regarding UAS brought by all INOUI partners; and
- Literature research has been performed for [INOUI D5.0] and [INOUI D5.5]. For the first document, safety criteria have been searched that could support the development of suitable criteria for the integration of UAS. For the second deliverable, various references regarding SESAR and UAS have been consulted in order to identify the changes regarding ATM and UAS expected between now and 2020.

7.2 Findings of the Work Package

7.2.1 Safety Criteria for Integration of UAS [INOUI D5.0]

[INOUI D5.0] ‘Scope of Risks & Quantified Safety Criteria’ has proposed safety criteria for the integration of Unmanned Aircraft Systems (UAS) in non-segregated airspace in the European Air Traffic Management (ATM) System of 2020. The developed safety criteria set upper bounds for the probability of certain accident types per flight, depending on aircraft category. Moreover, they take estimated air traffic increase from now until 2020 into account and involve an apportionment, which allows focusing of safety assessments on specific flight phases.

Standard regulatory references regarding safety criteria in connection with changes to the ATM system are [ESARR 4] – the Eurocontrol Safety Regulatory Requirement for Risk Assessment and Mitigation – and its incorporation in the European Commission’s ‘Common Requirements’ for the provision of Air Navigation Services [CR 2096/2005]. These are mandatory regulations applicable for changes to the ATM System. As such, the ECAC Safety Minimum expressed in ESARR 4 as a “maximum tolerable probability of ATM directly contributing to an accident of a Commercial Air Transport aircraft of 1,55 * 10^{-8} accidents per Flight Hour” seems an obvious starting point for safety criteria for the integration of UAS.

However, the aforementioned ECAC Safety Minimum is not fully adequate for the integration of UAS as this presents a change extending widely beyond the ATM System, and it is moreover too restrictive to consider only risk for which ATM is primary factor.

The first part of [INOUI D5.0] is therefore aimed at setting a more appropriate scope of risks for the analysis of integrating UAS in the ATM System, whereas the second part is to provide the quantitative criteria for the risks within this scope.

Review of a series of documents concerning safety criteria for ATM and UAS, and additional workshops with experts in this area has yielded that the following occurrence categories generate an appropriate scope of risks, as prevention of collisions is a primary task for ATM in controlled airspace:

- Collisions between aircraft;
- Collisions between aircraft and vehicles; and
- Wake vortex encounters.

Accidents of these categories are called ‘ATC related accidents’, see [ATC Quarterly 2009]. For Commercial Air Transport aircraft, high quality accident statistics exist for ATC related accidents, and these constitute the starting point for the safety criteria to be developed. Clearly this starting point needs to be developed regarding the following aspects:

- Many aircraft and especially unmanned aircraft are considerably smaller than Commercial Air Transport and fly in different contexts, and therefore may have very different accident statistics;
- How do the safety criteria for unmanned and manned aircraft relate?
- Air traffic will grow considerably between now and 2020, and the safety criteria have to compensate for this to prevent an increase of the absolute number of accidents; and
- In order to be able to focus safety assessments on specific ATC environments of parts of flights, an apportionment of risk needs to be realised.

Regarding the differentiation between different aircraft sizes and categories, FAA aircraft system regulatory documents state overall aircraft hull loss rates for:

- Aircraft with a Maximum Take-off Mass (MTOM) above 2,730 kg;
- Single-Engine Turbine (SET) or Multi-Engine Piston (MEP) aircraft below 2,730 kg; and
- Single-Engine Piston (SEP) aircraft below 2,730 kg.

The hull loss rate for the second category is a factor ten higher than for the first, and the rate for the third category is yet another factor ten higher. It is assumed that the proportions of ATC related accident rates for the aforementioned aircraft categories are identical, and that the first category can be identified with Commercial Air Transport aircraft regarding the ATC related accident rate.

Regarding the relation between safety criteria for unmanned and manned aircraft, the principle is that integration of UAS must respect the safety criteria for the manned aircraft with which it can interfere. This implies that a UAS flying among Commercial Air Transport aircraft needs to satisfy the same challenging safety criteria as Commercial Air Transport aircraft. UAS flying only among light and single engine piston aircraft only need to satisfy the less challenging criteria for the latter category.

Regarding air traffic growth, it is estimated that up to 2020, air traffic in Europe will increase with a factor that is at most equal to three. In accordance with the Eurocontrol Strategy for 2000+ [ATM 2000+], the accident probability per flight needs to decrease with at least the same factor, such that the absolute number of accidents does not increase.

In order to be able to focus safety assessments on parts of flights, an apportionment of risk over the type of ATC service and generalised flight phases called ATC subproducts can be realised:

Table 4 Flight partitioning according to the type of ATC service and the ATC subproduct

ATC type	ATC subproduct
Tower Control	Landing
	Line-up
	Start-up and pushback
	Take off
	Taxiing
Approach Control	Departure
	Initial and intermediate approach
	Final approach
Area Control	Control Area inbound
	Control Area outbound
	Control Area transit

Elaboration of the Commercial Air Transport statistics for ATC related accident probabilities per flight along the aforementioned aspects leads to the safety criteria proposed in [INOUI D5.0]. These proposed safety criteria involve maximally allowable ATC related accident probabilities per ATC subproduct per flight for manned aircraft with a MTOM over 2,730 kg, of MEP/SET aircraft of less than 2,730 kg and SEP aircraft of less than 2,730 kg.

Table 5: Proposed maximally allowable ATC related accident rates per ATC subproduct

ATC type	ATC subproduct	Aircraft over 2,730 kg MTOM	MEP/SET aircraft under 2,730kg	SEP aircraft under 2,730kg
ACC	CTA inbound	$3x10^{-9}$	$3x10^{-8}$	$3x10^{-7}$
	CTA outbound	$1x10^{-9}$	$1x10^{-8}$	$1x10^{-7}$
	CTA transit	$3x10^{-9}$	$3x10^{-8}$	$3x10^{-7}$
Approach	Departure	$1x10^{-9}$	$1x10^{-8}$	$1x10^{-7}$
	Initial and intermediate approach	$3x10^{-9}$	$3x10^{-8}$	$3x10^{-7}$
	Final approach	$1x10^{-9}$	$1x10^{-8}$	$1x10^{-7}$
Tower	Landing	$8x10^{-9}$	$8x10^{-8}$	$8x10^{-7}$
	Line-up	$3x10^{-9}$	$3x10^{-8}$	$3x10^{-7}$
	Start-up and pushback	$8x10^{-9}$	$8x10^{-8}$	$8x10^{-7}$
	Take off	$8x10^{-9}$	$8x10^{-8}$	$8x10^{-7}$
	Taxiing	$6x10^{-8}$	$6x10^{-7}$	$6x10^{-6}$

The above figures can be directly applied to manned aircraft.

For application to unmanned aircraft also the context of the manned aircraft surrounding the UAS is necessary to determine which column of criteria is to be applied. If there are aircraft of a higher category with which the UAS can interfere, the highest category should be taken.

7.2.2 Safety Analysis for Integration of UAS in the Present/Near Future

7.2.2.1 Scenarios for UAS Integration [INOUI D5.1]

Performing a general safety analysis for the integration of UAS in non-segregated airspace is a very broad task, as there is a wide range of sizes, speeds and performances of the unmanned aircraft, as well as a great number of application areas for UAS and very different air traffic environments. Therefore, developing general Safety Objectives and Requirements, which cover all possible kinds of UAS, application areas and environments is not very helpful, as hazards which are very critical in one context, may be uncritical in another. Underlying aspects, such as the ability of ATC or the UA pilot to resolve a conflict with other air traffic, strongly depend on the actual situation and circumstances at hand.

To handle such large bandwidths, ‘scenarios’ concentrating on two subsets of UAS with corresponding missions have been selected. These scenarios have been described in more detail in [INOUI D5.1] entitled “System Description for Safety Analysis”. The selected scenarios are not unlike the ones Eurocontrol has defined for their safety assessment activities. The scenarios have been selected as representatives of the wide range of civil applications identified in [INOUI D1.2] and described regarding integration in [INOUI D1.3]. The scenarios which are characterised by:

- The type of airspace where the operation takes place; and

- The UAS performance in relation to the other traffic flying in the scenario.

As INOUI Work package 06 and the safety analysis task WP5.4 deal with operations of UAS at aerodromes, the scenario descriptions in [INOUI D5.1] and the safety analysis tasks in WP5.2 and 5.3 are restricted to the flight phases outside the Aerodrome Traffic Zone.

As a further measure to concentrate the effort on the integration of UAS in non-segregated airspace, the present or near future ATM context is considered, instead of the environment of 2020. The latter 'SESAR' environment would have required extensive attention for its description and analysis and – as it is still largely to be developed – it would have generated large uncertainties additional to those in the present analysis. Hence the analysis first focuses on the recent or near future context and the last task of the INOUI Safety Analysis work package is dedicated to find tendencies of how the results of the present analysis would change when the SESAR environment is considered instead.

The following scenarios have been described and assessed within the present or near future ATM environment:

- Scenario 1 concerns a UAS with a performance similar to that of commercial aircraft, climbing (respectively descending) through controlled airspace with high traffic density (comparable to busy en-route sectors or Terminal Manoeuvring Areas) to (respectively from) its en-route segment around flight level 500, where the air traffic density is very low. The UAS flies under Instrument Flight Rules and ATC is responsible for separating it from all surrounding traffic; and
- In Scenario 2, a UAS is considered with a performance that is at most equal to what is common in general aviation. This UAS flies in low density airspace between Minimum Sector Altitude and flight level 100. Although it flies under Instrument Flight Rules in controlled airspace, there may be surrounding traffic under Visual Flight Rules for which ATC is not responsible for separation. All aircraft are assumed to carry transponders though.

Apart from TCAS for the high performance UAS, no Sense/Detect and Avoid systems are assumed.

The document also analyses the roles and responsibilities of the actors involved in the operation of the UAS, which concentrates on the UA pilots and air traffic controllers. To conclude the definition of the scenarios to be considered in the INOUI safety analysis, a brief review of the operational procedures, human factors aspects and technologies available has been performed. It is important to highlight that the technology enablers identified in the project are those currently in the market or available in the short term, avoiding the definition of procedures based on the use of future technologies which are not currently available or even developed.

7.2.2.2 Safety Objectives for UAS Integration [INOUI D5.2]

[INOUI D5.2] provides a Functional Hazard Analysis (FHA) for the integration of UAS in non-segregated airspace. The purpose of this first phase of a safety analysis is to identify hazards and corresponding maximum tolerable frequencies of occurrence, which are called ‘Safety Objectives’. By indicating ‘how safe the system should be’, the Safety Objectives help to focus the more detailed development of the integration of UAS on the critical aspects. In the second phase of the safety analysis, reported in [INOUI D5.3] more specific Safety Requirements are derived, based on the Safety Objectives.

The Functional Hazard Analysis has identified 12 generic hazards, which are valid for both scenarios. The identified hazards involve (combinations of) the following failure modes:

- The UA leaves its cleared/planned route;
- ATC has no position information of the UA;
- The UA is out of control of the UA pilot;
- There is a sudden loss of communication between UA pilot and ATC;
- There is delay in ATC and UA communications; and
- The UA pilot ends the UA flight.

Each of these hazards can result in the following effects on safety of air traffic:

- No safety effect;
- Minor separation infringement;
- Medium separation infringement;
- Large separation infringement; and
- Accident due to a midair collision.

For both scenarios, Safety Objectives have been derived for the identified hazards. Due to differences in the scenarios, the Safety Objectives for the identified hazards are not identical. The various results are described and discussed in [INOUI D5.2]. Without going into details, it can be stated that most Safety Objectives have turned out to be difficult or very difficult to achieve, indicating that the integration of UAS into the ATM system according to the sketched scenarios is a very safety-critical change. This implies that it will be necessary to identify very effective Safety Requirements and Safety Measures in order to safely integrate UAS into the ATM system.

This general result should however not be over interpreted as being ‘prohibitive’ for the introduction of UAS in non-segregated airspace. Reasons for this are the following:

- The scenarios are still very generic, and in a worst case approach that needs to be followed then, the bandwidths in quantitative and qualitative aspects inevitably lead to conservative results; and
- A second, more fundamental reason is that the integration of UAS in non-segregated airspace is a change for which ‘working experience’ and statistical data have been largely unavailable as basis for the estimates to be made in the course of a safety analysis. Although UAS projects have been performed during the past 35 years, these were mostly of a military nature, taking place in restricted

airspace. Most of the experience gained with these military systems is classified; only information cleared for public release can be used. Hence, the estimates made in the context of this document are based on the experience of controllers with manned aircraft, which have been extrapolated to what is expected for the considered UAS. Therefore, these estimates are rather to be interpreted as first assumptions or educated guesses regarding the possible behaviour of UAS, than definite reference values. When the integration of a specific UAS in non-segregated airspace is safety assessed, these quantitative aspects need to be reassessed and founded on more extensive and specific data. The experimental usage of UAS, corresponding flight trials and experience building from both the operating as the ATM side, possibly combined with advanced modelling and simulation, will contribute to filling this gap.

The value of the Functional Hazards Analysis presented in the present document lies therefore primarily in providing an example of how such an analysis is performed. The FHA presented is according to the methodology that has been followed for almost ten years for changes to the ATM System (it has of course been developed in the course of time), and that is in compliance with the safety regulations from Eurocontrol and the European Commission. The analysis performed in this document provides the way of working, the hazards, their effects and descriptions, and the decision trees which, updated with reliable data for specific UAS and applications will yield a Functional Hazard Analysis as the first step of a safety assessment necessary for regulatory approval of integration of specific UAS.

7.2.2.3 Safety Requirements for UAS Integration [INOUI D5.3]

[INOUI D5.3] has provided ideas and justifications for Safety Requirements with which the scenarios developed in [INOUI D5.1] and analysed in [INOUI D5.2] can be improved. As such this document provides a further step in the convergence process towards scenarios for safely integrating UAS in non-segregated controlled airspace.

The approach to these ideas and justifications for Safety Requirements has been based on two methods:

- Expert workshops in which existing literature and operational expertise has been involved to identify per failure mode, hazard or ‘out-of-the-box’ such ideas and justifications for Safety Requirements; and
- A rigorous method using Unified Modelling Language, with which safety requirements are derived from systematic descriptions of scenarios and hazards.

These two methods have been used in synergy: Preliminary results of the second method have been input to the expert workshops, and the formal method is used to further structure the results of the expert based method.

Some key messages resting upon the expert based method to obtain ideas and justifications for safety requirements for Scenario 1 are the following:

- The loss of control of the UA by the UA pilot on itself has not been assessed as a very safety critical hazard. Presumption for this result is however that the UA predictably and reliably follows the procedure for such occurrences. Appropriate procedures for loss of control need to be developed taking into account similar procedures for loss of communication procedures for manned aircraft and the specific missions and needs of UAS in such circumstances. This is one of the challenges of integrating UAS;
- The Safety Objective for loss of communication between UA pilot and ATC has been assessed as difficult to achieve. This needs to be addressed by Safety Requirements concerning the data link between the Control Station and the UA as well as establishing independent communication means between UA pilot and ATC, which does not a priory seem infeasible;
- In combination with other failure modes, failure of the UA's transponder (which results in ATC has no position information) results in significantly stricter Safety Objectives. Common causes for such failure modes would render the corresponding Safety Objectives extremely difficult to achieve;
- Similarly, the combination of "Sudden loss of communication between UA pilot and ATC" and "UA out of control of UA pilot" seems another of the challenges for the integration of UAS in non-segregated airspace. The point is that in many of the envisaged UAS, communication and (command and) control are envisaged to involve the same data link. In such a case, achievement of the Safety Objective seems very difficult. Multiple independent data links seem necessary; and
- The UA pilot should be provided with a traffic display providing situation awareness regarding near traffic. This system will enhance the situational awareness of the UA pilot including the case of an in-flight conflict. Such a display would in all cases where the UA pilot is normally in command and control of the UA provide significant improvements to the ability to prevent collisions, provided the UA pilot is appropriately trained. This safety requirement would facilitate the achievement of Safety Objectives for various hazards.

Along the same reasoning, some key messages have been derived from the expert based method to obtain ideas and justifications for safety requirements for Scenario 2. Focus is on differences with Scenario 1:

- One of the main challenges encountered for Scenario 2, is to maintain continuous control of the UA by the UA Pilot, as the presence of uncontrolled VFR aircraft may necessitate quick evading actions, initiated by ATC. As for Scenario 1, this involves reliable communication between ATC and UA pilot. As this communication can be lost due to several reasons (e.g. related to the VHF radio connection between ATC and the UA or the connection via data link between the UA and the UA pilot in the control station), it has been deemed crucial to establish a direct communication means (e.g. direct telephone line) between UA pilot and ATC;
- Sense/Detect and Avoid systems will be one of the enablers for UAS operating in an environment such as the one described in Scenario 2, due to the surrounding VFR traffic that is not controlled and possibly not even in communication with ATC. This view is shared among the UAS Community (e.g. Eurocae WG 73 and RTCA SC 203);
- When comparing the same hazards for Scenario 1 and Scenario 2, experts have deemed that most of the Safety Objectives are at least as difficult to achieve. This

renders Scenario 2 as significantly more difficult to realise safely, as cost is a more important factor for low-performance UAS; and

- Apart from the aforementioned results related to safety requirements, Scenario 2 is considered impracticable from an ATC point of view: The limited performance of the UA implies insufficient controllability by ATC. Means to separate the low-performance UA from other traffic should be associated with the UAS itself.

7.2.3 Aerodrome Safety Analysis [INOUI D5.4]

[INOUI D5.4] presents the process and results of a high level safety analysis for the integration of UAS at aerodromes. The results are to serve as safety feedback to support development of safe integration of UAS at aerodromes at an early stage. Further development of the integration of UAS at aerodromes is required together with specific safety analyses in order to integrate UAS at aerodromes safely.

The main contents of [INOUI D5.4] are:

- A summary of the concept as developed by INOUI Work package 06 “New Aerodromes Concepts for UAS” and documented in [INOUI D6.1] for which the analysis is performed;
- The hazards that have been identified related to the integration of UAS at aerodromes. Due to early stage of development of the integration of UAS at aerodromes, quantitative safety objectives have not been derived for these hazards, as would have been done in a full Functional Hazard Analysis (FHA);
- The set of hazards has been structured according to causality using event networks: Some hazards take place early in the event sequence that may lead to an accident or other safety relevant effect – these are called causes –, others are just one step before a safety relevant effect; and
- The hazards for which an accident was assessed as a conceivable effect have been selected as most important clues for generating safety feedback. For these hazards, so-called “preliminary safety related recommendations” were developed by operational experts in cooperation with the INOUI team. These recommendations are believed to improve the safety of the concept for integrating UAS at aerodromes.

The INOUI concept to integrate UAS at aerodromes is based on a number of assumptions:

- The UA operating at aerodromes will be fixed wing aircraft powered by turbojet engines. The behaviour of such UA (ground capabilities, air speed, climb and descent rates) and their dimensions are close to the ones of the other manned aircraft operated on most of the aerodromes. These UAS may have to be equipped with different instruments to enable them to behave like manned aircraft. This for instance concerns support the UA pilot regarding situational awareness;
- Only controlled aerodromes where civil and governmental (e.g. police) applications take place are considered;
- UAS are assumed to be certified before entering into operation, referring to EASA Policy Statement for Airworthiness Certification of Unmanned Aircraft System issued on 25 August 2009 [EASA Policy Doc E.Y013-01]; and

- UA pilots are assumed to be licensed.

Important aspects underlying the hazards for which a resulting accident has been assessed as conceivable are the following:

- The unmanned aircraft pilot's situational awareness may not be comparable to that of a manned aircraft pilot. This may result in the unmanned aircraft proceeding differently from UA pilot's intentions and ATC's instructions. There is for instance increased potential for taxiing wrongly and causing runway incursions, which in manned aviation are often related to situational awareness issues. Other possible results include lining up, taking off or landing without clearance and taking off with a wrong set up of the UA. Timely recognition of runway incursions performed by other aircraft may also be hampered;
- Latency regarding the data link between control station and unmanned aircraft affects timeliness of command and control, and of communication with ATC, which may result in delayed reaction of the UA to situations in which a quick action is necessary, such as the aforementioned runway incursions. These delays also reduce the decision speed V1, which in turn reduces the time window during which a take off can be aborted;
- The possibility that an unmanned aircraft is out of control of the UA pilot (in particular due to loss of data link) is especially critical in the take-off and landing phases, where quick reaction may be necessary; and
- The unmanned aircraft may behave differently from manned aircraft and the controller's expectation, which may lead to a false traffic picture of the controller and suboptimal instructions.

The principle that UAS should behave as much as possible as manned aircraft is underlined by [INOUI D5.4]. This is reflected by the preliminary safety related recommendations derived for the hazards that may lead to an accident; a few of these are summarised below:

- As UA pilots are not on board the UA, their situational awareness with regard to the UA position and other aircraft position is reduced. For this reason it is recommended to equip UA with high-resolution cameras and/or a combination of sensors transmitting their signals to the UA pilot in the control station;
- The development of onboard equipment to detect intruders on the runway or taxiway is recommended to prevent in particular runway incursions;
- Several hazards can be provoked by UAS system malfunctions. For this reason it is recommended to equip UAS with self-monitoring systems which, in case of ground operations, automatically stop the UA in case a critical system fails. These self-monitoring systems should alert the pilot, in order to let him/her inform the ground/tower controller about the situation;
- Directly accessible back-up communication means between the UA pilot in the control station and the ground/tower controller are recommended to mitigate the loss of radio communication due to e.g. loss of data link between unmanned aircraft and its pilots;
- Especially in an aerodrome context, timely communication is critical. It is recommended to develop procedures as well as technical equipment (data link)

capable to comply with the maximum delay that is acceptable for UAS operations at aerodromes; and

- It is recommended that ground/tower controllers as well as UA pilots are trained to be able to manage the new situations brought by the introduction of UAS at aerodromes.

7.2.4 Interpretation of Safety Analysis results in the context of SESAR [INOUI D5.5]

[INOUI D5.5] has aimed to shed light on safety aspects regarding the integration of UAS in non-segregated airspace in the SESAR context of 2020, based on safety analysis results for integration of UAS in the present/near future ATM system, and the relevant changes expected between now and 2020.

Assuming that UAS keep up with innovation, in particular also with what is needed by SESAR regarding ATM developments (see for instance [SESAR D3] and [INOUI D1.1]), a number of expected developments will facilitate integration:

- Introduction of 4D trajectories and redundant and more precise navigation and positioning means will enable more reliable and precise adherence to more precisely defined flight paths, and this will decrease probability of deviations, which moreover are expected to be detected earlier;
- Advanced Airborne Collision Avoidance Systems tailored for UAS, Cockpit Display of Traffic Information to support the UA pilot's traffic awareness and Sense/Detect and Avoid to support the recognition and resolution of conflicts in particular also with non-cooperative traffic are expected to reduce the risk of collisions with other aircraft;
- The standardisation and improvement of data links and possibly SWIM will make occurrences of lost communication between UA pilot and lost command and control less probable; and
- The increased support by automation, the improved information context enabled by SWIM and the improved HMI to provide the information to UA pilots will support their situational awareness in a better way than is possible now.

Nevertheless, the foreseen traffic and safety context also require considerable improvements:

- The number of manned and in particular unmanned aircraft flights will have increased and the traffic density will be higher; and
- Safety criteria need to be tightened considerably to compensate for the expected increase in manned and unmanned air traffic.

The general picture is that many of the safety issues related to the integration of UAS become less probable. They will however still occur and now take place in a context where traffic density can be significantly higher. Moreover, ATC may have to revert to conventional control for such exceptional occasions if it cannot be handled appropriately by the increased level of automation. Altogether the occurrence of the safety issues will be more safety critical in the context of the ATM system of 2020. This is however not specific for safety issues related to integration of UAS.

Hence, it is concluded that several of the characteristic issues regarding the integration of UAS may become less difficult in the SESAR context. SESAR itself however presents a considerable challenge as traffic will become denser and exceptional situations seem to become less probable, but may become more safety critical.

7.3 Conclusions and Recommendations

Safety criteria for integration of UAS

The integration of UAS in non-segregated airspace is a change fundamentally affecting ATM regarding its primary task to prevent collisions between aircraft. The Eurocontrol Safety Regulatory Requirement [ESARR 4] “Risk Assessment and Mitigation in ATM” is a standard safety regulatory document for changes to the ATM system. According to the INOUI proposal [INOUI Annex 1] and according to current practices in European ATM, [ESARR 4] has been used in INOUI Work package 05 for the safety analysis of the integration of UAS in non-segregated airspace.

[ESARR 4], and in particular the safety criteria contained in it, is however not fully appropriate for the integration of UAS. Important reasons for that are that integration of UAS is a change largely outside of the ATM system (although changes in the ATM system may be involved, as well), the fact that many UAS are incomparable to the Commercial Air Transport aircraft considered in [ESARR 4], and this regulatory requirement’s restriction to risk with direct ATM contribution, although it is in particular the risk contributed by the integration of UAS that must be addressed.

For these reasons, more appropriate safety criteria for the ATM aspects of integrating UAS in non-segregated airspace have been developed. Main characteristics of these proposed safety criteria are:

- The scope of risks focuses on collisions between aircraft;
- The criteria differentiate for aircraft categories; and
- Air traffic growth until 2020 has been incorporated.

Safety analysis for integration of UAS in present/near future ATM system

The first phases of a safety analysis have been performed for two scenarios to integrate UAS in the non-segregated airspace of the present/near future ATM system. This has yielded hazards being combinations of the following aspects:

- The UA leaves its cleared/planned route;
- ATC has no position information of the UA;
- The UA is out of control of the UA pilot;
- There is a sudden loss of communication between UA pilot and ATC;
- There is delay in ATC and UA communications; and
- The UA pilot ends the UA flight.

The effects of the hazards have been assessed regarding severity, and the conditional probabilities of the effects given occurrence of the hazards have been estimated making use of decision trees. This has allowed the derivation of Safety Objectives, i.e. maximum acceptable frequencies of occurrence of the hazards. Interpretation of these frequencies has yielded that almost all of these are presently difficult to achieve.

These results should not be over interpreted as prohibitive for the following reasons:

- Integration has been considered in present context;
- The scenarios were generic, necessitating a conservative approach; and
- No extensive experience and statistical data have been available for estimates.

In view of these results it is therefore recommended:

- To aim first for safely integrating UAS in non-segregated airspace for simple and special cases, e.g. in low density airspace of class C; and
- To gain experience regarding the operation of UAS to obtain feedback for developing the integration and to collect data for the safety case building.

<u>Safety analysis for integration of UAS at aerodromes</u>

A preliminary safety analysis has been performed for the integration of UAS at aerodromes in order to support the development of the operation of UAS at aerodromes. To this end, a series of preliminary safety related recommendations have been derived. These are summarised below:

- It is recommended to equip UA with sensors transmitting their signals to the UA pilot in the control station to enhance his situational awareness;
- The development of onboard equipment to detect intruders on the runway or taxiway is recommended to prevent in particular runway incursions;
- It is recommended to equip UAS with self-monitoring systems which, in case of ground operations, automatically stop the UA in case a critical system fails;
- Directly accessible back-up communication means between the UA pilot in the control station and the ground/tower controller are recommended;
- It is recommended to develop procedures as well as technical equipment (data link) capable to comply with the maximum delay that is acceptable for UAS operations at aerodromes; and
- It is recommended that ground/tower controllers as well as UA pilots are trained to be able to manage the new situations brought by the introduction of UAS at aerodromes.

Integration of UAS in the context of SESAR

The results of the safety analysis for integration of UAS in the context of the present/near future ATM system have been reconsidered after taking into account the changes expected up to 2020 regarding ATM and UAS, the first of which will be largely shaped by SESAR.

The general picture is that many of the safety issues related to the integration of UAS become less probable, points towards the positive effect of the expected developments regarding integration of UAS.

These safety issues will however still occur and now take place in a context where traffic density will be significantly higher and where the safety issues will be more safety critical in the context of the ATM system of 2020.

This is however not specific for safety issues related to integration of UAS. It is therefore concluded that several of the characteristic issues regarding the integration of UAS may become less difficult in the SESAR context. SESAR itself however presents a considerable challenge as traffic will become denser and exceptional situations seem to become less probable, but may become more safety critical.

7.4 User of the Results

Table 6 Users of the results specified per deliverable

Deliverable	User
D5.0 Scope of Risks & Quantified Safety Criteria	Developers and users of safety regulations: ▪ EASA; ▪ Eurocontrol; and ▪ National CAAs and NSAs.
D5.1 System Description for Safety Analysis D5.2 Functional Hazard Analysis D5.3 Towards Safety Requirements for the Integration of UAS D5.4 Aerodrome safety analysis	Organisations and personnel involved with the integration of UAS in the present/near future: ▪ ANSPs; ▪ UAS manufacturers and operators; ▪ Safety analysts for integration of UAS; and ▪ Developers of concepts for the integration of UAS.
D5.5 Interpretation of safety analysis results in the context of SESAR	Organisations and personnel involved with the integration of UAS in 2020: ▪ ANSPs; ▪ UAS manufacturers and operators; and ▪ People involved in the development of SESAR.

8 Work Package 6 « Aerodrome Concepts for UAS Operations »

8.1 Scope of Work and Method of Research

Subject of the work package

WP6 focuses on the operational and technological perspective from an aerodrome point of view providing a global view of UAS operation in the air transport system, complementing the studies performed in WP1 "UAS ATM Concepts. Procedures and Requirements for 2020" and WP2 "UAS-enabled ATM Architecture".

The objectives of the work package 6 are:

- To define an operational concept to integrate UAS into the aerodrome 2020 and beyond
- To assess systems and technologies for enabling UAS operation in the aerodrome 2020 and detect needs in the subject
- To study and investigate the potential of future "solutions" to improve the integration of UAS into the aerodrome 2020 and beyond

Deliverables of work package

INOUI WP6 consists of two deliverables, each one showing different aspects of the results of this work package. These deliverables are:

D6.1 "New Aerodrome Concepts for UAS"	Assessment of UAS operation at aerodromes and their impact in current aerodrome system.
D6.2 "Technology Watch for the Operation of UAS in the Airports"	Assessment of technologies and their applications to enable the operation of UAS at aerodromes.

Methods of research

The research undertaken in this work package has employed four main inputs, namely:

- SESAR D3 The ATM Target Concept
- ICAO Annex 14
- UAS Simulation 2008 project, Swedavia
- JAPCC, military UAS operation

In addition to these sources, a workshop was held by the INOUI project (2nd INOUI Stakeholder Workshop "Innovative Concepts for UAS Integration at Aerodromes") which served to collect information from the stakeholders.

To complete the information, several consultations were directed to EUROCAE WG-73 and the INOUI D5.4 was used as an internal input.

The INOUI team participants in these tasks were Isdefe, DFS, Boeing, ONERA, RDE :

- ISD with expertise and experience in aerodrome operation, procedures and regulations.
- RDE with expertise and experience in technologies applicable to the UAS operation in aerodromes.
- DFS with expertise and experience in aerodrome operation, procedures and regulations.
- ONE with expertise and experience in technologies applicable to the UAS operation in aerodromes.
- BRTE with expertise and experience in technologies applicable to the UAS operation in aerodromes.

In order to achieve INOUI WP6 objectives a parallel development of both tasks has been followed:

7) First, a concept of operations for the integration of UAS at controlled aerodromes (either civil, military or mixed) is developed in the D6.1. Such a concept elaborates on the UAS operation in the aerodromes (even in mixed traffic with commercial manned aviation), the aerodromes layout and infrastructures, the roles of the actors in the UAS operation (pilot, ATCO, ground personnel, maintenance personnel), the task to be accomplished in every phase of flight and the UA performance. The concept of operation established the needs for the technology to be addressed in the next task, D6.2.
8) Secondly, an analysis of the current and future technologies to support the UAS operation at aerodromes is performed. The concept of operations defined in the previous task will impose requirements to be accomplish by the supporting technology. It is analysed whether the current and the future systems can cope with the concept of operations expectations. In case the needs are not accomplished, room for further research and development is identified and proposed. The technologies are related to the UA, the CS, the ATCO position, the ground surveillance systems, the commercial manned aircraft and the handling and airport operation vehicles.

It has to be noted that each step above described match to each WP 6 sub-work package, namely:

WP6.1 "New Aerodrome Concepts for UAS"

WP6.2 "Technology Watch for the Operation of UAS in the Aerodromes"

8.2 Findings of the Work Package

The WP6 defines a concept of operations for the integration of the UAS into the controlled aerodromes. It is assessed whether any UAS can be operated in any type of aerodrome, independently of the traffic already existing on it. It is also analysed what are the conditions and limitations for this operation and what technological support is needed. It also defines the technological needs and assess whether the current and known future technologies can accomplish such requirements.

8.2.1 Building Blocks for the Concept

- Current Aircraft Classification for Aircraft operating at Aerodromes (ref. ICAO Annex 14 Aerodromes) based on
    - 1st criteria: A/C reference field length
    - 2nd criteria: Wing Span
    - 3rd criteria: Main wheel gear span
- INOUI targets MALE and HALE UA operating at aerodromes.
- UA fitting in ICAO Aircraft Classification is considered.
- Mixed type of traffic (commercial aircraft and UAS) is considered.
- UA performance at aerodromes are key features to enable their smooth integration at them.
- SESAR focuses at three Key Performance Areas when elaborating on the aerodromes:
    - turn round management
    - runway throughput
    - improved environmental performance
- SESAR proposes several technologies to enable the improvement in the previous areas of the aerodrome operation:
    - GNSS including the use of augmentation systems,
    - Multilateration techniques based on multiple sensors,
    - Surveillance data processing and distribution,
    - Arrivals and departures management (AMAN, DMAN),
    - ADS-B data link applications.

8.2.2 Proposal for Type of Aerodrome

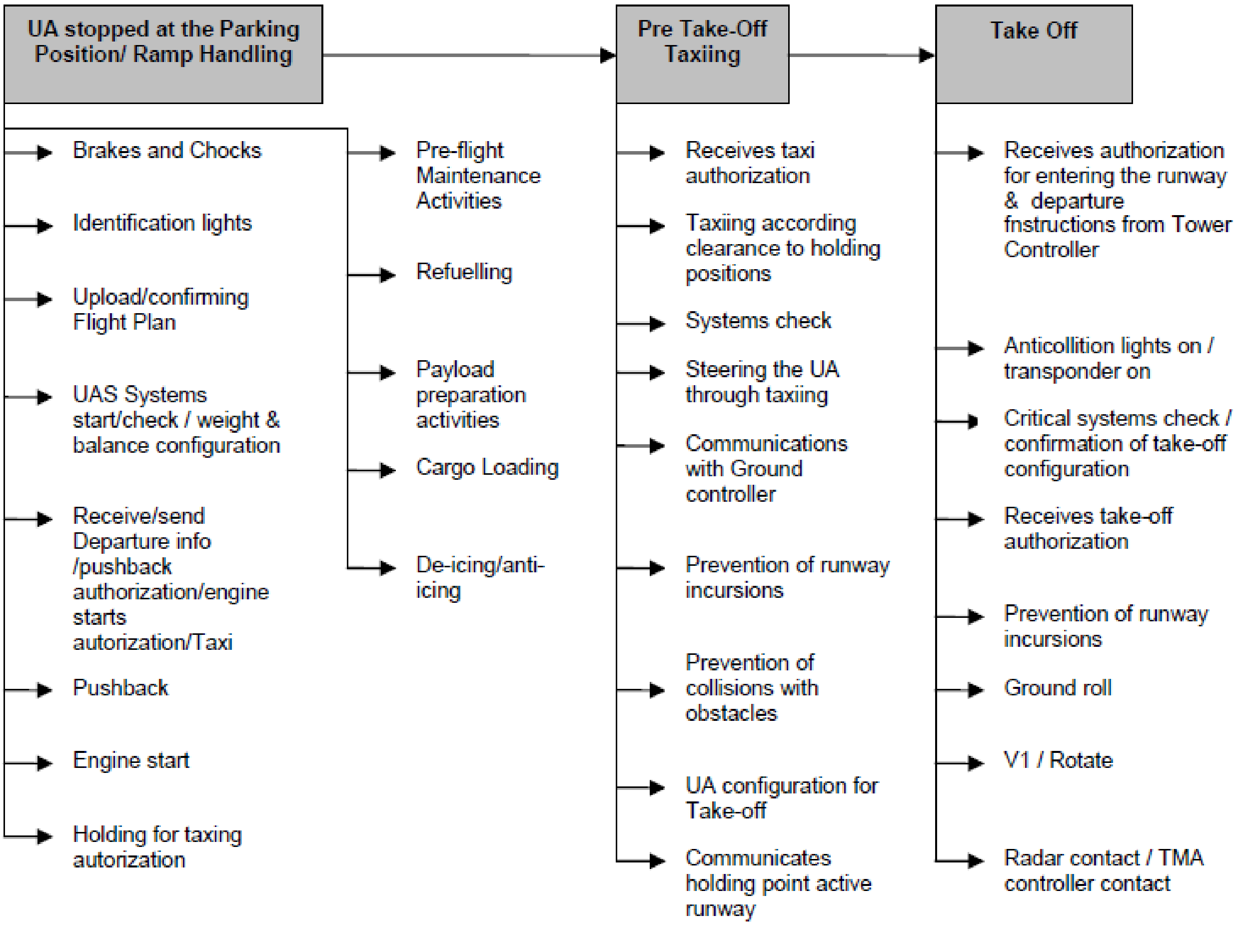
In general UAS operations are possible at every aerodrome, but...Would it be feasible to operate UAS from aerodromes with high traffic levels? To answer this question, the impact of the UAS operation in the aerodrome has been analysed for different types of UAS applications/ missions, as the type of UAS (and thus its performances) can be different in every mission. The applications/missions considered are the following: Customs and Coast Guard Applications, Civil and Homeland Security Applications, Fire Fighting Applications, Science and Research Applications and Contractor Supplied Services Applications.

In the assessment of the UAS operation in the aerodromes, it has to be pointed out that runway occupancy is a key driver for the aerodrome capacity. Therefore the UA performances are key in the feasibility of operating a UAS in an aerodrome. This factor is especially important for those aerodromes with a high traffic volume. In case the UA performance is worse (i.e, higher runway occupancy times) than the typical performance of a commercial aircraft, the aerodrome capacity would be decreased due to the UA operation, and the aerodrome authorities and operators will be reluctant to operate UAS in high traffic volume airports due to the impact on their business.

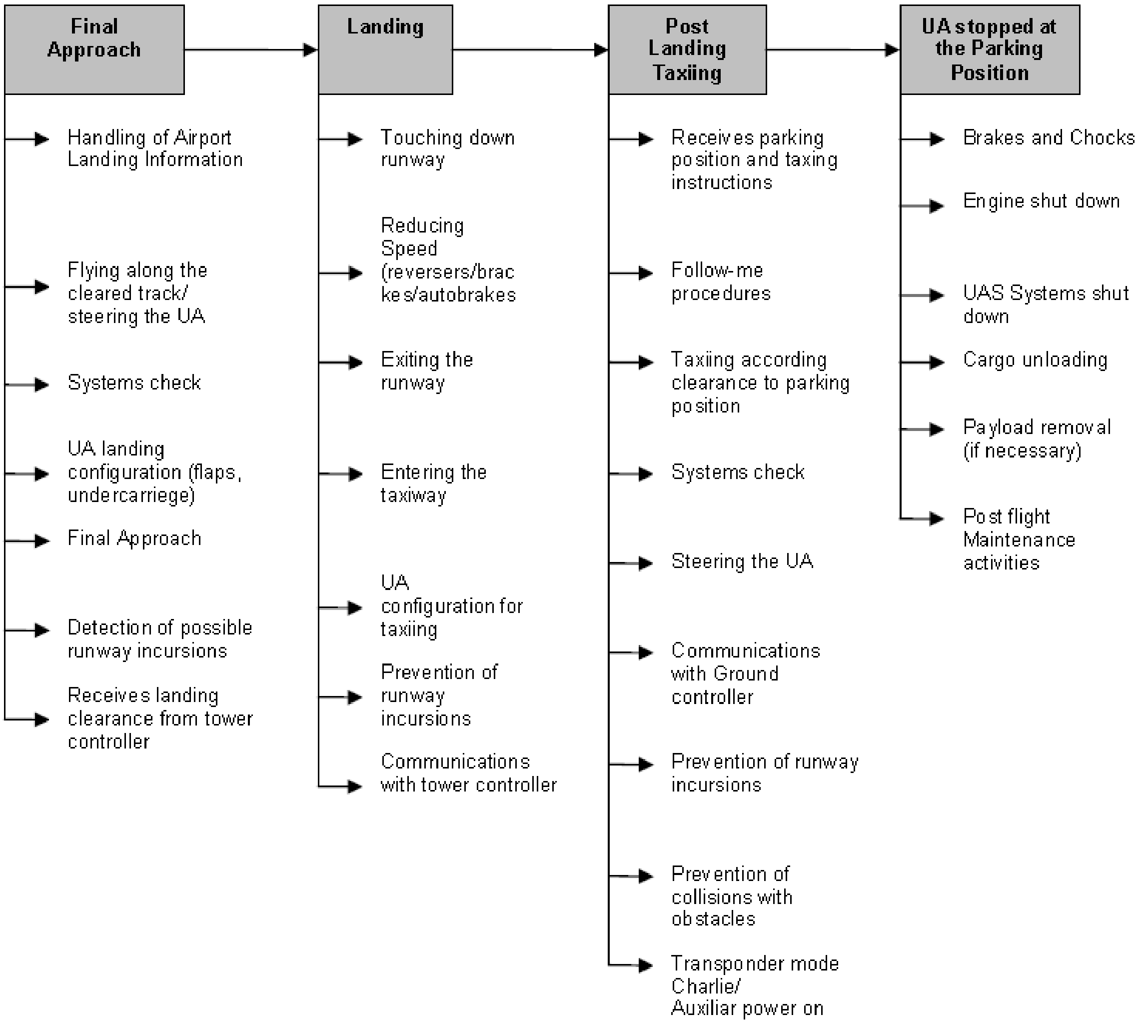
As a general conclusion, aerodrome capacity issues do make unfeasible the operation of UAS at aerodromes with high traffic levels, except for cargo missions as they are intended to use the same airframes as current manned cargo aircraft (thus same aircraft performance). Therefore UAS operation other than cargo seems more feasible in aerodromes with medium or low volume of traffic. Even the UAS could be operated in dedicated aerodromes of new creation what would create a new business opportunity.

8.2.3 Proposal for UAS Tasks at Aerodrome

The UAS needs to perform a set of tasks for each part of the flight in the same way as aircraft do nowadays. These tasks are summarized in following figures for take-off and landing. The tasks are based on the currently performed in manned aviation although some of them had to be re-defined to include the UA case.


UA stopped at the Parking Position/ Ramp Handling
Pre Take-Off Taxiing
Take Off
Brakes and Chocks
Identification lights
Upload/confirming Flight Plan
UAS Systems start/check / weight & balance configuration
Receive/send Departure info /pushback authorization/engine starts autorization/Taxi
Pushback
Engine start
Holding for taxing autorization
Pre-flight Maintenance Activities
Refuelling
Payload preparation activities
Cargo Loading
De-icing/anti-icing
Receives taxi authorization
Taxiing according clearance to holding positions
Systems check
Steering the UA through taxiing
Communications with Ground controller
Prevention of runway incursions
Prevention of collisions with obstacles
UA configuration for Take-off
Communicates holding point active runway
Receives authorization for entering the runway & departure fnstructions from Tower Controller
Anticollition lights on / transponder on
Critical systems check / confirmation of take-off configuration
Receives take-off authorization
Prevention of runway incursions
Ground roll
V1 / Rotate
Radar contact / TMA controller contact

▪



Source: INOUI D6.1

Every of these tasks is described in the D6.1 document, the roles of the actors (ATCO, UA pilot, UA, Ground observer, Maintenance staff) and the technology enablers (Voice COMM, Data Link COMM, other) are defined for every of the tasks.

8.2.4 Proposal for Aerodrome Layout

The aerodrome layout does not have to change specially due to UAS operation. Three factors have to be considered when starting to operate UAS in aerodromes:

Direct vision of the airfield from the UA pilot is recommended. Otherwise systems to enable pilot situational awareness are needed.

The position of the data link antenna is crucial. Antenna location must avoid shadowing, masking, and other effects that jeopardise the C2 linkage between pilot and UA. Interference with other equipment must be avoided.

New high speed exits from the runway may facilitate UAS integration.

It has to be noted that these factors may induce limitations when integrating UAS into existing aerodromes. The actual layout of the aerodrome and the position of its buildings can limit the possibilities of having an adequate position for the UAS control station and the data link antenna.

The deployment of new high speed exits from the runway to minimize the runway occupancy times of the UA, operating in the aerodrome is a question of cost-benefit analysis for the aerodrome.

8.2.5 Proposal for UA performance

In order to facilitate the integration of the UAS into the aerodromes operation, especially when targeting aerodromes with mixed traffic where the UAS will have to operate with commercial manned aviation, the UA have to improve their performances at the airfield, making them similar to those of the equivalent commercial aircraft. Hence, two aspects are subject of improvement:

- The runway time occupancy
- Automation in UA ground movements

The UA are to be equipped with breaking systems to enable them to perform braking distances similar to those in the equivalent aircraft. Hence the runway occupancy times will be the same than the ones in commercial aircraft and UAS operation will not jeopardise the aerodrome capacity.

The automation of the UA to perform the runway exiting and taxiing is also key for the smooth integration of UAS in the aerodromes. It will not be acceptable that the runway is blocked once the UA has stopped because there is not automation to continue with the taxiing and the UA has to wait until a handling truck removes it from the ground. Hence new technologies are to be deployed (e.g. guidance systems, recognition of markings and aids, etc).

8.2.6 Proposal for Technologies

As part of the work conducted under this Work Package 6, "Aerodrome Concepts for UAS Operations", research into potential technologies and their applications to enable the safe operation of UAS on aerodromes was performed. An analysis of the current and future technologies to support the UAS operation at aerodromes was performed bearing in mind whether the current and the future systems can support the concept of operations expectations.

As a result of such analysis. a number of technologies were identified as potential candidates for the operation of UAS in the 2020 ATM environment. These technologies were reviewed with special interest on its application around aerodrome operations. The scope of the technologies considered included the UA, the CS, the ATCO position, the commercial aircraft, the handling and airport operation, as well as ground surveillance systems.

The table below (**Fehler! Verweisquelle konnte nicht gefunden werden.**) represents the enabling technologies currently available and those, evolving to a mature state, that may be key to the operation of UAS in aerodromes.

	Flight Phase			
	Arrival	**Taxi**	**Handling**	**Departure**
Current Enabling Technologies	ILS GPS ADS-B Augmentation Systems by differential correction of the GPS signal Surface Movement Radar Microwave Landing Systems TIS-B JPALS	GPS ADS-B Moving Maps (EFB) Augmentation Systems by differential correction of the GPS signal Surface Movement Radar TIS-B	Conventional Push Back TIS-B	ILS GPS ADS-B Augmentation Systems by differential correction of the GPS signal Surface Movement Radar TIS-B

	Flight Phase			
	Arrival	**Taxi**	**Handling**	**Departure**
Evolving Technologies	Information Sharing (SWIM) Aero Swim (Communications) Smaller on board sensors and technology CPDLC	Information Sharing (SWIM) Enhanced EO and visual cues ASDE-X	Information Sharing (SWIM) Enhanced EO and visual Advanced Docking Systems ASDE-X Smaller on board sensors and technology	Information Sharing (SWIM) Aero Swim (Communications) Smaller on board sensors and technology CPDLC
Obsolete Technology	ILS will move towards differential GPS and multi lateration	Conventional airport signs and markings		

Table 7 Enabling Technologies for UAS Operations at Aerodromes

The current increasing levels of automation in ground systems and the availability of advanced computer systems onboard needs to be used to their full capabilities, and improve the interoperability and integration between them. This situation should be solved in the coming years, and so the existing initiatives at both sides of the Atlantic are directed to increase the integration between ground and airborne systems. A key common technological enabler for the operation of UAS at aerodromes is an enhanced data link which can provide the required performance for command and control and sensor data transfer for ground operations and advanced on board sensors.

One interesting point to highlight from the work conducted under the technology review is that the integration of UAS at aerodromes, from a technological point of view, stems from the fact that technologies that will enable the operation of aircraft in the SESAR framework are not focused on UAS. The study shows that most of the Communications, Navigation and Surveillance technology required for current UAS operation of manned aircraft is already available. It needs, however, validating for the use in unmanned aviation. It is important, therefore, to highlight the fact that the operation of UAS at aerodromes is possible from a technological perspective. In other words, technology is not the main barrier for future UAS aerodrome operation.

Furthermore, most of the necessary technologies are available under development for manned aviation, and so it is an exercise of adapting, if at all, some of the present technology to unmanned systems. This consequently implies that potential benefits may exist for manned aviation from the technological and operational improvements introduced by the operation of UAS at aerodromes, in particular in the areas of:

- Sense and Avoid
- Virtual map of the aerodrome
- Increased automation leading to improved predictability of the aircraft movement, thus enhancing the ATCO situational awareness
- Potential safety increase due to the new technologies, especially in low visibility conditions (even with an increase in the airport capacity in these conditions)

All in all it can be said that the technology required to operate UAS at aerodromes is available or under development, and that focus should be put under regulatory compliance and procedures. Clear UAS specific operational concepts and procedures at an aerodrome need to be defined; technology will then support such procedures. There is a strong need for clear responsibilities for the actors involved supported by procedures for UAS aerodrome operations, including alternative procedures to unmanned aviation needed in case of emergency situations (e.g. data link loss, recovery).

8.3 Conclusions and Recommendations

UAS appear on the aerodrome scene as a new user with a high potential to become a significant segment in number of operations, and thus business. Nevertheless, the operation of UAS from medium and large commercial aerodromes may be limited due to the operative conditions of high density airports.

UAS could use existing controlled secondary aerodromes ("low densitiy airports") by complying with a few prerequisites. Aerodromes devoted to UAS will offer to them the same basic services as currently provided to manned commercial, business and general aviation. Just a few characteristics of existing aerodromes have to be adapted, since the absence of an onboard pilot as well as the inclusion of new technologies imposes new conditions for the aforementioned operations. The selection of an aerodrome for UAS operation depends on many factors: operational needs, vicinity, investments in infrastructure, capacity of the airport, volume of traffic, aerodrome layout, runway management, etc.

Apart from the required adaptations for UAS operation, remaining capacity at an aerodrome is a factor that will become most important for the decision of an aerodrome to offer / allow UAS operation:

- Runway management is significantly important for UAS operations and directly linked to the capacity of the airport. UA are generally slower and have lower performances than their equivalents in commercial aviation regarding wing span. Therefore the operation of UA at aerodromes may jeopardise the aerodrome capacity and operational efficiency.
- The option of operating UA from large airports with very low remaining capacity must not be disregarded, especially in the case of cargo aircraft being substituted by UA with similar performance to the current cargo aircraft.

- Improvements of performances are needed for the UA and new high speed exits are to be build in the aerodromes.

From INOUI project researches results, the operation of UAS from large and even some medium airports is foreseen as difficult, exceptions to be made on the air cargo application. The other UAS applications should be operated from less busy aerodromes or even from new aerodromes specially built for the UAS operation. INOUI recommends to further elaborate the UAS operation from small and low traffic medium aerodromes and also mixed civil-military aerodromes.

From a technological point of view, most of the necessary UAS technologies presently already exist or are under development for manned aviation. So it is an exercise of adapting, if at all, to unmanned systems. This implies that potential benefits may exist for manned aviation from the technological and operational improvements introduced by the operation of UAS at aerodromes, in particular in the areas of:

- Sense / Detect and Avoid
- Virtual map of the aerodrome
- Increase automation leading to improved predictability of the aircraft movement, thus enhancing the ATCo situational awareness
- Potential safety increase due to the new technologies, especially in low visibility conditions (even with an increase in the airport capacity in these conditions)

However this also implies that further research and validation is required in the adaptation of such technologies, and the following questions should be considered:

- How will UA pilot receive data in the control station?;
- Will he receive information on time to avoid collisions?;
- Will UA be fitted with technologies such as MLAT, ADS-B or similar to comply with the requirements of such manned aviation technologies?;
- Will size, weight and power consumption (among others) requirements of UAS be capable of support the avionics needed?

UAS specific operational concepts and procedures at an aerodrome need to be defined in detail and to be validated, technology will then support such procedures. There is a strong need for clear responsibilities for the actors involved, supported by procedures for UAS aerodrome operations including alternative procedures to manned aviation needed in case of emergency situations (e.g. Data link loss, recovery).

All in all it can be said that the technology required to operate UAS in aerodromes is available or under development, and that focus should be put under regulatory compliance and procedures.

8.4 User of the results

The most obvious user of the INOUI results is the UAS community at large. This community can be defined as the people that act in the design, the manufacture, the regulation and the use of UAS. A preliminary list of those groups and bodies is as follows:

- SESAR WPE Long Term
- SESAR WPB Target Concept
- SESAR WP6 Airport Operations
- SESAR WP8 SWIM
- UAS manufacturers
- Avionics manufacturers
- ICAO
- EASA
- EUROCAE WG-73

Dedicated target group of WP 6 are also airport operators respectively aerodrome / airport management companies.

9 Work Package 7 « Dissemination and Exploitation »

9.1 Scope and Activities of the Work Package

9.1.1 Work package 7 overview

The tasks performed by WP7 covered all activities necessary to disseminate and exploit the results from the project to all involved stakeholders. The objective was to promote the achievements of the project - the regulatory, operational and technological challenges to integrate UAS into ATM - within the related UAS community.

The dissemination activity plan mainly comprised the actions:

- Creation and maintenance of a web site for the INOUI project,
- Participation in international events related to any issue that deals with any INOUI research aspects, and
- Organisation of a workshop to debate with stakeholders by the mid of the project and one dissemination forum at the end of the project to disseminate its results.
- Production of public documents for external use, brochures and info-packages

The focus of the dissemination activities performed was finally in period 2 of the project, when step by step results and documents of the INOUI deliverables were ready for discussion and presentation with the relevant stakeholder groups. [7]

The exploitation activity aimed at discussing with the stakeholders the concepts proposed by INOUI in order to achieve a mature and consolidated European approach, including the input for preparation of validation trials in the future once the technologies are implemented.

9.1.2 The INOUI positioning within the UAS Stakeholder Community

SESAR as the future ATM target concept formed the major cornerstone for INOUI.

The INOUI consortium was well aware that the integration of outside ideas and opinions is crucial to this project. The team members participated in UAS congresses & workshops, UAS research, working groups and publications.

- The input of the Stakeholder Community was of the utmost importance. Therefore, INOUI project members invited the UAS stakeholders to participate in two

[7] The 1st period of the project emphasised on the alignment with organizations as EUROCONTOL, Eurocae WG 73 and – for the utmost importance of INOUI – with SESAR and the SJU.

workshops to ensure their valuable input, to validate the work done and to get further input for future activities.

- The UAS Stakeholder Community is fragmented and the challenges are tackled in several working groups. The INOUI project represents a holistic approach to the future UAS integration into the ATM environment 2020+.
- The goal of INOUI was providing a stepwise approach to enable the earliest possible use of UAS applications

9.1.3 List of Activities performed

Work Package	Partner	Action Description	Results (Doc. Ref. Code)
WP 7.1	DFS	• Update of the INOUI Dissemination and Exploitation Plan, elaborated early in the project to enable the performance of the dissemination activities. • Continuous update of the Dissemination and Exploitation Plan • Documentation of Dissemination Activities	D INOUI-WP7.1-DFS-D7.1-DP-CO-v0.01.doc INOUI-WP7.1-DFS-D7.1-DP-CO-v0.3.pdf
WP 7.2	ISD	• Technical maintenance of the INOUI website • Update of the content of the INOUI website • Relaunch of the INOUI project website in February 2009 (task performed on top to the obligations in the contract)	D 7.2 http://www.inoui.isdefe.es/INOUI/
WP 7.3.	DFS	• Leading and coordinating the participation of INOUI members in UAS related external activities/events/working groups/forums/exhibitions. • Dissemination of INOUI in related forums and working groups • INOUI Mid Term Assessment. As no specific assessment was planned by the EC in the first project year, the INOUI consortium decided to use the 1st INOUI Stakeholder Workshop of WP1 for extended assessment also of other work package subjects with the relevant stakeholders (esp. WP 3).	D 7.3 Retrospective to 1st INOUI Stakeholder Workshop 21-23 October, 2008
WP 7.3.	All	• Participation of INOUI members in UAS related external activities, events, working groups, forums, exhibitions etc.	D 7.3.
WP 7.4	DFS	• Facilitating the exploitation of the results and support the dissemination by securing the overall consistence of the results of the separate working packages and enabling the dissemination of the results in a consolidated approach. • The challenges for UAS implementation into the non-segregated airspace are still significant and a holistic approach is needed. The Content Integration Team developed that approach and safeguarded the respective work in the working package.	Meeting minutes and reference documents of CIT meetings Structure and content of the INOUI Booklet

WP 7.5	DFS	• Supporting the EC for the preparation of EC / EDA UAS political conference
		  • Participation in meetings, phone conferences etc.
		  • Creation of specific documents
			Documentation
			
			INOUI Booklet

Table 8 Activities and results by work package 7 and partner

In addition to the initial set-up of the INOUI webpage according to WP 7.2 / D7.2 the INOUI webpage was re-launched in February 2009. The re-launch encompassed an optimised user-friendly structure for providing information and documents to the stakeholders (content structure, page flow etc.) and also a new design ("look & feel")

The registration for the 2nd INOUI stakeholder workshop and for the Dissemination Forum was performed via the INOUI webpage as online-registration work-flow.

9.1.4 Deliverables

Del. no.	***Deliverable name***	***Work package no.***	***Date due***	***Actual delivery date***	***Lead contractor***
D 7.1	*INOUI Dissemination Plan and Exploitation Plan*	*WP 7.1*	*T0+3 (draft)* *TO+24 (final)*	*March 2009 (draft)* *Continuous updates, final version end of the project*	*DFS*
D 7.2	*INOUI Website specification*	*WP 7.3*	*T0+4*	*T0+4*	*ISD*
D 7.1	*INOUI Dissemination Activities Report*	*WP 7.3*	*T0+29*	*March 2010*	*DFS*

9.1.4.1 Examples of the INOUI webpage content

9.1.5 Milestones achieved

Milestone no.	*Milestone name*	*Work package no.*	*Date due*	*Actual/ forecast delivery date*	*Lead contractor*
M 7.1	*Development of the INOUI Website finished*	*WP 7.2*	*T0+5*	*March 2008*	*ISD*
M 7.2	*Mid Term Assessment*	*WP 7.3*	*T0+12 (indicative)*	*During 1st Stakeholder Workshop 21-23 October, 2008. and 2nd Stakeholder Workshop 10-12 March, 2009. Meetings with SJU (31.7.2008), Eurocontrol (17.9.2008) and SESAR WPB (several during 2008-2010)*	*DFS*
M 7.3	*INOUI Dissemination Forum*	*WP 7.3*	*T0+27*	*1 – 2 December 2009*	*DFS*
M7.4	*EC Conference*	*WP 7.5*	*T0 + 29*	*21 April 2010*	

9.2 Communication with Stakeholders

The UAS Stakeholder Community is fragmented and the challenges are tackled in several working groups. The INOUI project represents a holistic approach to the future UAS integration into the ATM environment 2020+. INOUI was summarizing the existing knowledge, identifying and filling gaps and with that work benefiting the European Roadmap for UAS integration. The results of this coherent approach shall help and accelerate to bring UAS into the air in the earliest possible timeframe.

The main sources and the beneficiaries of the INOUI work were identified in the 1st working period (9.10.07 – 8.10.2008) of the project. This overview was presented to EUROCONTROL, agreed by SESAR and presented to the UAS Stakeholders (e.g. at the 1st INOUI Stakeholder Workshop October 2008).

Alignment of INOUI with other European UAS activities and projects

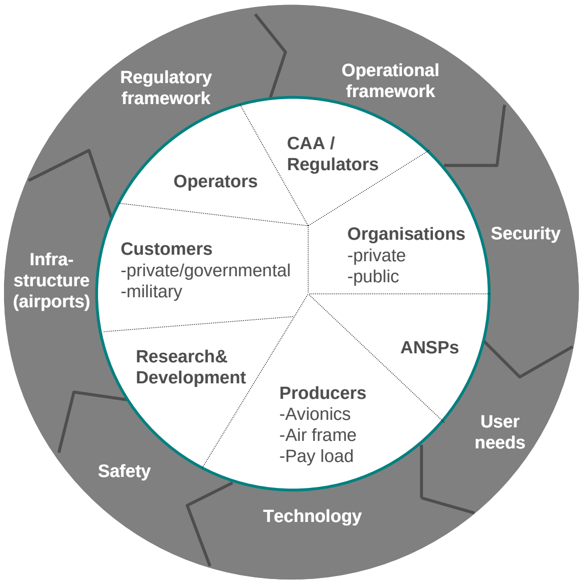
	Sources	Beneficiaries
WP1 – UAs Concepts, Procedures and Requirements for 2020	•SESAR Definition Phase: ATM Target Concept, ConOps, Architecture and CNS Technologies •Other UAS related projects and activities as USICO, CAPECON, USEP, Air4All etc., but they are focused on short term integration and current ATM environment	•SESAR Development Phase (i.e. WP B): INOUI will suggest certain technological and procedural requirements/ solutions. Creating reports and dissemination activities will foster the acceptance of UAS within SESAR and pave the way for integration solutions.
WP2 – 2020 Seamless "UAS-Enabled" ATM Enterprise Architecture	•SESAR Definition Phase •Eurocontrol studies •SOFIA / Pegase	•SESAR Development Phase (i.e. WP B)
WP3 – Certification Blue Print for UAS in Europe	•EASA •EUROCAE WG73 •NATO STANAG 4670 DUO •JAA/Eurocontrol UAV Task-force – final report	•EASA •EUROCAE WG73 •Regulatory authorities (Eurocontrol, SESAR) •Industry partners
WP4 – 2020 UAS Common Operation Picture (SWIM enabled) – Activities	•SESAR Definition Phase •SWIM-SUIT	•SESAR Development Phase •Technical and operational interoperability (SESAR "entreprise architecture")
WP5 – Safety Analysis for civil UAS applications	•EASA •ESARR 4 •EUROCAE WG73 •Flight trials & simulations (e.g. WASLA-HALE, VUSIL)	•SESAR Development Phase (i.e. WP 16) •EUROCAE WG 73
WP6 – New Airport concepts for UAS	•Hardly any informations/publications existing •Other UAS activities focus on integration in airspace, not on airport concepts	•SESAR Development Phase

In period 2 the focus was on interchange with the respective other working groups and a close alignment with SESAR. Within SJU and SESAR WP B "Target concept and Architecture Maintenance" was agreed to be WP B the anchor for INOUI, bringing UAS into SESAR. A close cooperation took place between SESAR WPB and the INOUI team.

Identification of the INOUI Stakeholders

One of the most important tasks for an optimized work within the INOUI project and for the dissemination of the results was the identification of parties that might be interested in the findings of INOUI, means defining the UAS stakeholder group. The INOUI view was confirmed during the two stakeholder workshops in is described in the below graph. The inner cycle of the graph includes the UAS Stakeholder segments; the outer cycle describes the framework for a successful UAS integration in the ATM environment.

The UAS Stakeholder Framework



Source: INOUI, October 2008

The INOUI mailing list of UAS Stakeholders was enhanced continuously as a major basis for dissemination activities. The list contained finally about 450 active names / mail-addresses of UAS Stakeholders, including the main UAS organisations and working groups as well as members from Europe and the US.

Important elements of the INOUI project have been two stakeholder workshops. These workshops had the task to exchange experiences and views between stakeholders for taking their needs and requirements into account in the INOUI project. The first workshop was part of WP1 "UAS ATM Concepts, Procedures and Requirements for 2020" and took place from 21 – 23 October, 2008. The second workshop was part of WP6 "New Aerodromes Concepts for UAS" and took place from 10 - 12 March, 2009. The final Dissemination Forum was held 1 – 2 December, 2009 in Cologne / Germany.

The stakeholder workshops and the dissemination forum were open for registration to all interested parties and persons.

9.2.1 First INOUI Stakeholder Workshop

The first INOUI Stakeholder Workshop was part of WP 1 „UAS ATM Concepts, Procedures and Requirements for 2020" and took place from 21-23 October 2008 in Palma de Mallorca / Spain. It was mainly organised by DFS as the WP1-Lead and Project Coordinator. Objectives of this workshop were exchange of experiences and views between stakeholders and informing the participants about SESAR as this is the framework of the future ATM environment and thus of high relevance for integrating UAS. Furthermore, the results of the workshop shall be used as input for the SESAR concepts and shall feed into upcoming deliverables of INOUI. As INOUI is fully aligned with SESAR and in close contact with the SESAR Joint Undertaking, which are open to and even expect input from the UAS community, the participants had the opportunity to add a UAS piece to the SESAR puzzle.

The 54 participants from Europe and USA represented all UAS stakeholder groups: private, governmental and military users, operators, CAA/regulators, research & development institutes, producers, ANSPs and other relevant organisations like EUROCAE WG73 or Air4All. According to participants' feedback, newcomers and experts in the UAS business received a concise but broad overview of the whole UAS spectrum and the challenges to be faced.

Key note speakers were Gilles Fartek, European Commission DG TREN2, and Peter Ahlers, DFS and designated head of WP B of SESAR Joint Undertaking (SJU). The workshop consisted of presentations of different stakeholders and working sessions, both concerning the topics "Challenges for the integration into future SESAR ATM environment", "User needs", "Use of UAS technology for manned aviation" and "Regulatory issues". The results per working session were finally presented and discussed in the plenary, for example the group "Regulatory issues" developed a plan for the implementation of rules & regulations and will set up a working forum on the INOUI webpage. The overlap and synergies between non-military and military use of UAS applications were discussed and in addition further close cooperation was agreed.

The INOUI project represents a holistic approach to the future UAS integration into the ATM environment 2020+. It was a common understanding between the European Commission and the stakeholders that there exist different applications but all experience similar problems and have to strive for common solutions.

Thus the 1st INOUI stakeholder workshop was an important milestone for the INOUI project and the alignment with the UAS Stakeholder community. The discussions between the participants fostered an integrated approach benefiting the European roadmap of UAS integration 2020.

The INOUI webpage provided a retrospective to the workshop and all presentations for download. The "Retrospective to the workshop" was also sent out by mail to the UAS Stakeholders (INOUI database).

9.2.2 Second INOUI Stakeholder Workshop

The second INOUI Stakeholder Workshop was part of WP6 "New Aerodromes Concepts for UAS" and took place from 10 - 12 March, 2009 in Las Palmas de Gran Canaria / Spain. It was mainly organised by ISDEFE as WP6 lead with support from the Consortium. The 46 participants from Europe and USA represented all UAS stakeholder groups: private, governmental and military users, operators, CAA/regulators, research & development institutes, producers and ANSPs Also organisations like e.g. EUROCONTROL, EDA, JAPCC and UNITE were present. As Key note speaker the INOUI consortium welcomed Gilles Fartek, European Commission DG TREN2.

The results of the workshop fed into upcoming deliverables of INOUI as well as being important input for the SESAR concepts. INOUI was fully aligned with SESAR and in close contact with SESAR work package leader, which are open and even expect input from the UAS community. This way the participants of the INOUI workshops had again the opportunity to add a UAS piece to the SESAR puzzle.

Objective of this 2nd INOUI workshop was to create a common view on UAS operations at aerodromes as well as to identify technologies needed to enable UAS operations at aerodromes. Attention was also given as how to establish a linkage between users, manufacturers, regulators and ANSPs allowing them to exchange experiences, views and needs. The workshop consisted of presentations of different stakeholders varying from users and research perspectives to a technological view and two parallel working sessions: "Concepts for UAS operating at aerodromes" and "Technologies to enable UAS operations at aerodromes". The results per working session were finally presented and discussed in the plenary. Another objective of this workshop was to continue the discussions initiated during the first workshop regarding the integration of UAS under operational and regulative perspectives in the future ATM environment defined by SESAR.

One of the key findings also of this 2nd workshop was that a global aviation solution for UAS is necessary, from the conceptual as well as from the technological point of view. Strategies from manufacturers for potential customers and aerodromes are required to establish a new market. Concerning the aerodrome operations the pilot control of the UA was discussed, it was a common conclusion that for the time being voice will remain the main COMM channel. There will be complementary use of data link for non time critical instructions. Generally the spectrum for data link remains a key issue. Analysing the technological perspective at aerodromes, it was concluded that technology is not the main barrier for future UAS aerodrome operations because all necessary technologies are present or under development already. Clear UAS specific operational concepts and procedures at an aerodrome need to be defined; technology will then support such procedures. Notwithstanding there is room for enhancing data link performance and development of smaller and more efficient on board sensors. The discussions confirmed again one of the conclusions of the 1st INOUI workshop that civil/governmental use and military missions of UAS face the same challenges and problems and have to strive for common solutions.

The last day of the workshop was devoted to follow up from the issues of the 1st INOUI Workshop and included presentations about the ICAO UAS Study Group, SESAR and the JARUS initiative. DFS (WP1 lead) discussed with the participants about statements regarding the future operational concepts. Issues like communication, loss of data link, detect and avoid amongst others were discussed and potential operational and procedural solutions were highlighted. To wide the basis stakeholders will be given the opportunity to comment on the operational concepts developed in INOUI. Isdefe (WP3 lead) and ONERA discussed statements and developments concerning certification and licensing. From the regulation and certification issues side, the attendees remarked the importance of considering ergonomic and HMI in the certification blueprint. Nevertheless, the INOUI view on ongoing standardisation work about airworthiness was agreed. The discussions served as valuable inputs for the final documents in WP1 and WP3.

The 2nd INOUI stakeholder workshop was thus another important milestone in the INOUI project and for the alignment with the UAS Stakeholder community. The discussions between the participants fostered an integrated approach benefiting the European roadmap of UAS integration 2020.

It was again common understanding that there exist different applications but all experience similar problems and have to strive for common solutions. The goal of INOUI is providing a stepwise approach to enable the earliest possible use of UAS applications. Part of that work is the continuous alignment work of INOUI with SESAR and further cooperation with SESAR WP B as central anchor point.

The INOUI webpage provided a retrospective to the workshop and all presentations for download. The “Retrospective to the workshop” was also sent out by mail to the UAS Stakeholders (INOUI database).

9.2.3 INOUI Dissemination Forum

The research results of the project were presented at the INOUI Dissemination Forum in Cologne, Germany, on 1 - 2 December 2009. The forum was open to all interested UAS stakeholders, as it had been the case for the Stakeholder Workshops.

The 85 participants from Europe and USA represented all UAS stakeholder groups: private, governmental and military users, operators, CAA/regulators, research & development institutes, producers, ANSPs and other relevant organisations like EASA, European Defence Agency (EDA), EUROCAE resp. EUROCAE WG73 and JAPCC. According to participants’ feedback, they received a concise overview of the work of the INOUI project, the key results and the future challenges.

As key note speaker the INOUI consortium welcomed Gilles Fartek, European Commission DG TREN; Jukka Justi, Director Armament EDA; Peter Ahlers, DFS and Head of WP B SESAR; and Jules Kneepkens, Rulemaking Director, EASA. The work package leaders of INOUI presented the content and the results of the six work packages and 21 deliverables. The attendees had the opportunity to ask questions and to discuss follow-up topics.

SESAR defines the common future ATM system in Europe. Although UAS are recognized by SESAR as legitimate airspace user, the topic of UAS was only briefly mentioned in SESAR Definition Phase and the related deliverables. Consequently, the results of the INOUI project feed into upcoming work within the SESAR Development Phase. On behalf of the SJU the work was appreciated by Peter Ahlers, head of SESAR WP B (Target Concept and Architecture): “SESAR needs the expertise gathered in INOUI concerning UAS operations and requirements. We will consider and integrate UAS operations in concepts and system architecture and the results of INOUI will be used to update the CONOPS”. “Detailed conceptual descriptions and requirements concerning UAS operations will be developed in operational and technical thread work packages, the material developed by INOUI will be used and considered. SESAR can possibly learn from UAS technology which is already available”.

The second day included a panel discussion devoted to the next steps for UAS integration. Panel participants included representatives from the European Commission and the European Defence Agency and the INOUI work package leaders. The forum participants also placed questions and voiced their concerns to the panel about the future challenges. In addition a European UAS congress was announced by EC and EDA, which was scheduled for 21st April 2010 in Brussels.

The INOUI webpage provided a retrospective to the forum and all presentations for download. The “Retrospective to the Forum” including the link to the INOUI webpage was also sent out by mail to the UAS Stakeholders (INOUI database).

9.2.4 Publication of the INOUI results

The publication of the results of the INOUI project, i.e. of the 21 deliverable documents, took place primarily in the project period 2, focussed in year 2009.

All **21 deliverables** of the INOUI project, an **Executive Summary per work package** and the **complete documentation of the Stakeholder Workshops and the Dissemination Forum** were published on the INOUI webpage (respectively in early 2010 as soon as European Commission approval has been obtained).

A **comprehensive glossary of UAS terms and terminology** used in the project was concluded and updated and can also be found on the website.

Furthermore a **INOUI booklet** was compiled to provide the UAS stakeholder community an overview of the content and the results of the INOUI project and points the interested reader to the detailed INOUI deliverables. The booklet itself is designed to present the wider public with a broad view on the current problems and the challenges for successful integration of UAS into non-segregated airspace. It is also available for download on the INOUI webpage.

10 Management of the Project (WP 0)

10.1 Project Management

10.1.1 Tasks performed

The main objective of WP0, Management, was to manage the work done in the INOUI project so as to ensure timely completion of the work with the highest possible level of quality. An additional objective of WP0 was to liaise with external projects i.e. SESAR and associations involved in developing operational concepts and /or procedures related to INOUI activities.

WP 0 was generating management documents, managing PMB and Consortium meetings, and gathering project management information and transmitting this information to the European Commission (EC). The work package had been divided into two tasks, as follows:

WP 0.1 Overall Project Management (T0 – T0+29)

- Convening PMB (Project Management Board) and Consortium meetings, providing the calling notices and the minutes. The consortium and the PMB met in a four-monthly basis.
- Preparing and keeping current the Project Participant Directory.
- In general, ensuring that the overall work done in the project teams meets the project schedule and is delivered with the highest level of quality.

The INOUI project was aligned with SESAR (31.7.2008) and acknowledged by EUROCONTROL (17.9.2008). Due to the time required for the alignment and to scope enhancements of several work packages a prolongation of the project by 5 month was suggested and finally contracted with EC in an amendment to the contract.

WP 0.2 Coordination with External Projects and Associations (T0+12 – T0+29)

WP 0.2 was responsible for liaising and coordinating with external projects and associations. This task worked closely with WP 7, providing the necessary documentation and contacts to fully achieve its intended coordination work and establishing and maintaining contact, e.g. s with projects such as SESAR, SWIM, UAVNET, CANSO UAV task force, EUROCONTROL – JAA task force, US UNITE, among others and associations and organizations like ICAO, FAA, ARINC, EUROCAE / WG73, EASA and EUROCONTROL, contacting with their working groups and panels.

All INOUI partners were involved for years in UAS issues. Therefore, a lot of contacts to working groups and projects were already established. These contacts were intensified after the official start of the INOUI project and continued in period 2. Additional and more formal contacts by INOUI Project Coordinator (PCO) were initiated to improve the visibility of the INOUI project in the wider UAS stakeholder community.

The contacts with SESAR and EUROCONTROL, being of utmost importance for the success of the INOUI project, were coordinated by the EC together with INOUI PCO.

Work Package	Partner	Action Description	Results (Doc. Ref. Code)
WP 0.1 Overall Project Management	DFS	Calling for meeting and writing the Meeting Minutes for Consortium Meetings (CM) and Project Management Board Meetings (PMB) Continuously tracking the progress of the work within the work packages, the progress of the deliverables (time and quality)	Call for Meetings Meeting Minutes (dates of the meetings see meeting list) Respective mails / PCO presentations in CM + PMB
WP 0.2 Coordination with External Projects and Associations	DFS	Contacts initiated with the respective other projects. Continuous contact with other working groups, partly by PCO and partly by participation of INOUI members in the respective groups, projects and congresses. The knowledge was shared within the INOUI team per work package, discussed during INOUI Technical Meetings and Consortium Meetings as well as in bilateral discussion between the involved INOUI participants per subject. Implementing SESAR WP B as anchor for INOUI within SESAR; ongoing bilateral communication. SESAR WP B presentation at INOUI stakeholder workshops, Dissemination Forum and INOUI internal meetings	D 7.2. + Integrated in the creation of INOUI deliverables See presentations and retrospectives published

Table 9 Activities and results by work-package 0 and partner

10.1.2 Deliverables

Del. no.	Deliverable name	Work package no.	Date due	Actual delivery date	Lead contractor
D 0.1	Project Management Plan	WP 0	T0+1	March 2008	DFS
D 0.2	Project Quality Plan	WP 0	T0+1	March 2008	DFS
D 0.3	Risk Management Plan	WP 0	T0+1	March 2008	DFS
D 0.4	Project Documentation Plan	WP 0	T0+1	March 2008	DFS
D 0.5	Project Participant Directory	WP 0	T0+1	March 2008	DFS
D 0.6	Meeting Calling Notice and Minutes	WP 0	4monthly	ongoing	DFS
D 0.7	Consolidated Periodical Progress Reports	WP 0	T0+12	February 2009	DFS
D 0.8	Project Final Report	WP 0	T0+29	End of project	DFS

D 0.7 and D 0.8 were to be delivered in INOUI reporting period 2, D 0.6 was an ongoing task during the complete project time frame.

Due to scope enhancements and the problems of the alignment with SESAR and EUROCONTROL in period 1 the schedule was delayed. This delay mandated the rescheduling of the 1st INOUI Stakeholder Workshop, part of work package 1, from spring 2008 to October 2008 (T0+13 / period 2) and as a knock on effect the rescheduling of the depending other work packages became necessary. The delays were reported to the EC during the PMBs and acknowledged by the EC. An updated time schedule was therefore agreed within the contract amendment. This time schedule took into account the delays of project year 1 and guaranteeing on the other hand the most possible quality of the INOUI deliverables.

10.1.3 Milestones achieved

Milestone no.	Milestone name	Work package no.	Date due	Actual/Forecast delivery date	Lead contractor
M 0.1	Management Documentation (PMP, PQP, PDP, PPD)	WP 0	T0+1	March 2008	DFS
M 0.2	Consolidated Progress Report Period 1	WP 0	T0+12	February 2009	DFS
M 0.3	Final Report and Consolidated Progress Report	WP 0	T0+29	End of project	DFS

10.1.4 Effort Overview in MM per Work Package

Person-Month Status Table

CONTRACT N°: TREN/07/FP6AE/S07.69061/037191
ACRONYM: INNOVATIVE OPERATIONAL UAS INTEGRATION

Complete Period: 9.10.2008 - 8.03.2010

Partner - Person-month per Workpackage

			TOTALS	DFS (Coord.) *)	ISD	BRT	INA	RDE	ONE
Workpackage 0:	Project Management	Actual WP total:	22,21	16,4	1,2	1,2	0,0	1,4	2,0
		Planned WP total:	20,95	15,6	1,2	1,2	0,0	1,4	1,6
Workpackage 1:	UAV ATM Concepts, Procedures and Requirements for 2020	Actual WP total:	42,20	17,2	8,5	6,5	0,0	6,0	4,0
		Planned WP total:	46,30	17,5	8,5	8,8	0,0	6,0	5,5
Workpackage 2:	2020 Seamless "UAV-enabled" ATM Enterprise Architecture	Actual WP total:	33,50	11,6	10,0	6,4	0,0	3,5	2,0
		Planned WP total:	36,10	12,5	10,0	7,6	0,0	3,5	2,5
Workpackage 3:	Certification Blue Print for UAVs in Europe	Actual WP total:	21,90	1,5	9,4	2,0	0,0	2,0	7,0
		Planned WP total:	20,50	2,0	8,5	2,5	0,0	2,0	5,5
Workpackage 4:	2020 UAV Common Operation Picture	Actual WP total:	53,30	0,2	3,0	16,1	28,5	4,5	1,0
		Planned WP total:	39,00	3,0	3,0	20,0	9,0	4,0	0,0
Workpackage 5:	Safety Analysis for civil UAV applications	Actual WP total:	58,15	16,6	14,0	9,6	0,0	8,0	10,0
		Planned WP total:	56,50	17,0	14,0	12,5	0,0	6,0	7,0
Workpackage 6:	New Airport concepts for UAVs	Actual WP total:	21,60	1,4	9,5	5,0	0,0	3,7	2,0
		Planned WP total:	24,75	2,5	9,5	7,0	0,0	2,8	3,0
Workpackage 7:	Dissemination	Actual WP total:	34,30	11,6	7,0	4,7	0,0	6,0	5,0
		Planned WP total:	42,95	16,6	7,5	4,7	0,5	6,2	7,6
Total Project Person-month		Actual total:	287,36	76,7	62,6	51,5	28,5	35,1	33,0
		Planned total:	287,05	86,7	62,2	64,3	9,5	31,9	32,5

note: 1) Data: rounded values 2) Planned effort based on contract amendment, dated October 2009
3) INA: Corrected data for period 1 compared to initial reporting

Table 10 Efforts in MM per work package

10.2 Consortium Management

10.2.1 Tasks performed

Consortium management activities were focussed to provide an appropriate management framework linking together the individual project components and to maintain the communication with the Commission. The INOUI consortium management activities included:

- Coordination of the technical activities of the project
- The overall legal, contractual, ethical, financial and administrative management
- Coordination of knowledge management and other innovation-related activities
- Overseeing the promotion of gender equality in the project
- Overseeing science and society issues related to the research activities conducted with the project

And in detail for the contract management in period 2:

- o Processing of the amendment of the contract
- o Obtaining the financial securities such as bank guarantees, when requested
- o To proceed the allocation of the payments to the consortium partners according to the provisions of the contract
- o Maintenance of the consortium agreement
- o Obtaining the audit certificates after end of period 1

Within the INOUI project existed four different communication levels. The communication of the project coordinator with the respective consortium members depended on the issue and was based on the provisions of the consortium agreement and on the project management plan (PMP).

Communication levels within the consortium:

1) Consortium partners: Represented by the Point of Contact per company (POCs) (members of the Consortium Meeting)
2) Work Package Leaders (WPLs) (members of the PMB)
3) Work Sub-Package leaders
4) INOUI team members (all project participants)

10.2.2 Consortium Members

The INOUI consortium consists of six organisations including a UAS Manufacturer, an Air Navigation Service Provider, Research Centres and Consultancy Companies. More specifically, the following organizations participate:

- DFS Deutsche Flugsicherung GmbH (DFS),
- Ingeniería de Sistemas para la Defensa de España, S.A. (Isdefe),
- Boeing Research & Technology Europe, S.L. (BR&TE),
- Fundación Instituto de Investigación INNAXIS (INNAXIS),
- Rheinmetall Defence Electronics GmbH (RDE),
- The French Aerospace Lab (Office National d’Etudes et Recherches Aérospatiales) (ONERA).

Company	Points of Contact (POC)	E-mail
DFS	Achim Baumann, Marita Lintener	achim.baumann@dfs.de marita.lintener@dfs.de
ISD	Juan Alberto Herreria	jherreria@isdefe.es
BRT	Carlos Montes	carlos.montes@boeing.com
ONE	Claude Le Tallec	Claude.Le_Tallec@onera.fr
RDE	Klaus Wohlers	Klaus.Wohlers@rheinmetall.com
INA	Paula Lopez-Catala	plopez@innaxis.org

Table 11 Consortium members and Point of Contacts

10.2.3 Project participants

First Name	Last Name	Organisation
Gilles	Fartek	EC
Hoang	VU DUC	EC
Achim	Baumann	DFS
Marita	Lintener	DFS
Stefan	Tenoort	DFS
Hans	de Jong	DFS
Andreas	Udovic	DFS
Udo	Gebelein	DFS
Bernd	Mohrhard	DFS
Nanda	Geelvink	DFS
Diana	Durrett	DFS
Michael	Jung	DFS
Frederik	Meysel	DFS
Juan Alberto	Herreria	ISDEFE
Jorge	Bueno	ISDEFE
Carlos	Planter	ISDEFE
Iñigo	Muñoz	ISDEFE
Cristina	Martinez	ISDEFE
Marga	Martin	ISDEFE
Rodrigo	Priego	ISDEFE
Mendi	Juan	ISDEFE
Carlos	Montes	BRTE
Roberto	Molina	BRTE
David	Esteban	BRTE
Claude	Le Tallec	ONERA
Michel	Lemoine	ONERA
Antoine	Joulia	ONERA
Klaus	Wohlers	RDE
John	Tattersall	RDE
Reimund	Kueke, Dr.	RDE
Norbert	Martinkat	RDE
David	Perez	INA
Paula	Lopez-Catala	INA
Ricardo	Herranz	INA

Table 12 Project participant list

10.3 Deliverable schedule

(acc. to Annex I contract amendment 1/10/2009)

Deliverable No	Deliverable title	Delivery date	Nature	Dissemination level
D0.1	Project Management Plan	T0+1	R	CO
D0.2	Project Quality Plan	T0+1	R	CO
D0.3	Risk Management Plan	T0+1	R	CO
D0.4	Project Documentation Plan	T0+1	R	CO
D0.5	Project Participant Directory	T0+1	O	PU
D0.6	Meeting Calling Notice and Minutes	As needed	R	CO
D0.7	Consolidated Progress Report	T0+17	R	CO
D0.8	Project Final Report	T0+29	O	PU
D1.1	Definition of the UAS environment	T0+5	O	PU
D1.2	Concept of the civil UAS applications	T0+12	O	PU
D1.3	First proposal for the integration of UAS	T0+18	O	PU
D1.4	Harmonized proposal for the integration of UAS	T0+25	O	PU
D2.1	Report on Technology Systems Solutions	T0+12	O	PU
D2.2	Assessment of Technology for UAS Integration	T0+20	O	PU
D.2.3	Conclusions and Recommendations on New Technological Developments	T0+25	O	PU
D3.1	Regulatory Aspects for UAS Operations, Operators and Personnel Qualification	T0+21	O	PU
D3.2	UAS certification	T0+17	O	PU
D3.3	Regulatory Roadmap for the UAS Integration in the SES	T0+25	O	PU
D4.1	Research Report "Elements of the UAS systems within the 2020 SWIM-enabled ATM."	TR0+15	O	PU
D4.2	Research Report describing the new UAS-related COP actors	T0+20	O	PU
D4.3	Research Report describing the Level of Autonomy of UAS in COP	T0+25	O	PU
D5.0	Scope of Risks and Qantified Safety Criteria	T0+18	O	PU
D5.1	System Description for Safety Analysis	T0+21	O	PU
D5.2	Functional Hazard Analysis	T0+21	O	PU
D5.3	Towards Safety Requirements for the Integration of UAS	T0+25	O	**PU**
D5.4	Airport Safety Analysis	T0+25	O	**PU**
D5.5	Interpretation of Safety Analysis in the context of SESAR	T0+26	O	**PU**
D6.1	Operational Concept for the UASs in the Airports	T0+25	O	PU
D6.2	Technology Watch for the Operation of UASs in the Airports	T0+26	O	PU
D7.1	INOUI Dissemination Plan and Exploitation Plan	T0+3 (Draft) T0+29 (Final)	O	PU
D7.2	INOUI Website Specification	T0+4	R	CO
D7.3	INOUI Dissemination Activities Report	T0+29	O	PU

Table 13 Deliverable time schedule

10.4 Meeting Schedule

The table lists the meetings of INOUI during the project. Project Management Board Meetings and Consortium Meetings were scheduled on a 4-monthly basis in agreement with the partners and the EC. Additional technical meetings took place according to the needs of the individual sub-work packages.

Meeting	Abbr. acc. to Annex 1	Schedule according to Annex 1 (timetable)	Status	Actual date / Final forecast date
INOUI Kick Off Meeting	KOM	T0	done	9. Oct 07
Technical Meeting, WP1 & 3, KOM WP2, Madrid			done	12./13. Nov 07
Technical Meeting, WP1,2,3, Madrid			done	19./20. Dec 07
Project Management Board Meeting 1	PMB1	T0+4	done	7. Feb 08 (combined)
Consortium Meeting 1	CM1	T0+4	done	
Technical Meeting WP1 & 2, Langen			done	14. May 08
Technical Workshop all WPs, Madrid			done	8./9. Jul 08
Kick-off Workshop WP 5, Langen			done	23./24. Jul 08
Project Management Board Meeting 2 (PMB 2)	PMB2	T0+8	postponed in agreement with EC (Elizabeth Martin)	
Consortium Meeting 2	CM2	T0+8	Integrated in technical meeting MAD July 08	/
Meeting with SESAR JU			done	31. Jul 08
Technical Meeting all WPs (esp. 1,2,5)			done	2./3. Sep 08
Consortium Meeting 3	CM3	T0+12	done	4. Sep 08
Meeting with Eurocontrol			done	17. Sep 08
Project Management Board Meeting 2 (PMB 2)	PMB2		done	17. Sep 2008
Preparation Stakeholder Working Sessions for 1. INOUI Stakeholder Workshop			done	6. - 7. Oct 08
Workshop WP5			done	7.-9.Oct 08
Requirements Capturing Workshop 1 (part of WP1) (Consortium + EC + Stakeholders)	RCWS1	T0+5	done	21.-23.Oct 08
Mid Term Assessment (indicative) (Consortium + Stakeholders + SESAR)	MDT	T0+12	Mid term assessment by the stakeholders and SESAR was part of the 1st INOUI Stakeholder workshop 21-23 Oct 2008 and meeting with SJU (31 Jul 2008)	31 Jul 2008 21.-23.Oct 08
Workshop WP5			done	18.-20. Nov 08
Content Integration Team			done	ongoing (part of Tech. Mtg. 14. Jan 09)
Technical Meeting (Kick-off WP 6, Follow up WP 2,3,4)			done	13./14. Jan 09
Consortium Meeting 4	CM4	T0+16	done	15. Jan 09
Project Management Board Meeting (PMB 3)	PMB3	T0+12	done	16. Jan 09
Technical Meeting WP5			done	24.-27. Feb 09
Requirements Capturing Workshop 2 (part of WP 6) (Consortium + EC + Stakeholders)	RCWS2	T0+17	done	10-12 March 09
Content Integration Team			done	4.5.2009
Consortium Meeting 5	CM5	T0+20	done	8. Jun 2009
Project Management Board Meeting (PMB 4)	PMB4	T0+16	done	8. Jun 2009
Technical Meeting WP 5			done	26.-27. Oct 2009
Consortium Meeting 6	CM6	T0+20	done	27. Oct 2009
Project Management Board Meeting (PMB 5)	PMB5	T0+20	done	28. Oct 2009
Consortium Meeting 7	CM7	T0 + 24	done	18. Feb 2010
Content Integration Team and Technical Meeting of WP 2,3,4,6			done	8.-10. Sep 09
INOUI Dissemination Forum	DF	T0+26	done	1.-2. Dec 2009
Consortium Meeting 8	CM8	T0+28		18. Feb 2010
Project Management Board Meeting 6 (Final Project Meeting; PMB 6)	PMB6	T0+28		18.-19. Feb 2010

Table 14 INOUI Meetings

11 Other issues

11.1 Ethical issues

The INOUI project did not generate any ethical issues in reporting period 1. Within the project all ethical requirements were and will be adhered to.

11.2 Gender issues

The INOIU project did not generate any gender issues. Within the project all gender requirements were and will be adhered to.

11.3 Adherence to National & EC Ethical Legislation

The INOUI partners did and will adhere to National and EC Ethical Legislation.

Annex: Plan for using and disseminating the knowledge and Dissemination Report

Exploitable knowledge and its Use

The INOUI objective, as part European R&D community, was to contribute for the solution of UAS integration in the 2020 Air Traffic Management system, especially the SES implementation program SESAR.

Unmanned Aircraft Systems (UAS) are becoming increasingly important for non-military applications such as aerial photography, agricultural remote sensing and application, pipeline and power line surveillance, fisheries and wildlife monitoring, fire-fighting, weather and climate studies, law enforcement, rescue and recovery missions. The integration in non-restricted airspace is currently almost ignored.

A wealth of civil and governmental UAS applications exist, they face similar problems and now strive for a common solution. Furthermore military UAS missions face exactly the same problems and challenges as non-military UAS. The main issue is the integration of all UAS as a new airspace user into the future ATM System. For the time being UAS are only partially considered by SESAR DoWs.

The UAS market is facing significant problems:

- o Lack of international regulations for UAS > 150 kg and diversified national regulations, certifications and licensing for UAS < 150 kg hamper product development for global markets
- o Manufacturers are ready to start further testing and validation, including UAS flight trials, real time simulation(s) or combination of both. Theoretical concepts valid for practical operations are already available plus experience based on national tests.
- o Producers/Manufacturers and potential users need reliability on regulatory and certification issues. Fragmented national rules for non-military UAS prevent an integrated approach from the industry for civil and governmental applications
- o Missing and/or fragmented rules & regulations are cost drivers for the industry
- o Political and public acceptance is necessary to promote flight trials and stepwise implementation
- o Operational safety concepts need to be concluded.

Flying in segregated airspace is no standard solution. The goal of INOUI was providing a stepwise approach to enable the earliest possible use of UAS applications within non-segregated airspace.

The results of INOUI are not being directly exploitable for industrial or commercial applications. The INOUI project represents a holistic approach to the future UAS integration into the ATM environment 2020+. INOUI is summarizing the existing knowledge, identifying and filling gaps and with that work benefiting the European roadmap for UAS integration. The results of this coherent approach shall help and accelerate the different stakeholders, especially the UAS Industry (manufacturers and operators) to bring the UAS into the air in the earliest possible timeframe.

The INOUI project covers the following issues:

- Operational framework
- Regulatory framework
- User needs
- Technology
- Infrastructure (esp. aerodromes)
- Safety
- *(Security only partly within the Safety analysis and as part of the analysis of SWIM)*

Main beneficiary of the INOUI results will be the SESAR programme, providing the future roadmap for European ATM and Airline Industry. The long-term targets of SESAR have been defined as political vision and goals for the design of the future ATM System, and as EC objectives of the SESAR programme. They are to achieve a future European Air Traffic Management (ATM) System for 2020 and beyond which can, relative to today's performance:

- Enable a threefold increase in capacity which will also reduce delays, both on the ground and in the air
- Improve the safety performance by a factor of 10
- Enable a 10% reduction in the effects flights have on the environment
- Provide ATM services at a cost to the airspace users, which is at least 50% lower.

The relationship with SESAR is clear since INOUI considered it as one of the main references for its work, as SESAR defines the common future ATM system in Europe.

Exploitable Knowledge (description)	**Exploitable product(s) or measure(s)**	**Sector(s) of application**	**Timetable for commercial use**	**Patents or other IPR protection**	**Owner & Other Partner(s) involved**
Input for UAS Operations, Operators and Personnel Qualification	n/a	Regulators (nat./international), Legislation (nat./international)	2010+	n/a	n/a
Input for UAS Certification	n/a	Regulators (nat./international) UAS manufacturers and operators	2010+	n/a	n/a

Dissemination Report

See separate Document >INOUI-WP7.1-DFS-D7.1-Final Diss Report-PU-v1.0.pdf< submitted to EC 04/06/2010.