# **Roadmap** for the integration of **civil Remotely-Piloted Aircraft Systems** into the European Aviation System

## **Final report** from the European RPAS Steering Group

## ANNEX 2

A Strategic R&D Plan for the integration of civil RPAS into the European Aviation System

**JUNE 2013**


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# Table of Contents

# EXECUTIVE SUMMARY

In order to accommodate Remotely Piloted Aircraft Systems (RPAS) integration into non-segregated air traffic management (ATM) environments (i.e. airspace and aerodromes) on a European scale, the European Commission has, through Directorate General (DG) Enterprise and DG Move, established a European RPAS Steering Group (ERSG) with the objective of developing a European RPAS roadmap (the “Roadmap”) aiming at an initial RPAS integration by 2016.

The Roadmap reflects the RPAS integration from not only a regulatory, research & development (R&D), but also from a social & liability perspective of which this document represents the foreseen R&D contributions (the “R&D Roadmap”).

In order to produce the R&D Roadmap, contributions from relevant stakeholders have been collected from both the industry and relevant research organisations such as ASD, EDA, EREA, ESA, JARUS, ULTRA, UVSI, EUROCONTROL and the SJU. The R&D Roadmap has also taken into consideration all known previous studies and projects on the subject, in order for a good and solid R&D baseline roadmap.

It should be noted that the R&D Roadmap is based on the objective described above and therefore assumes that the activities start during 2013. However, a delay of the endorsement of the R&D Roadmap does not mean that the sequence of activities will have to change, but that the 2016 objective will stand a less reasonable chance of being met as further described in Chapter 6.

The R&D Roadmap have been structured to initially provide an introduction of the objectives and the high level principles governing the R&D Roadmap, followed by the identification of the integration requirements, as well as the identified operational and technological system gaps of enablers that are required to achieve full RPAS integration. R&D activities have, based on these findings, been grouped in specific operational and technical gaps around specific types of foreseen operations considering not only the specific timeframes according to the ATM Master Plan (which is already linked to the ICAO Global Plan and the Aviation System Block Upgrades), but also bearing in mind possible early opportunities or quick wins.

The identified activities focus clearly on the intended operations and bundle the operational and technical gaps focusing on stepwise results towards more complex operations. Within each identified activity, the foreseen deliverables are described including key milestones, the timeline and an initial estimation of the required types of expertise, as well as the level of resources (FTE´s) needed for its achievement.

The R&D Roadmap includes a first analysis of the risks related to the unsuccessful implementation of the complete set of identified R&D Roadmap activities required to achieve full RPAS integration.

As the objective of the Roadmap is to support the integration of RPAS operations into non-segregated airspace from 2016, the synergies with the current SESAR work programme (the “SESAR Programme”) is crucial for the successful deliberations of activities described herein. Although most ATM CNS and avionics topics are already under development in the current SESAR Programme, specific input from a pure RPAS perspective is missing.

Therefore, the last chapter identifies the key dependencies and synergies not only with the SESAR Programme, but also between the R&D activities themselves, as well as between the R&D and the regulatory roadmap activities.

It should be noted that the development of this R&D Roadmap is undertaken in full coordination with the requirements for manned aviation, as described in the European ATM Master Plan.

As RPAS activities are already being undertaken in several European states, the R&D Roadmap has identified the need to establish a set of demonstration activities at flight test centres or centres of excellence with access to the required relevant airspace, bringing together RPAS operators, manufacturers, ANS service providers and regulatory authorities, with the aim of collecting best practices in parallel to developing operational, technical documentation and proposal for standards.

With the upcoming demand for the use of RPAS for civil applications, many states have started to develop national regulations to allow the use of light RPAS. It is therefore essential that the development of this roadmap and the implementation thereof is addressed at European level.

Finally, it should be noted that even if this R&D Roadmap forms part of the overall Roadmap, it can be read and used as a separate document, as the links to both the regulatory roadmap and the social and

liability specifics have been captured (ref. App B of this document). However, for the best results we suggest that the Roadmap shall be the starting document using the R&D Roadmap for the more specific R&D issues involved.

# 1 INTRODUCTION

## 1.1 Background Information

UAS is the term that is used by ICAO to describe the family of Unmanned Aircraft Systems. RPAS is one type, or subset, of this family, and it is the type of unmanned aircraft that is addressed throughout this document. The RPAS subset consists of two parts, the Remotely Piloted Aircraft (RPA) and the Remote Pilot Station (RPS). The other type or subset of the UAS family is the fully Autonomous Systems, which will not be further addressed in this document.

RPAS do not replace manned aviation, but make it possible to accomplish missions that would not be possible with manned aircraft, or are more cost effective in comparison thereto.

Three main categories of RPAS have been identified by ICAO, namely; military, governmental non-military[1] and civil.[2]

Military RPAS operations are currently dominant and this segment has increased its operations in the past ten years. In recent years, we also note increasing operations and applications in the governmental-non-military and civil operations segment.

There are currently more than 250 RPAS manufacturers designing, developing or producing more than 400 RPAS in the EU. The majority of these manufacturers are SMEs and a substantial supply chain of sub-systems, often consisting of products from highly specialised SMEs.

Most of the current civil RPAS products are still at the level of demonstrators with a very limited production. This is due to lack of regulation and fragmentation, as well as to the limited access to airspace. Another factor is that the market is not mature enough to identify a clear demand within the civil sector. Indeed, most of the users are either at the stage of experimentation, niches of applications, or cost/benefits demonstration.

In other regions of the world, industry has taken advantage of recent important military programmes and a strong industrial restructuring has taken place, thus developing global actors constituted by both traditional aeronautics leaders and new entrants addressing the whole range of RPAS products.

From a true market perspective, the largest market value within the next years in Europe will be constituted by military and governmental non-military applications, requiring all types of RPAS from small to large, while in the civil sector, applications seem to develop from low end niches using small RPAS to progressively higher end RPAS, meeting requirements of growing complexity and higher market value.

There is already a substantial RPAS industrial community in Europe. The following European Union (EU) countries conduct RPAS design and production activities (at systems level): Austria, Belgium, Bulgaria, Czech Rep., Finland, France, Germany, Greece, Hungary, Italy, Latvia, Netherlands, Poland, Portugal, Slovenia, Spain, Sweden, UK. In addition, Norway and Switzerland are also actively involved at systems level. It is of interest to remark that not all of these countries are traditional aviation industry countries

Currently, non-military RPAS operations are already known to take place in a significant number of European Union (EU) countries (Austria, Belgium, Bulgaria, Czech Rep., Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Netherlands, Poland, Portugal, Slovenia, Spain, Sweden, UK), as well as in Norway and Switzerland.

Several of these countries have national rules and regulations in place permitting a limited variety of RPAS operations [Czech Rep., Denmark (has adapted Swedish rules), France, Ireland, Sweden, Switzerland, UK]. Several countries are preparing the publication of national rules and regulations [Belgium, Netherlands, Norway (will adapt Swedish rules)]. In most other EU countries, non-military

[1] State Flights (police, customs, border guards, coast guard) & non-state flights (civil protection, fire fighters). - 104 types of operations have been identified

[2] General Aviation (Corporate Operators); Specialized Operations (advertising, observation, survey, patrol-inspection, agriculture, fire fighting, logging/forestry, photography/TV/cinema, search & rescue)] – 98 types of operations have been identified.

RPAS operations are currently being permitted on an exemption basis. By far the majority of the authorized RPAS operations that are taking place today are performed within Visual Line-of-Sight (VLOS). Beyond Visual Line-of-Sight operations are legally possible in France and have taken place in Denmark (Greenland) and Norway.

In most EU countries, RPAS at system & sub-system level have become part of the university ”aeronautical” curriculae and a substantial amount of EU universities participate in RPAS - related studies on a European & international level.

The global RPAS market is currently dominated by non-European entities. Through the overall RPAS integration effort, Europe has a unique opportunity to secure its place on the RPAS global market. The substantial export potential of RPAS (products and services) outside the EU is worth to be pointed out.

Due to the fact that RPAS can be considered as “a system-of-systems” and that it incorporates a wide range of technologies, which in many cases are not exclusively aviation-related, the relevant industry base is very wide. It should also be noted that many of the technologies involved have cross-over and spin off potential i. e applications in other sectors including manned aviation.

The integration principles for operations under Instrument flight Rules (IFR) and Visual Flight Rules (VFR) are such that RPAS will have to adapt to the Instrument Meteorological Conditions (IMC) and Visual Meteorological Conditions (VMC) accordingly, as well as to the ATM environment with no negative impact. However, for RPAS operations (VLOS, EVLOS and BVLOS) at Very Low Level (VLL), integration will require a completely new approach in order to ensure the safe operations of both small and large RPAS operating below 400ft above ground level and under specific meteorological conditions, as well as very close to obstacles.

The B-VLOS operations, under either IMC or VMC, will open up a new paradigm, not only for ATM, but also for the aviation sector as a whole.

The results of the RPAS R&D activities, relating to the R&D Roadmap in terms of operational and technical system requirements and specifications, will need to be integrated into the European ATM Master Plan, which describes the transition of the present fragmented ATM environment into a future efficient and harmonised European ATM environment.

R&D efforts to close the identified operational and technology gaps will include the need to develop operational procedures, technical systems models or prototypes leading to proposed standards in parallel, but clearly linked to the development of regulations and standards for the safe and efficient integration of RPAS. Several, if not most of the topics, are of such complexity that an iterative and stepwise approach will be needed.

Finally, it should be noted that the R&D activities that have been identified for the purpose of integrating RPAS into the general airspace and ATM environments could as well serve the evolution of operational procedures and technical systems for manned aviation to increase safety, efficiency and environmental friendliness.

# 2 IDENTIFICATION OF REQUIREMENTS FOR RPAS INTEGRATION

## 2.1 Introduction

This chapter describes the integration principles and the requirements per expected operation and operational airspace and ATM environment. It aims to capture the key requirements and main milestones for the integration of RPAS providing the link to the technical gaps described in chapter 3 of this document. The requirements are linked to the ATM master plan[3] and the ICAO Global Plan/ASBU timeline, in order to ensure synchronisation with the road map on regulatory matters that is being developed in parallel. The timeframes and the herein identified expected type of operations are supported by the appropriate regulations, operational procedures technical systems development.

## 2.2 Integration principles

The overall approach towards integration is that RPAS will have to fit into the ATM system and not that the ATM system needs to significantly adapt to enable the safe integration of RPAS. RPAS will have to prove to be as safe as current manned operations, or safer. RPAS behaviour in operations will also have to be equivalent to manned aviation, in particular for the air traffic control (ATC), as it will not be possible for the ATC to effectively handle many different types of RPAS with different contingency procedures.

### 2.2.1 High Level Operational Requirements

- The integration of RPAS shall not imply a significant impact on the current users of the airspace;
- RPAS shall comply with existing and future regulations and procedures;
- RPAS integration shall not compromise existing aviation safety levels, nor increase risk: the way RPAS operations are conducted shall be equivalent to manned aircraft, as much as possible;
- RPAS shall comply with the SESAR trajectory management process;
- All RPAS shall be able to comply with air traffic control rules/procedures;
- RPAS shall comply with the capability requirements applicable to the airspace within which they are intended to operate.

## 2.3 Operations

### 2.3.1 Classification

It is envisaged that RPAS will operate in the airspace and ATM environments, mixed with a variety of manned aircraft (e.g. from gliders to large airliners) under instrument flight rules (IFR) or visual flight rules (VFR) adhering to the requirements of the specified airspace in which they are operating.

While commercial air transport (CAT) normally flies to move passengers, freight or mail from aerodrome ‘A’ to aerodrome ‘B’, following a profile including a climb phase, en-route at relatively high altitude composed by essentially straight segments, descent and landing, RPAS comprise a much

[3] The ATM Master plan is the basis for the new generation of European ATM systems for 2030 that will help achieve “more sustainable and performing aviation” in Europe. The plan contains roadmaps for the essential operational and technological changes required from all stakeholders (airspace users, ANSPs, airport operators, the military and the network manager) to achieve the performance objectives set by Single European Sky (SESA). It provides the basis for the timely, coordinated and efficient deployment of new technologies and procedures, whilst ensuring alignment with ICAO’s Aviation System Block Upgrades (ASBU) for global interoperability and synchronisation.

wider range of possible operations, and in many ways similar to the operations of General Aviation, Rotorcraft, and Military missions including:

1. **Very low level (VLL)** operations (alias non-standard VFR or IFR operations) below the typical IFR and VFR altitudes for manned aviation: i.e. not to exceed 400 ft. above ground level; they comprise:
   A. **Visual line of sight (VLOS)** in a range not greater than 500 meters from the remote pilot, in which the remote pilot maintains direct unaided visual contact with the remotely piloted aircraft;
   B. **Extended Visual Line of Sight (E-VLOS)** where, beyond 500 meters, the pilot is supported by one or more observers, in which the crew maintains direct unaided visual contact with the remotely piloted aircraft;
   C. **Beyond VLOS (B-VLOS)** where the operations are also below 400 ft., but beyond visual line of sight requiring additional technological support.
2. **RPAS operations in VFR or IFR,** above 400 ft. and above minimum flight altitudes; they comprise:
   A. **IFR (or VFR)** operations **in radio line-of-sight (RLOS)** of the RPS in non-segregated airspace where manned aviation is present. The key capability of 'detect and avoid' (D&A) is required in relation to cooperative and non-cooperative nearby traffic (otherwise specific procedures and restrictions would apply);
   B. **IFR (or VFR)** operations **beyond radio line-of-sight (BRLOS) operations,** when the RPA can no longer be in direct radio contact with the RPS and therefore wider range communication (COM) services (including via satellite) are necessary. In this case COM would typically be offered by a COM service provider.

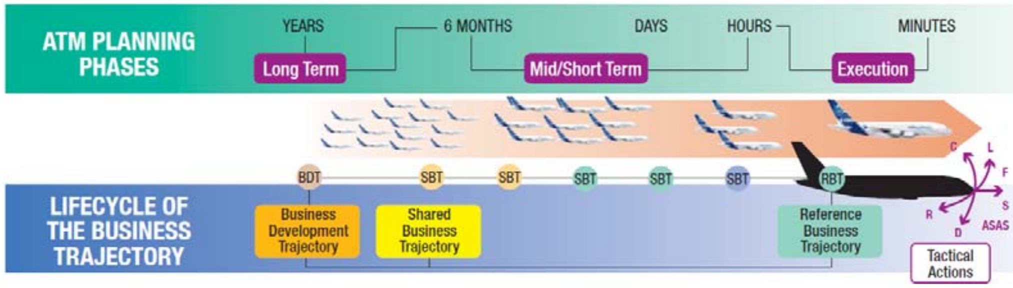
The altitudes that are identified for the above mentioned operations are of a generic nature not taking into consideration National differences and exemptions.

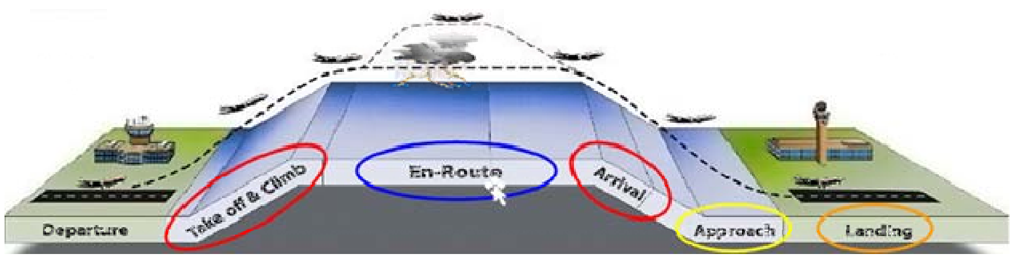
### 2.3.2 Flight phases and profiles

The integration of RPAS will also encompass all phases of flight:

- Planning phase;
- Departure phase;
- Take off & climb phase;
- Enroute phase;
- Arrival phase;
- Landing phase;
- Taxi phase.

The phases as illustrated below are the SESAR manned flight phases from planning through execution with postflight evaluations for the next planning cycle.




**Additional RPAS profiles**

Apart from the classical phases of flight as shown above, the planning of RPAS operations is in many cases specific when it comes to flight preparations which are similar to military operations planning in terms of flight file preparation, validations and post flight download and evaluation of flight data. In terms of operations, RPAS are expected to have, initially, predominantly more loitering type of operations. RPAS operations are often expected to depart and land at the same location and conduct surveys over an area with or without a fixed flight profile or survey borders. Another aspect is that RPAS are capable of extending their operations in time, distance and altitude.

## 2.4 ATM Security considerations

Apart from the security aspects that will be addressed in the foreseen R&D work, it is also of importance to place security in a bigger context. As it is mostly the case, security is something that has always been addressed separately. It is essential that security is fully embedded in the overall ATM environment, and more specifically in the foreseen RPAS R&D work. ATM security is a major component of aviation security (AVSEC) and comprises two key areas:

- **Self-protection of the ATM system**: this addresses security and resilience of physical infrastructure, personnel, information and communication systems, ATM/CNS infrastructure and networks;
- **ATM Collaborative Support** to civil and military authorities responsible for national security and Defence.

ATM security has an interface with airspace security which focuses on national security and defense requirements, operational aspects of collaborative support, and technological security and interoperability between civil and military systems. To ensure safe operations of RPAS additional aspects need to be addressed. Assets that require to be protected to avoid security risks are the following:

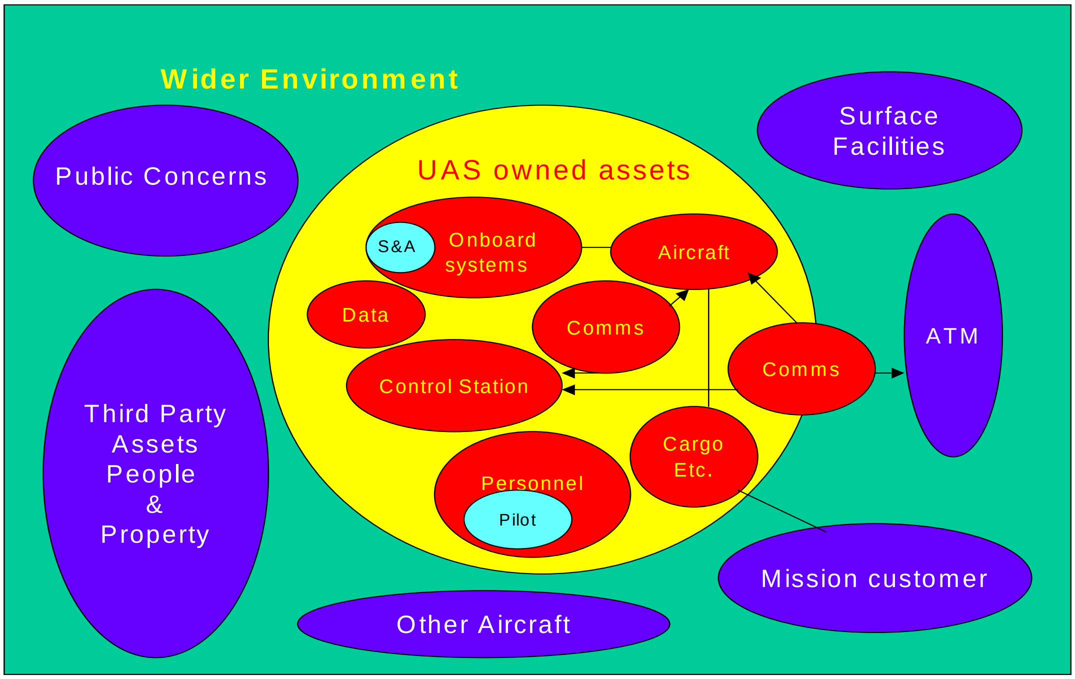
- Third party assets;
- The ATM system;
- The mission and its customer;
- RPAS owned assets.

The security goals are also concerned with protecting the wider public interest from damage caused by abuse of the facility to operate unmanned aircraft widely in ECAC airspace. Thus in addition to the above asset register there are wider concerns that are treated in a similar manner to assets in the next steps.

- The wider public interest:
    - Prevention of serious crime;
    - The Environment;
    - Public Health and Safety.

The illustration below clearly describes the RPAS assets and the wider environment that needs to be protected.

In the drawing below the term “UAS owned assets” should read “RPAS related assets”. To be noted is the communication asset which may also be a contracted service.




## 2.5 Operational demonstrations/best practices data collection

The most important element that is required for a successful R&D activity is using data from demonstrations, validations and real operational best-practice data. In the manned aviation community this practice is common and well-established and is used as a basis for and a complement to R&D work. It is recognised that demonstrations and the collecting of data will support more than R&D activities alone, and must be seen as an essential element to both the present and future RPAS operations.

There is also a need to establish a responsible data collection entity. It is required to obtain data from civil and governmental non-military operations that are already being conducted. If possible non-sensitive data from military operations would be an added value in this overall activity.

The following aspects (but not restricted to) should be collected:

- Airprox;
- Flight hours;
- Data link;
- Human factors;
- ATC issues;
- Airport ops;
- Lessons learned;
- Civil military aspects;
- Meteo.

### 2.5.1 RPAS project data

Apart from the collection of operational data it is essential that data is collected and disseminated on earlier and on-going RPAS and RPAS related projects. This will enable the RPAS community to have a single data point where the results of earlier projects and the scope and expected timeline of on-going projects can be brought together. A big advantage is consistent interpretation of the results, which is a strong tool to avoid duplication of effort.

## 2.6 ATM Environments and Operational Scenarios

An overview of the ATM environments, requirements and operational scenarios are presented in a table in Appendix A.

### 2.6.1 2013 - ATM Master Plan Baseline & Step 1

It is expected that in this time frame, VLOS and E-VLOS civil, military and governmental non-military RPAS operations are already taking place. Such operations can be conducted in all airspace classes. Initially, it could be envisaged that VLOS operations over or in urban areas will have additional safety/security requirements. Operations at airports will most probably be undertaken segregated from other traffic.

B-VLOS operations will be taking place in remote areas and under strict conditions. It is not expected that this will be expanded in this time frame.

A case-by-case approach for IFR operations and demonstrations under strict conditions is expected to take place. They will be limited to airspace classes A-C.

The use of Ground-Based Detect and Avoid (D&A) systems will be further investigated, and it is foreseen that the initial D&A challenge will be resolved in the ATM Master Plan step 1 timeframe.

Other required enablers for these identified operations will be in place.

#### 2.6.1.1 Impact of RPAS operations on ATM performance requirements

The foreseen SES performance requirements for this timeframe are not expected to be affected by the envisaged operational scenarios.

#### 2.6.1.2 Visual Line Of Sight (VLOS) operations

Visual line of sight operations are already expected to be conducted in all airspace classes. The RPAS is operated within a horizontal distance of 500 meters between the remote pilot and the aircraft and at a flight altitude of less than 400 ft. (Very Low Level – VLL) above ground level (AGL) The types of operations envisaged, but not limited to the following:

- Security;
- Agriculture;
- Terrain mapping;
- Survey;
- Inspection;
- Bird control.

Restrictions could be applied in and over urban areas and environments with a permanent or temporary high population density or large crowds.

#### 2.6.1.3 RPAS Extended Visual Line Of Sight (E-VLOS) Operations

Extended VLOS operations in which the VLOS operations are extended in range through the use of an observer are expected to start in this time frame as well.

#### 2.6.1.4 RPAS Beyond Visual Line Of Sight (B-VLOS) Operations

B-VLOS operations are expected to continue on a case by case approach, probably also supported through ground based Detect and Avoid systems or through segregation of airspace to accommodate the safe execution of the flight.

#### 2.6.1.5 RPAS operations under Instrument Flight Rules (IFR)

In this time frame it is expected to have initial IFR operations under certain conditions using ground-based D&A (GBD&A) to enhance safety. The type of operations expected will be mostly military or governmental non-military. This type of operation could encompass all phases of flight, keeping in mind that the arrival, departure and airport operations will at this point in time not be integrated with manned aviation.

#### 2.6.1.6 RPAS operations under Visual Instrument (VFR)

It is not envisaged that VFR operations will take place in this time frame.

### 2.6.2 2014 – 2018 - ATM Master Plan Step 1

In this time frame VLOS and E-VLOS RPAS operations are expected to gradually become a daily occurrence in all airspace classes. These types of RPAS operations will also be conducted over and in urban and highly populated areas by civil, military and governmental non-military operators.

It is expected that further progress will be made in enabling IFR RPAS operations in class A-C airspace, however not in the standard arrival and departure operations in major high traffic density Terminal Airspace, surface and enroute environments.

In this time frame it is expected that the specific RPAS SARPS and adaptation to existing SARPS will be finalised which will open the door towards full integration.

B-VLOS (VLL) operations will be further developed, which could enable operations in very low dense populated areas or high seas by civil, military and governmental non-military.

VFR operations could be allowed under certain conditions.

Generically, operations will have a loitering nature with possible first point to point operations for cargo in remote areas.

The enablers for these identified operations should be in place at the latest in this time frame but might be available earlier.

#### 2.6.2.1 Impact of RPAS operations on ATM performance requirements

The foreseen performance requirements for this timeframe will not be affected by the envisaged operational scenarios. It is possible that D&A solution could contribute to enhancing safety for manned aviation.

The following operating environments / phases of flight will be included:

- Aerodrome (taxi, take-off and landing); (segregated from other traffic);
- Terminal (arrival and departure); segregated form the existing Stars and SIDs;

- En-route, taking into consideration that the trajectories for aerial work may be significantly different from the routes used by commercial air transport flights from point A to B.

The following operational scenarios are envisaged in the timeframe of ATM MASTERPLAN-1.

#### 2.6.2.2 RPAS Visual Line Of Sight (VLOS) operations

Visual line of sight RPAS operations are already expected to be conducted in all airspace classes and initial operations from surface and urban areas.

Restrictions could still be applied over or in urban areas and environments with a permanent or temporary high population density or large crowds.

#### 2.6.2.3 RPAS Extended Visual Line Of Sight (E-VLOS) operations

Extended Visual Line of Sight is expected to be conducted in all airspace classes and urban areas.

Restrictions could still be applied over or in urban areas and environments with a permanent or temporary high population density or large crowds.

#### 2.6.2.4 RPAS Beyond Visual Line of Sight (B-VLOS) operations

Further investigations into the B-VLOS type of operations will be developed and it can be expected that more trails are to be conducted. Due to the similarities with VFR operations and the additional requirements for terrain & obstacle avoidance it is not expected to have regular operations in this time frame:

- Demonstration flights;
- Scientific research flights.

#### 2.6.2.5 RPAS operations under Instrument Flight Rules (IFR)

In this time frame it is expected to have more IFR RPAS operations still under certain conditions using GBD&A to enhance safety. It is expected that the first prototypes of GBD&A system will be operationally validated. The type of RPAS operations in this time frame will include civil operations.

This type of RPAS operation will encompass all phases of flight, keeping in mind that the arrival, departure and airport operations will possibly be small scale integration with manned aviation.

IFR RPAS operations will be mostly of a loitering nature with some initial point to point flights. It is not expected that RPAS will be able to integrate in busy and complex environments. See 2.3.

#### 2.6.2.6 RPAS operations under Visual Flight Rules (VFR)

Initial VFR RPAS operations are expected to start in this time frame, mostly with military RPAS. Due to the absence of standards and acceptable/approved (suitable) D&A solutions it is not foreseen that VFR operations will be conducted on a regular basis:

- Demonstration and validation flights;
- Loitering.

### 2.6.3 2019 – 2023 - ATM Master Plan Step 1

In this timeframe it is expected that all the required documentation will be available to enable certified and operationally approved RPAS to operate IFR in all airspace classes. It is expected that based on the performance requirements some areas will still be off limit to RPAS, such as major surface and Terminal Airspace in Europe for all airspace users. It is for example not foreseen to have RPAS operations at Heathrow or in the London TMA.

Initial VFR RPAS operations will start, pending on the maturity of the D&A system and expected simplification of airspace classification applications for all airspace users.

VLOS and E-VLOS RPAS operations will be fully integrated in day-to-day activities by all airspace users.

B-VLOS operations will be further expanded and possibly enter populated areas.

RPAS will be SESAR compatible and will play a supporting role as information nodes for SWIM.

The enablers for these identified operations will be in place at the latest in this time frame but might be available earlier.

#### 2.6.3.1 Impact of RPAS operations on ATM performance requirements

The foreseen performance requirements for this timeframe are to be met by RPAS operations and should not negatively impact operations. It is possible that specific RPAS technological developments would contribute to enhancing performance for manned aviation.

RPAS will have to be able to exchange 3/4 D trajectories where required.

The following operating environments / phases of flight are included:

- Aerodrome (taxi, take-off and landing);
- Terminal (arrival and departure);
- En-route, taking into consideration that the trajectories for aerial work may be significantly different from the routes used by commercial air transport flights from point A to B;
- Oceanic.

The following operational scenarios are envisaged to be developed.

#### 2.6.3.2 RPAS Visual Line Of Sight (VLOS) operations

Visual line of sight operations are expected to be fully integrated in day to day operations.

#### 2.6.3.3 RPAS Extended Visual Line Of Sight (E-VLOS) operations

Extended Visual line of sight operations are expected to be fully integrated in day to day operations.

#### 2.6.3.4 RPAS Beyond Visual Line Of Sight (B-VLOS) operations

B-VLOS operations will initially start in remote areas. These types of operations can be conducted from surface or remote launching stations, starting the operation in VLOS.

Additional requirements for terrain avoidance will have been developed bringing additional benefits to manned aviation. It is not foreseen to have B-VLOS operations in urban areas yet.

#### 2.6.3.5 RPAS operations under Instrument Flight Rules (IFR)

In this time frame it is expected to have IFR partially integrated using approved D&A solutions. The type of operations will include civil operations in all phases of flight. It is expected that RPAS will not be integrated in all environments based on operational and economic restrictions.

IFR RPAS operations will be point to point and loitering of nature in mixed civil/military environments. Airport operations will start initial RPAS integration with manned aviation.

#### 2.6.3.6 RPAS operations under Visual Flight Rules (VFR) operations

VFR RPAS operations are expected to start in this time frame, mostly in remote areas for all airspace users. As standards for D&A will be in place it is expected that VFR operations will expand.

- See 2.3.

## 2.7 Requirements to enable full RPAS ATM integration

The requirements for the intended operations that are listed in the sections above have been organized in 7 different topics that have identified all aspects that need to be developed through R&D activities. This could be done through technical or procedural means. These requirements have been projected on a timeline which is included in Appendix A.

### 2.7.1 Airspace access and surface operations

- Define RPAS minimum IFR performance requirements:
  - Climb and turn performance;
  - Speed.

- Assess airspace entry requirements (CNS)S:
  - Other means of compliance.

- Set requirements for transparent contingency procedures:
  - Essential for ATC.

- Assess airspace impact of B-VLOS:
  - Type of operations;
  - Airspace classification.

- Assure interoperability of D&A system with ACAS.

- Assess Airspace design impact on RPAS integration:
  - B-VLOS aspects.

- PBN requirements Impact on RPAS per airspace:
  - Assess alternative means of compliance.

- RPAS additional Infrastructure requirements:
    - Data link.

- Automatic landing requirements:
    - Enable operations in IMC.

- SID/STAR performance compatibility:
    - Speed;
    - Climb/descent;
    - Turns.

- Terrain data base requirements impact (BVLOS):
    - Additional requirements for terrain outside airports and remote areas.

- Enhanced Situational awareness (human factors):
    - Through use of airborne or ground D&A;
    - Trust authority and presence.

- D&A requirements:
    - Minimum performance requirements;
    - Cooperative and non-cooperative targets.

- GBSAA performance limitations:
    - Identification of performance limits.

- ATC requirements:
    - RTF;
    - Flight planning for all operations;
    - Emergency procedures;
    - Lost link procedures;
    - Training;
    - ATC system requirements.

- Airport and surface operations:
    - D&A;
    - Automated landing and take-off;
    - Platform operations;
    - Ground movements;
    - Contingency;

- CTR traffic integration.

### 2.7.2 Comms C2 data link

- Assessment of RPAS operations on ATM communication systems;
- Characterize the capacity and performance requirements of RPAS operations on ATC communications systems;
- Develop and validate detailed command and control communications technical performance requirements based on communications policy and procedures, communications architectures, and safety and security considerations to be established;
- Requirements for Integrity, continuity, availability of data link;
- Spectrum availability.

### 2.7.3 Detect & Avoid

- Enhanced situational awareness;
- Conspicuity;
- Collision avoidance function;
- Traffic avoidance function;
- Interoperability aspects with other safety nets;
- Assessment Meteo conditions
- Terrain and obstacles;
- Ground operations;
- Other hazard:
  - Birds;
  - Wake turbulence.

### 2.7.4 Human Factors

- Definition of Roles and Responsibilities. Potential issues related to change in roles and responsibilities among RPAS, ATC, other airspace users and flight dispatchers.

### 2.7.5 SESAR compatibility

- MAP ATM Master Plan requirements;
- Trajectory management for RPAS;
- Initial 4D trajectory based operations;
- SWIM;
- Delegated separation.

### 2.7.6 Contingency

- Transparent contingency procedures;
- Loss link procedures.

### 2.7.7 Security

- Classification
- Security of ground station;
- Security of remote pilot (VLOS);
- Unlawful interference;
- Jamming;
- Spoofing;
- Security of data link;
- Additional ATM security requirements.

# 3 TECHNOLOGY AND OPERATIONAL ENABLERS

## 3.1 Introduction

This chapter identifies the operational requirements, the technical and systems enabler gap fillers required to enable full RPAS integration.

The key technologies and enablers are identified from:

- Analysis of the operational requirements listed in chapter 2;
- Results from past or on-going studies and activities, including but not limited to earlier identified technology gaps and R&D roadmaps.

### 3.1.1 List of technology gaps

To meet operational requirements defined in chapter 2, chapter 3 describes a list of identified key technology gaps called "Gap EC x.y"[4], listed using the terminology and in the order of the EC Staff Working Document, from EC 1 to EC 6 as follows:

- EC 1 Development of a methodology for the justification and validation of RPAS safety objective :
    - Gap EC 1.1 - Short-term validation: current ATM;
    - Gap EC 1.2 - Long-term validation methodology: future ATM environment, liaison with SESAR, integration into SES and SWIM.
- EC 2 Secure command & control / data links / bandwidth allocation:
    - Gap EC 2.1 - Secure C2 systems and links;
    - Gap EC 2.2 - Infrastructures associated with RLOS and BRLOS, including SATCOM;
    - Gap EC 2.3 - Radio bandwidth management.
- EC 3 Insertion of RPAS into the air traffic management system, detect & avoid (air and ground) and situational awareness (including for small RPAS), weather awareness:
    - Gap EC 3.1 - ATM interfaces in current context (Classes A-C);
    - Gap EC 3.2 - ATM interfaces in SESAR context;
    - Gap EC 3.3 - Airborne Based Detect and Avoid;
    - Gap EC 3.4 - Ground Based Detect & Avoid and other emerging technologies;
    - Gap EC 3.5 - Ground station HMI;
    - Gap EC 3.6 - Ground and Obstacle Avoidance;
    - Gap EC 3.7 - Weather detection and protection;
    - Gap EC 3.8 – Detectability solutions;
    - Gap EC 3.9 – Observer & pilot roles and responsibilities (E-VLOS);
    - Gap EC 3.10 – Other hazards including protection against wake vortices.
- EC 4 Security issues attached to the use of RPAS:
    - Gap EC 4.1 - RPAS system security threats and potential mitigations Gap EC 4.2 – RPAS operations overview.
- EC 5 Safe automated monitoring, support to decision making and predictability of behaviour:

[4] The EC working paper was a result of the 5 UAS panel workshop that were held to identify the issues regarding RPAS integration. As a result of this, technological gaps were identified and numberd as gap EC x.y. The working paper can be obtained at : http://www.uasvision.com/wp-content/uploads/2012/09/EC_SWD_Euro-Strategy-RPAS_120904.pdf

- Gap EC 5.1 - Safe and standard recovery procedures for contingencies and emergencies;
- Gap EC 5.2 - Safe automated health monitoring & Fault detection;
- Gap EC 5.3 - On-board real-time smart processing.

- EC 6 Automated take-off and landing and surface operations:
  - Gap EC 6.1 - Automatic Take-off and landing, Auto-Taxiing and automated aerodrome Operations.

### 3.1.2 Mapping of technology gaps according to operational requirements

The system gaps corresponding to the operational requirements identified in section 2.4 here above are summarized in Appendix A.

## 3.2 Background context of the main European studies or activities

Several studies have been performed on the topic; some are still on-going. For reasons of availability and impact on the joint European efforts to agree on the R&D Roadmap, focus is set on European studies.

The main European Projects contributing to the technology gap analysis are:

- EC:
  - INOUI;
  - ULTRA.
- EUROCONTROL:
  - RPAS C3 Channel Saturation Study;
  - ACAS compatibility study;
  - RPAS generic safety case;
  - RPAS Security study;
  - RPAS simulation;
  - RPAS human factors study.
- EDA:
  - MIDCAS;
  - Air4All Roadmap;
  - E4U;
  - SIGAT.
- EDA/ESA:
  - Feasibility Studies on the use of Satellites for RPAS Air Traffic Insertion;
  - SINUE;
  - IDEAS;
  - DesIRE.

## 3.3 Key Technologies description

The key technologies compiled from major European projects and specifically Air4All and E4U conclusions are listed according to the proposed activities described in the EC Staff Working document,[5] using the terminology and in the order they appear in this document.

For each key technology, the main enablers which can pave the way to the development of the corresponding technology are described.

### 3.3.1 EC 1 Development of a methodology for the justification and validation of RPAS safety objectives

#### 3.3.1.1 Scope

RPAS integration can be looked at from a present ATM environment or from a future ATM environment. It is necessary to identify, justify and develop the necessary requirements in terms of safety objectives, procedures and technologies allowing a safe integration of RPAS in the airspace.

Such requirements will cover:

- Airspace access and surface operations;
- Overall safety objectives;
- Required CNS avionics;
- Human factors.

#### 3.3.1.2 Enablers

Based on the requirements that were identified above, the following system enablers are identified:

- Procedures and Concepts:
  - Key requirements;
  - Required performances;
  - Results of safety analysis.
- Proofs of concepts:
  - Simulators;
  - In Flight demonstrators;
  - Technology prototypes.

#### 3.3.1.3 Identified gaps

**Gap EC 1.1 Short-term validation: current ATM:**

- **"Minimum Safety Objectives"**: definition of the minimum requirements to guarantee the safety of the over-flown population and so to allow RPAS operations in controlled airspace airways;
- **"Collision avoidance"**: this is a pilot task. Specific solutions will have to be developed;

[5] Note: the EC working paper was a result of the 5 UAS panel workshop that were held to identify the issues regarding RPAS integration. The working paper can be obtained at : http://www.uasvision.com/wp-content/uploads/2012/09/EC_SWD_Euro-Strategy-RPAS_120904.pdf

- **“Separation Provision”:** ability for RPAS to respond to mandatory ATC instructions intended to achieve prescribed separation from other aircraft. This includes in particular the elaboration and update of a tactical situation to be permanently displayed to the RPA pilot;
- **"Communication”:** definition of minimum communication requirements between RPA pilot and ATC. Communication switching from one ATC sector to another one will have also to be provided;
  *Note: initial operations will be made in national airspace and in a second step in "cross borders" operations.*
- **"Demonstration"** : purpose of this study is to develop and demonstrate (Proof of Concept) RPAS operations in the airspace;
- Particular attention will have to be paid to the VLL flight, which constitutes a new class of flight profile. An equivalent of “flight rules” like IFR or VFR must be defined.

**Gap EC 1.2 Long-term validation methodology: future ATM environment, liaison with SESAR, integration into SES and SWIM:**

- **"Conflict management" :** adoption of 4D mission trajectory based operations to RPAS specificity (RPA pilot is on ground and so can have direct access to all information to update the mission trajectory and take appropriate action.). Conflict management is composed of separation and collision avoidance;
- **"Traffic Avoidance"**: participation of the RPAS pilot to the separation with possibility for the ATCo to delegate separation to the RPA pilot. In uncontrolled airspace separation with non-cooperative aircraft will be provided by specific systems to be defined by MidCas;
- **"Collision Avoidance"**: in controlled airspace collision avoidance can use cooperative sensors and must be fully compatible with the ACAS system. For non cooperative aircraft specific solutions based on MidCas will be implemented;
- **"Communication"**: RPA~~S~~ pilot can have direct, continuous access to the ATC network to exchange the information and an ability to accept ATC sector handover for which a specific solution will have to be developed. Communications will be based on data link and will use terrestrial as satellite ones, Specific emphasize will be put on the integration on the "4D trajectory" that SESAR is developing in L band (with terrestrial and satellite applications);
- **"Navigation"**: navigation will be based on GNSS, due to RPAS specificity, a specific back-up solution might have to be defined (RPA pilot might have access at ATC position);
- **"Weather detection"**: RPA pilot will benefit of SWIM weather information, specific RPAS solution will have to be developed;
- **"Airspace classification"**: with the ADS-B deployment all classes of airspace even the non controlled ones can become "controllable" allowing RPAS to operate safely in all the airspace;
- **"ADS-B Technology”**: with the development of ADS-B solutions adapted to the users (UAT, VDL4, 1090 ES ) to allow all the users to report their position. Other technologies (GSM, Flarm…) as provided by MidCas project and more adapted to light aircraft and light UAV will be envisaged;
- **"Operations at high altitude"**: to develop vertical navigation mode to allow stable and safe operations of RPAS.

### 3.3.2 EC 2 Secure command & control / data links / bandwidth allocation

#### 3.3.2.1 Scope

RPAS include typically a control station, an aircraft and a set of payloads, both connected to and controlled from the ground over a set of data-links. In some cases, for long range missions when the RPAS is beyond Radio Line of Sight of the control station, it is necessary to relay this transfer through a communication relay, generally using a satellite (or another aircraft). A ground relay can also be constituted by a secondary control station connected through a ground network to the main control station.

Safe and reliable communications are a key driver for RPAS ATM integration, particularly in non-segregated airspace, and loss of a data-link is a critical failure for RPAS. The resulting requirements on data link include adequate integrity of information, availability, quality of service and protection against jamming or spoofing in the system design. Two types of data-link are typically used for RPAS command & control, comprising:

- A command & control link for the flight (C2 data-link) with typically a low data rate, in the order of 10 to 100 Kb/s. However, this data link is highly critical, as its loss would directly affect the flight safety and the ability to command the RPA and relay the ATC communications. The C2 data link is thus mainly addressed when considering information integrity, availability, continuity of service and resistance to jamming;
- A data-link for the payloads (mission or payload data-link). This data-link typically operates at much higher data rates, in the order of 10 – 100 Mb/s for downloading large volumes of mission data. These much larger download rates are more demanding on frequency spectrum. However, loss of this link is less critical as it would only affect the capability to perform the mission goals.

With RPAS emerging onto a market that already faces critical pressures on the use of spectrum; they face severe pressure in finding sufficient spectrum for their activities. Access to this scarce resource has become a critical issue, especially for air operations, with their attendant safety concerns and reliance on available, reliable, high-integrity spectrum, free from harmful interference.

At an international level, radio-frequency (RF) allocation and spectrum management are regulated by the International Telecommunications Union (ITU) who holds a month-long World Radio Conference (WRC) every 3 ~ 4 years to update the allocation of spectrum. Access to suitable spectrum is of the highest importance for RPAS operations, if no spectrum is available, RPAS will simply not be able to operate. The WRC-2012 has already allocated a new protected bandwidth for the C2 LOS data-link between the RPA and the control station and authorized the use of existing protected bandwidths for the BRLOS satellite communication data-link. Actions and studies have been decided to continue addressing the allocation of spectrum for RPAS operations in non-segregated airspace and to prepare the next WRC (in 2015) for the satellite communication data-link.

#### 3.3.2.2 Enablers

- Secure data link:
  - Spectrum-efficient waveform design;
  - Network-based communication protocol design;
  - RF/Hyper components;
  - Airborne and SATCOM antenna technologies.
- Simulation tools for transmission performance assessment.
- Involvement in contributing working groups on frequency allocation and waveform standardization.

### 3.3.2.3 Identified gaps

**Gap EC 2.1 Secure C2 systems and links**

Secure and sustainable links for command and control (C2) of the air vehicle flight are a key component of a RPAS system operating in non-segregated airspace. The aim of this gap is to identify the requirements and define the specifications of C2 links, both in radio line-of-sight (RLOS) and beyond-radio-line-of-sight modes.

The project will address the following issues:

- Determine the minimum C2 links requirements in terms of robustness, availability, integrity, Quality of Service, continuity and latency;
- Study the safety aspects and define the relevant specifications;
- Define the system specifications of the C2 links;
- Assess the system performances of the C2 links by modelling and simulation;
- Define the specifications in case of degraded modes (failures, link loss) : contingency plans, alternate modes, reacquisition strategies;
- Address the specific issues related to low level flight (impact of obstacle/terrain masking and interferences with ground infrastructures on link availability);
- Demonstrate the relevant functional capabilities, both in RLOS and BRLOS modes.

**Gap EC 2.2 Infrastructures associated with RLOS and BRLOS including SATCOM**

This gap addresses the requirements for infrastructures needed for RLOS and BRLOS communications between the RPA and the control station. Infrastructures are defined as means which are external to the RPAS, but required for its operations (e.g. satellites). The use of such infrastructures is generally associated to services provided by state or private operators ("providers").

The following cases are considered:

- Satellite communications for en-route flight (BRLOS);
- Aerial relay for en-route flight (BRLOS);
- Ground network for range extension and communication relay between Air Vehicle and ground operator.

For each of these cases, the following issues will be addressed:

- Identification of existing and future solutions (infrastructures and services);
- Definition of related communication capabilities (data rate, frequency, bandwidth) and performances (Quality of Service, latency);
- Redundancy / Procedures in case of communication loss;
- Impact of latency on RPAS operation;
- On-board equipment requirements: RPAS communications specifications (volume, power consumption, …), antenna specifications, integration constraints.

**Gap EC 2.3 Radio bandwidth management**

This gap is related to the support actions to frequency allocation proposals for RPAS in view of future World Radio Conferences (WRC-2015 and beyond).

The activities include the refinement of technical analyses (spectrum requirements, waveform definition, performance assessment) consistently with customer's requirements and the integration of new considerations related to RPAS integration in the existing and future ATM. The aim is to provide the required justification framework to formulate European Radio Regulations proposals towards ITU-R; and to bring the technical support to frequency allocation negotiation and trade-off.

These activities will be conducted in continuity of SIGAT study.

The technical issues include:

- Spectrum availability update;
- Functional requirements update (e.g. Detect & Avoid);
- Sharing issues;
- Standardisation and interoperability.

The following stakeholders shall be involved : ITU-R, CEPT, ICAO, EASA, NATO, EDA PT-RS (Project Team – Radio Spectrum), National Frequency Agencies, National CAAs, National Ministries of Defense, Ministries of Transportation, EUROCONTROL, ANSPs, EUROCAE WG-73-& WG93.

### 3.3.3 EC 3 Insertion of RPAS into the air traffic management system, detect & avoid (air and ground) and situational awareness), weather awareness

#### 3.3.3.1 Scope

For manned aviation the pilot, together with supporting systems, contributes to safe flight by avoiding traffic, ground, obstacles and dangerous weather. The scope of this set of topics is to support the establishment of requirements for these capabilities suitable for unmanned aviation as well as establishing corresponding solutions in order to maintain at least equivalent level of safety as for manned flight. The strategies to handle these topics is dependent on the type of ATM environment as the pilot's role as well as operational rules may differ. It might even be that some of the technologies developed for this purpose could contribute to the general ATM development.

~~D~~ The detection and avoidance of air traffic implies a harmonized approach for collision avoidance, as well as traffic avoidance assistance. The solutions will need to meet requirements on e.g. safety, reliability, minimum distances for avoidance and separation and compliance with ACAS future solutions. This is a major challenge for RPAS, due to the fact that current Collision Avoidance systems and procedures of manned aviation cannot be used for RPAS: no pilot on board, different flight envelope, non-cooperative traffic.

Detection and avoidance of ground and obstacles addresses the topics of ensuring safe clearance of Ground during normal operation and emergency procedures together with established systems such as Terrain Collision Avoidance Systems and Navigation Systems. The need for using emergency landing is part of topic EC 5.

Weather awareness supports the pilot with weather information and weather detection capability such that possible constraints on safe flight paths can be identified early enough to ensure proper mitigations including e.g. replanning and avoidance.

The scope also includes the ability to avoid other hazards like birds or wake turbulence, and any other aspect that would influence the safe execution of a flight that can be identified by visual means. It also includes the ability to interpret signs and markings during surface operations.

#### 3.3.3.2 Enablers

- Traffic Detection and Avoidance:
  - Non Cooperative Sensors: EO/IR, Radar;
  - Cooperative Sensors: Transponder Interrogator, ACAS, ADS-B IN;
  - Separation and Avoidance Logics including manoeuvres;
  - Navigation Data Base.
- Ground and Obstacle Detection and Avoidance:
  - Legacy systems (TAWS, etc.);

- Integration with other systems (e.g. Air Traffic Avoidance);
- Additional sensors (e.g. for obstacles);
- Extended Navigation Data Base.

- Weather Detection, Information and Mitigation:
  - Legacy systems including sensors for detection of bad weather, icing conditions, etc.;
  - Integration of weather data, SWIM integration.
- Means of demonstration: simulation tools, flying test beds.
- Reference simulation models: encounter model (e.g. ACAS), aircraft performance model.

### 3.3.3.3 Identified gaps

**Gap EC 3.1 ATM interfaces in current context (Classes A-C)**

In the context of today's ATM, the aim is to identify and develop the minimum requirements and functions in terms of safety objectives, regulations, procedures & technologies to allow RPAS operations in airspace classes A - C. In this airspace, all users are "cooperative" (transponder mode C as a minimum).

The objectives will be to allow initial operation of RPAS in controlled airspace. The RPAS will fly IFR, ATC providing separation. RPA pilot will use existing systems and available data with limited evolutions to assume collision avoidance.

**Gap EC 3.2 ATM interfaces in SESAR context**

In the context of the future ATM (SESAR & NextGen), the aim is to identify and develop the essential requirements and functions in term of regulations, procedures & technologies that RPAS as well ATM will have to consider for the safe integration of the RPAS in the airspace.

To face the traffic demand, operations in future ATM will be based on "4D Mission trajectory" for the flight plan, ADS-B for surveillance, GNSS for navigation, Data link for the communication.

Purpose of the study will be to adopt and adapt these systems to the RPAS missions requirements.

**Gap EC 3.3 Airborne Based Detect and Avoid**

Numerous studies have been performed on detect and avoid traffic on lower TRL levels. Several of the teams involved with these studies have gathered in MidCAS. MidCAS support standardization and develop generic solutions likely to be valid for all air space classes, for collision avoidance and separation. The highest demonstration maturity (approx TRL 6) will be reached for avoidance in air space classes A-C in line with the EUROCAE WG 73 roadmap. Gaps remaining beyond MidCAS include:

- Further developed solutions for detect and avoid where the generic functionality is integrated with the RPAS command & control and navigation capabilities within its avionics suite to e.g. ensure proper precedence at all stages;
- Demonstration and standardisation support for separation in the wider class of airspaces A-G;
- Development of miniaturised solutions feasible for installation on smaller RPAS including e.g. integrated sensor suites;
- Possible consequences of not yet finalized requirements from standardization on the topic in particular Target Level of Safety and its interpretation. One important aspect being the possibly different safety cases for small RPAS flying in an air space with limited air traffic giving provisions for less demanding solutions;
- Development of detect and avoid system products (necessary, but outside roadmap?).

**Gap EC 3.4 Ground Based Detect & Avoid and other emerging technologies**

Ground Based Detect and Avoid uses ground based sensors to ensure deconfliction. Principles for selection of traffic and collision avoidance manoeuvres are likely to be the same as for Airborne Detect and Avoid. However, the sensing strategy will obviously be different and the consequences of data links between the key components of the system will need to be considered.

The objective is to identify and develop the necessary emerging technologies (e.g. Ground Based Detect and Avoid) that might contribute to a safe integration of RPAS in the European airspace, in complementarity with other systems (e.g. Airborne Detect and Avoid).

**Gap EC 3.5 Ground station HMI**

The aim is to define requirements providing a reliable and interoperable RCS with proper HMI enabling the management of various types of RPAS and of the on-board mission systems, taking into account the security and safety issues, having the handover capability and having the proper connections with ATM:

- Survey of requirements;
- Identification of standard design rules (e.g. common symbols to be standardized);
- RCS and HMI requirements specification in a system framework (RPAS and networks);
- RCS and HMI development, integration and testing, verification and validation;
- Starting from STANAG 4586 as a baseline standard, demonstrate single and multiple RPAS flight and mission management, including handover and interoperability and LOS and BLOS control;
- Demonstration of the capability to support RPAS integration into Controlled Airspace and RPAS operations;
- Definition of standard specifications for RPAS Control Stations.

**Gap EC 3.6 Ground and Obstacle Avoidance**

The aim is to mitigate risks associated to potential collision with ground or obstacles on ground. Very limited work has been done at this stage. Outline activity would be:

- Analysis of legacy systems;
- Analysis of suitable scenarios and the process to avoid ground and obstacle on ground;
- Definition and potential development of suitable means of detection and avoidance;
- Dynamic mission management associated to ground and obstacle avoidance;
- Demonstration of optimised means and procedures, including ATM, data base and information from multiple sources (airborne and ground systems);
- Connexion to SWIM.

A particular application will be for VLL (Very Low Level flight), where a significant improvement of ground [6]obstacles data base has to be developed.

**Gap EC 3.7 Weather detection and protection**

The aim is to mitigate and/or avoid the effects of severe weather conditions to preserve the integrity of the RPA:

[6] The terrain and obstacles data bases that are used for manned aviation have a high level of detail around airports. For the use of terrain databases for VLL operations more details will be have to be provided for areas outside airports.

- Analysis on legacy systems;
- Analysis of suitable scenarios and the process of categorizing weather hazards for appropriate range of missions and operational scenarios;
- Definition and potential development of suitable means of detection and avoidance of atmospheric hazards (severe turbulence, lightning, icing, etc.);
- IFR;
- Terminal environment (taxi, take-off and landing phases of flight);
- Avoidance of clouds for VFR;
- Dynamic mission management to minimize risks associated to weather hazard on long duration flights;
- Demonstration of optimised means and procedures, including ATM and weather information from multiple sources (airborne and ground systems) of multiple types (point data, vertical profiles and gridded) at multiple scales (regional averages vs station data) with variable uncertainty and bias;
- Connexion to SWIM.

The case of VFR flights will constitute a further development issue.

**Gap EC 3.8 Detectability solutions**

One of the basic elements for safe operations is laid down in the rules of the air. It clearly states that the pilot is responsible for the safety of the flight, even if this implies going against ATC clearances. The visual aspects of rules of the air are based on the assumption that both aircraft are able to see the other and avoid each other or other hazards. This aspect needs to address as RPAS in general are smaller than manned aircraft the minimum requirements for detectability need to be set to ensure safe integration. These requirements should be seen as visual aspects like minimum size and strobe lights. During other projects where ground based sense and avoid solutions were tested, this aspect came up and lead to different end results, although the GBD&A worked totally satisfactory (VUSIL study).

Operating under Instrument Flight Rules can require “visual” detectability conditions for some small RPAS which, due to reduced dimensions and power, cannot be cooperative (i.e., cannot be equipped with transponders, at least those operating in airspace classes in which such transponders are strictly required). In such cases, in fact, also detectability through Primary Surveillance Radar (PSR) can become difficult due to the small dimension and low reflectivity of these aircraft.

**Gap EC 3.9 Observer & pilot roles and responsibilities**

The role between the pilot and observer needs to be clarified in regard to standard communication and end responsibility. Specifically where the position of the pilot or observer is obscured, the situational awareness needs to be identical to avoid conflicts in observation and execution. The means of communication also needs to be addressed, i.e. what type, security aspects in this and contingency aspects will need to be addressed as well.

**Gap EC 3.10 Other hazards including protection against wake vortices**

The airspace is exposing RPAS to hazards that have specific aspects relating to that e.g. the RPAS is operating in airspace differing from that normally used by manned aviation, as well as following from the limited size of some RPA. Examples of this include sensitivity to wake turbulence that may induce need for particular separation requirements as well as more robust handling of turbulence in general. Bird impact may differ substantially as some RPA operate at low level being exposed to a different set of birds, as well as frequency of encounters. This might be approached both from avoidance strategies and in terms of robustness.

## 3.3.4 EC 4 Security issues attached to the use of RPAS

### 3.3.4.1 Scope

This challenge refers to the risks related to potential malicious intrusions into the RPAS or to threats which might compromise safety of crew, of other airspace users, or of third parties.

These could be achieved by any means like physical attacks (e.g. destruction of parts of the RPAS components), electronic attacks (e.g. jamming or spoofing against data-link or satellite navigation) or cyber-attacks (e.g. hacking through Internet web, spoofing, and cyber-attack on specific networks of information like SWIM). Consequences of such cyber threats could represent major challenges for future RPAS operations. Threats like spoofing or hijacking could lead to command and control denial and platform loss with potential lethal consequences.

### 3.3.4.2 Enablers

- Cyber protection techniques;
- Physical security/protection of the crew and the systems;
- Secure crew authentification;
- Satellite navigation anti-spoofing techniques;
- Communication security techniques: encryption methods and crypto components;
- Transmission security techniques (frequency hopping, spread spectrum);
- National information management (awareness of RPAS operations).

**Current and past associated activities**

Apart from US studies in a military context, few studies have been conducted up to now in the specific case of RPAS. However, many techniques are well known and deployed by IT security experts. Recent incidents in the military domain have underlined the importance of this issue and should foster the development of adequate solutions for RPAS.

### 3.3.4.3 Identified gaps

**Gap EC 4.1 RPAS system security threats and potential mitigations**

The goal is to perform a system analysis of all threats on RPAS security and integrity:

- Identification and description of all types of attacks;
- Analysis of their functional consequences;
- Assessment of their impact on flight safety;
- Identification of protection techniques and operational procedures;
- Definition of minimum design rules.

The analysis will be organised according to the following main categories of threats:

- Ground system physical hijacking;
- Cyber-attacks (Internet, infrastructure network, SWIM, wireless means);
- Aggression on C2 data communication : jamming, spoofing, C2 denial;
- Satellite navigation spoofing or jamming;
- Others.

Part of this gap will be constituted by identification of potential mitigation actions including protection means and operating procedures, while taking into account the trade-off between security and necessary transparency to ensure ATM operations.

**Gap EC 4.2 RPAS activities awareness**

The goal is to develop a means through which RPAS operators will be able to report their intended operations for a specific date, time and location in order for the National security authorities to establish a situational awareness of RPAS activities.

The gap analysis will investigate what means to use and how to ensure secure communications.

Additional benefit will be that RPAS pilots and operators will be aware of other RPAS operations within their area of operations.

### 3.3.5 EC 5 Safe automated monitoring, support to decision making and predictability of behaviour

#### 3.3.5.1 Scope

In manned aircraft, pilots play an important role in the handling both nominal flight operations and irregular situations such as system degradations and reacting to external events (weather, icing, traffic).

For the safe integration of RPAS into general airspace, corresponding decision capability needs to be provided for the RPAS with safe automated monitoring and decision making capabilities that provides a standardized and predictable behaviour. The aim of this topic is to define such monitoring and decision making capabilities, to propose the rules and regulations and to finally demonstrate safe and efficient routine operation of RPAS. The topic needs to address RPAS operating in all types of airspace, including segregated, controlled and general airspace. It is essential to perform the work in cooperation with both certification authorities as well as European ATC representatives to develop accepted guidelines for industry.

The topic is of importance for normal flight, contingencies and emergency handling, non exhaustive examples are provided below:

- Nominal operation;
- Flight planning.

Extra flight planning tasks required due to lack of on-board pilot (e.g. ensuring that system degradation contingencies and emergency behaviour is predefined to a level sufficient to ensure predictability):

- Flight operation:
  - In-flight re-planning;
  - ATC communications and procedures;
  - Development of the rules and regulations needed to allow delegation of authority when under operator control.

Contingency operation:

- Contingency decision making for link loss vs pilot in-the-loop for both time critical and non-time critical events due to:
  - External events: icing, weather, traffic, etc.;
  - Internal events: RPAS failures, faulty planning (low fuel…), etc.
- Required level of decision making per contingency function (how to involve the pilot, if available);
- ATC procedures / communications: Control Station to ATC link vs UAV to ATC link.

Emergency operation:

- Flight termination / recovery: Basic techniques / implementation options;
- Definition of recovery areas (alternate landing area, impact area, etc.) and mission programming parameters;
- Propose emergency recovery procedures.

### 3.3.5.2 Enablers

- Safe and standard recovery procedures for contingencies and emergency:
  - Flight planning supporting predictability in contingency and emergency situations;
  - Predetermined predictable procedures;
  - Flight termination and recovery techniques and implementation options (Sensors for replacing the pilot view, Automatic landing systems for use outside Aerodromes, etc.);
  - Definition of recovery areas (alternate landing area, impact area, etc.) and mission programming parameters;
  - Emergency recovery procedures.
- Safe automated health monitoring & Fault detection:
  - Sensors replacing the pilot observation capability;
  - Health monitoring systems detecting early signs of anomalies (vibrations, noise changes, trim changes, …), capability to perform state analysis following events (e.g. lightning strike, and severe turbulence);
  - In service monitoring and analysis including fault signature monitoring;
  - Operational risk analysis for RPAS;
  - Logics for system degradations.
- On-board real-time decision making:
  - Predictable decision and advisory capabilities;
  - Handling of authority and presence for remote pilot together with on board decision capability;
  - Certification principles.
- Means of demonstration: simulation tools, flying test beds;
- Reference simulation models: safety cases simulations, ATM simulations and system degradation simulations, predictability management.

### 3.3.5.3 Identified gaps

**GapEC 5.1 Safe and standard recovery procedures for contingencies and emergency**

This gap covers the methods, technologies as well as procedures for mitigating contingencies and emergencies. Severe failures causing an emergency, such as engine failure, might require the RPA to head towards an emergency landing site or a low populated crash area (A crash or emergency landing at a predefined site is also subject to legal constraints). Other failures could be considered less catastrophic in which the RPA can perform flight, but in a degraded mode, e.g. loss of data link. In such contingency cases on board decision making and agreed procedures are also required.

The following issues have to be investigated:

- Flight planning including sufficient definition of foreseeable contingencies and emergencies to ensure predictable behaviour in such situations;

- Handling of system degradations (e.g. is the link available or not);
- Flight termination / recovery techniques (cameras for detection of people or buildings, automatic landing techniques outside aerodromes etc.);
- Definition of recovery areas (alternate landing area, impact area);
- Legal aspects of controlled crashes;
- ATC communication and procedures for emergency case.

**Gap EC 5.2 Safe automated health monitoring & Fault detection**

Provide a comprehensive health management capability for identifying and characterising faults on the major systems of the aircraft, such that appropriate response/mitigating actions can be identified and implemented. This will be an enabler to realize contingency and emergency handling as well as affordable through life cycle management and improved mission availability and capability. The topic should address:

- Identification of fault isolation capabilities with high confidence level (diagnostic accuracy);
- Establishing robustness of identified fault signatures in service operation;
- Establishing relationship between fault signatures to level of degradation/damage;
- Development of fault signature identification methods;
- Development of functional capability reasoning as input for operational risk assessment;
- Dynamic Simulation of Hard Faults based on Empirical Data and Stochastic Degradation Trend based on Use Conditions and Probability Distribution;
- Integration of maintenance system with high level autonomy function and wider maintenance support infrastructure ensuring reasoning capability with on board decision making capability and remote pilot.

**Gap EC 5.3 On-board real-time smart processing**

Several aspects are driving the need for on-board real time decision making, such as time critical decision (e.g. avoidance) and contingency/emergency handling (in particular in degraded communication situations), but also normal operations benefit from having on board decision making capability (e.g. long term within 4D clearance). On board decision making is also closely related to the ability to generate suggestions and advice during normal operations (e.g. suggesting a route avoiding bad weather). A key property of the decision capability is to maintain a predictability of the RPA behaviour. Within this topic it is suggested to establish certifiable on board decision making capability and corresponding implementation methodologies that enables e.g. to:

- Assess systems status and decide on appropriate actions in case of system degradation using the health monitoring capability described in gap EC5.3 and suggest or select emergency procedures when appropriate in line with gap EC 5.2;
- Decide or advise on flight path decisions, e.g. related to take off (and abort take off), land or change of flight path. This includes handling of 4D trajectories considering external factors such as weather (icing, CB, TS, etc.);
- Time critical decisions: handling of critical decisions where sufficient time may not be available to the remote pilot to execute a decision. e.g. last second avoidance manoeuvres and go around.

### 3.3.6 EC 6 Take-Off and landings and surface operations

Take-off and Landing constitute traditionally the most critical phases of flight. RPAS are likely to provide a full Automatic Take-off and Landing function, in order to suppress the need for any pilot and enhance the safety level during such critical phases.

Current regulation and procedures for landing in manned aviation such as CS AWO have been defined taking into account the presence of a pilot, e.g. in evaluating Decision Height or external visibility cues and do not adequately address the specific character of RPAS Automatic Take-off and Landing.

Taxiing is another challenge for RPAS, as in manned aviation; it is the pilot's responsibility and role to detect and avoid ground obstacles or ground traffic. Other means must be defined for RPAS taxiing.

### 3.3.6.1 Scope

Achieve safe operation of RPAS in the Aerodrome environment.

Provide requirements, guidance and possible technical solutions for conventional Automatic Take-Off and Landing Systems (ATOLS) and for Automatic Taxiing of RPAS in non-segregated aerodromes.

Describe the required RPAS functionalities, associated to updated regulations to be defined.

Demonstrate final evidence of functionalities and achievable performance on real demonstrators.

### 3.3.6.2 Enablers

- Technical means and solutions for Automatic Take-Off and Landing and for Taxiing, aircraft borne and/or ground based:
    - Legacy systems including ILS, MLS;
    - Other techniques like radar, optical, laser, GPS and GNSS, DGPS and DGNSS.
- Real time demonstrations on segregated and non-segregated aerodromes.

### 3.3.6.3 Identified gaps

**Gap EC 6.1 Automatic Take-off and landing, Auto-Taxiing and automated aerodrome Operations**

Gap Outline:

- Identify and define the requirements for take-off, landing and taxiing on non segregated aerodromes;
- Elaborate technical concepts / solutions;
- Demonstrate Performance of fully automated functionality using demonstrators on surrogate aircraft and real RPAS.

Identified Technical Issues:

- Interoperability and compatibility with legacy systems;
- Auto-abort issues – Lost link situations;
- Solution and sensor trade-offs;
- Specificity of VTOL landing configuration;
- Ground obstacle avoidance;
- Ground infrastructure – Links with Airport ATC;
- System Security and protection;

- All weather conditions;
- Taxiing.

# 4 R&D ACTIVITIES TO BE CONDUCTED

## 4.1 Introduction

Based on the findings in chapter 3 this chapter describes the R&D activities that need to be conducted in order to achieve full RPAS integration. The activities to be performed are organised in work packages together with their respective deliverables.

The basis for the activities defined in this section is formed by the list of requirements that is introduced in chapter 2, cross referenced with the ASBU time scale. At the moment, only ASBU0 and ASBU1 have been worked out in detail.

The identification of activities in support of RPAS integration will be used for the development of a detailed work programme. The intention is to take note of projects that are currently conducted as well as projects that will start shortly. As an example hereof it is worth mentioning the activity to be conducted by ESA and EDA which will, with support from regulatory stakeholders, jointly fund and manage a demonstration project addressing and validating C2 SATCOM communications BRLOS addressing the R&D gaps identified in chapter 3 in the context of ASBU1.

The main goal of this project is the validation through in-flight demonstrations of C2 via sitcom requirements including availability, reliability, integrity, latency, continuity, security (cyber-communications) and safe recovery systems in case of loss of link.

**Structure of each presented R&D activity**

Each operational requirement/ASBU combination is presented in one table below and given ~~as~~ an *activity title*. References to the related *technology gaps* are made. Where necessary, a distinction is made between IFR, VFR, VLOS, E-VLOS, B-VLOS, or flight altitude (specifically for very low flights), described in the *context*.

The table will then describe:

- *The nature and description of work*: a list of important elements and actions necessary to complete the requirement within the given time frame;
- *SESAR*: a description of where the work is carried out in SESAR and where relations to the work in SESAR can be expected;
- *Deliverables*: a list of deliverables, which can be documents, a roadmap, road map, etc.;
- *Key dependencies*: describes where a relation to other operational requirements or where a relation to other ERSG roadmaps can be found;
- *Planning elements*: describe the start and end year for the activity, in order to finish within the given ASBU timeframe, together with an estimation of effort necessary (in order of magnitude). The efforts are categorised as either small (under 10 FTE), medium (20 to 50 FTE) or large (above 50 FTE);
- *Required Expertise*;
- *Risks and Opportunities*.

Together, the activities form a list of most important technological developments necessary to achieve RPAS air traffic integration in the given ASBU timeframes.

### 4.1.1 Activity #1: 2013 – EVLOS/VLOS – RPAS activities awareness for security

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #1 | RPAS activities awareness for security | EC Gap 4.2 RPAS activities awareness |

**Context and objectives**

This activity addresses the security aspect of RPAS operation for national security authorities. The need to be aware of where RPAS operations are conducted and as a spin off provide situational awareness for on-going RPAS operations and their location.

**Description of work**

**Nature and description of work**

This activity concerns awareness of RPAS activities for security purposes that are taking place. The work will consist of three elements:

- Notification /flight planning of RPAS operations;
- How to notify or file a flight plan for RPAS operations;
- Who will have to be notified and how the awareness for security purposes should be maintained.

The activity will address use of recognised air picture (RAP) and Situational awareness for other airspace users, including other RPA pilots. It will take into considerations all phases of flight including the planning and post flight phases.

As there is currently no flight planning for VLOS necessary and the activity will address the need for safety and security reasons in terms of notification or flight planning of RPAS operations. The following scenarios will in this context be covered:

- Operations cross border or over high seas;
- Who are interested in this oversight – responsibilities/roles);
- Notification/or Flight plan filing content, procedures and distribution;
- ATC and other airspace user's needs.

RPAS operator and system interface requirements.

**SESAR**

This activity has impact on SESAR through:

- Flight (business/mission trajectories) predictability;
- Network information management;
- SWIM (information/service modelling and system interface requirements).

**Deliverables**

- Operational Services and Environment Description (OSED);
- Safety and Performance Requirements (SPR);
- Interoperability requirements (INTEROP).

| Key dependencies and pre-requisites |
|---|
| Related to the overall security issues e.g. hijacking, jamming, spoofing and physical security protection of the RPA pilot. |
| **Planning elements – duration of the activity** |
| Start: 2013.<br>End: 2013.<br>Effort estimation: small. |
| **Required expertise** |
| This activity requires the following expertise:<br>• Incident readiness organisation;<br>• ATM;<br>• Homeland security agencies to establish procedures;<br>• IT cyber security expertise;<br>• Etc. |
| **Risks and Opportunities** |
| Risks:Involvment of state authorities, lack of guidance related to cyber security issues, underestimation of the importance of the activity. |

### 4.1.2 Activity #2: 2013-2015 – EVLOS/VLOS – Operations in urban areas

| Activity ID<br>#2 | Activity title<br>Operations in urban areas | Related technology gaps<br>EC Gap 2.1 Secure C2 systems and links |
|---|---|---|
| **Context and objectives** | | |
| Operations in VLOS and EVLOS, conditions are in direct radio line of sight. In urban areas the line of sight C2 link will have to ensure secure and safe operations. Due to the built up areas, RPAS operations will have to take into account aspects like masking and interference from other sources. This activity will identify these obstacles and provide solutions to ensure safe and secure RPAS operations. | | |
| **Description of work** | | |
| **Nature and description of work** | | |

- Determine minimum C2 requirements to ensure that operations can be conducted safely addressing:
    - Robustness, determine what level is required;
    - Availability;
    - Integrity;
    - Quality of Service;
    - Continuity.
- Safety and security;
- Contingency, ensuring safe recovery during loss of link;
- Development of Enhanced/Synthetic Vision System;
- Aircraft Navigation capability improvements in poor GPS signal availability conditions in urban areas;
- Modelling, prototyping and demonstrations;
- Spectrum issues, ensuring suitable and available frequencies can be used.

**SESAR**

Not identified.

**Deliverables**

- Operational Services and Environment Description (OSED);
- Safety and Performance Requirements (SPR);
- Development of models and prototypes leading to validation activities;
- System/performance specifications;
- Spectrum requirements, including spectrum management issues.

**Key dependencies and pre-requisites**

The key dependencies and pre-requisites for a successful activity are the following:

- Spectrum availability and allocation;
- Trajectory/mission planning;
- Enhanced/Synthetic Vision;
- Automatic Navigation and Guidance system;
- Detectability of cooperative and non-cooperative aircraft;
- Digital maps of urban environments.

**Planning elements – duration of the activity**

Start: 2013.

End: 2014 (OSED, SPR, SPS and Spectrum requirements).

Effort estimation: small.

End: 2015 (validated and performance assessed and model and prototype solutions for initial integration).

| |
|---|
| Effort estimation: medium. |
| **Required expertise** |
| This activity requires the following expertise:<br>• Terrain/Urban/Obstacles database management;<br>• Automatic Guidance, Navigation and Control system and sensor fusion;<br>• Digital communications. |
| **Risks and Opportunities** |
| Risks: Spectrum availability, GNSS spoofing, contingency due to loss of signal, dependency to activity 1 and 13.<br>Opportunities: Enabling SMEs/SMIs innovative knowledge. |

### 4.1.3 Activity #3: 2013-2015 – EVLOS – Human Factors

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #3 | Human Factors in E-VLOS | EC Gap 3.9 Roles & responsibilities observer & pilot |

**Context and objectives**

The E-VLOS operations require sound and robust teamwork between the pilot and observer. It is essential that in this activity that both the pilot and the observer share the same situational awareness to ensure safe execution of an E-VLOS operations. It will address human factor issues related to the interaction of the crew in regard to communications, responsibility and non-standard events.

In E-VLOS operations, the pilot and one or several observers form a distributed team that use information and communication technologies to create a common situation awareness of the RPAS performance and potential hazards. This research activity investigates skill and information requirements for the pilot and observer based on an analysis of individual and joint task requirements.

**Description of work**

**Nature and description of work**

The observer's role in E-VLOS operations is to provide the pilot with critical information regarding RPAS performance and potential hazards. However, the pilot must also inform the observer of planned manoeuvers to enable proactive monitoring of the RPAS operations and any potential hazards. The pilot and observer therefore need to create and maintain a common situation awareness using information and communication technologies.

Since the experiences of E-VLOS operations are still limited, this research activity will use task modelling techniques to analyse individual and joint task requirements, critical information needs, and crew workload during potential operations. The analysis of task requirements provides an understanding of what, when, and how, the pilot and observer need to communicate to create common situation awareness. For example, how to communicate and/or present planned manoeuvres, potential hazards, and observer visibility restrictions. Information requirements and CONOPS are validated with demonstrators and evaluations. The CONOPS will improve the organisational understanding of the benefits and limitations of E-VLOS operations.

Further, a detailed task analysis of how the distributed team of pilot and observer perform E-VLOS operations enable investigations of personnel qualifications and training needs, such as the need for TRM/CRM.

The clear distinction between the pilot and observer in E-VLOS:

- TRM/CRM (Team/Crew resource management);
- Task modelling;
- Training;
- Qualification of personnel;
- Health and safety;
- Organisational and social;
- Human machine interface;

- Roles and responsibilities:
    - Workload;
    - Crew resource management.
- Situational awareness:
    - Communication;
    - Common situational awareness;
    - Demonstrations/studies.

**SESAR**

This activity has impact on SESAR through:

- Airport operations under consideration.

**Deliverables**

The deliverables of this research activity enable distributed teams of pilot and observer to safely and efficiently perform E-VLOS operations. The deliverables cover everything from crew roles and information needs to crew selection and training. The deliverables are:

- Operational Services and Environment Description (OSED) for pilot and observer;
- Safety and Performance Requirements (SPR);
- Interoperability requirements (INTEROP);
- Critical information needs;
- Generic training and qualification guidelines;
- CONOPS;
- Demonstrators.

**Key dependencies and pre-requisites**

Overview on TRM and CRM Human visual aquision expertise.

**Planning elements – duration of the activity**

Start: 2013.

End: end 2013 (CONOPS, OSED, SPR, Critical information needs, Generic training, Qualification guidelines).

Effort estimation: small.

End: 2015 (Demonstrations of solutions for initial integration).

Effort estimation: medium.

**Required expertise**

| |
|---|
| This activity requires the following expertise:<br>• Human factors experts;<br>• IFATCA;<br>• IFALPA;<br>• RPAS operators, pilots. |
| **Risks and Opportunities** |
| Risks: Inconsistent international standards requirements, lack of empirical data.<br>Opportunities: Re-use of experience of other activities where the pilots are dependent on observers. |

### 4.1.4 Activity #4: 2013-2014 – IFR/VFR – Visual detectability solutions

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #4 | Visual detectability solutions and detectability of the RPA by sensors | EC 3.8 Detectability solutions |

**Context and objectives**

This activity concentrates on the detectability of RPAS. In order to safely integrate RPAS, RPAS and other airspace users need to comply with the rules of the air. In order to do this, the RPA needs to be visible to other airspace users and to ATC (TWR). If the RPA is too small, it might not be detectable by other airspace users and thereby create potential hazardous situations. It also addresses the detectability from a surveillance perspective.

**Description of work**

**Nature and description of work**

The visual detectability of the RPA is a relevant issue in RPAS integration in non-segregated airspace due to the hazard represented by the traffic which cannot be easily detected by other airspace users. Specifically, small and light RPA may be a threat to other airspace users, if they cannot easily detect it. The aim of this activity is to determine the minimum requirements for airborne and/or ground based detectability.

The detectability in this activity addresses two issues:

- Visual detectability:

This aspect is important for ensuring safe operations during VFR and IFR (VMC) operations for all airspace users as that will require the rules of the air to be applied. It is also of importance for the ATC, specifically for the TWR controller to be able to visually detect RPA´s.

- Non/visual detectability:

This addresses the detect ability through surveillance techniques, including DF (Direction Finders). It is also of importance for the ATC, specifically for the TWR controller to be able to detect RPA´s.

Define minimum visual RPA detectability requirements and alternative means of identification by other airspace users.

Human factors issues (how do humans see and detect, what are limitations).

Validation activities (try out in real or simulated environments if aircraft can be detected); prototyping.

ATC visibility of the aircraft from the (remote) tower ATC.

Sensor visibility.

**SESAR**

This activity has impact on SESAR through:

- Safety;
- Remote towers.

**Deliverables**

- Operational Services and Environment Description (OSED);
- Safety and Performance Requirements (SPR);

| |
|---|
| • Results of validation activities. |
| **Key dependencies and pre-requisites** |
| D&A System.<br>ATC Operation and Procedures. |
| **Planning elements – duration of the activity** |
| Start: 2013.<br>End: early 2014.<br>Effort estimation: small. |
| **Required expertise** |
| • Optics and Optical sensor design;<br>• Surveillance expertise;<br>• Image Processing and sensor fusion. |
| **Risks and Opportunities** |
| Risks: Negative impact on the target level of safety which might render in constraint to operations, non-effective co-operative and non-cooperative solutions that may create an overload for ATC.<br>Opportunities: Image processing tools for detection of small RPAS in low-resolution digital images and sensor fusion techniques could further give strong support to detectability of non-cooperative RPA. |

### 4.1.5 Activity #5: 2013-2018 – IFR/VFR – D&A

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #5 | D&A | EC Gap 3.3 Airborne based detect & avoid<br>EC Gap 3.4 Ground based detect & avoid<br>EC Gap 3.6 Ground and obstacles avoidance<br>EC Gap 3.7 Weather detection<br>EC Gap 3.8 detectability solutions<br>EC Gap 3.10 other hazards including WAKE ref 2.4 |

**Context and objectives**

This activity addresses the ability of RPAS to replicate the human ability to see and avoid, which is called detect and avoid for RPAS. It is essential to have this capability as it one of the cornerstones of aviation called "rules of the air" in which the pilot is the person ultimately responsible for the safety of his flight. It addresses all aspects like collision avoidance to ground & obstacle avoidance, surface operations and other hazards for IFR and VFR flights.

**Description of work**

**Nature and description of work**

A detect and avoid system (D&A) is required for safe operations of RPAS in the airspace shared with conventional (manned) aircraft.

Due to the fact that the pilot is not located on board the aircraft but remotely located on the ground, his/her ability to correctly judge the situation is impacted. The ability is furthermore reduced in the case of lost link conditions, when the RPAS is to act on its own. The RPAS must be capable of detecting and avoiding cooperative and non cooperative traffic and performing avoidance manoeuvres not creating another dangerous situation with other aircraft, or with the ground. The manoeuvre must also be clearly readable to the other traffic – not to create any confusion.

Compatibility of the manoeuvre must also consider the current aircraft equipment status – e.g. all aircraft above certain weight (usually 5700 kg) are equipped with Airborne Collision Avoidance Systems (ACAS) and this system is generating avoidance instruction – resolution advisory. The RPAS must follow this instruction – basically without any further crosschecking of the manoeuvre. The detect & avoid system for RPAS must issue an instruction which is compatible with current TCAS and ACAS-X developments.

Detecting IFR traffic will be less demanding, as all IFR traffic is equipped at least with a transponder. Not all VFR traffic is transponder equipped, so some ways of detecting such traffic will be required.

Weather detection is also important. A flight conducted under VFR must not enter clouds and in a manned aircraft this is done by the visual recognition. This functionality should be achieved through adequate set of sensors with enough information to make a correct decision. Icing or thunderstorms are typical examples of hazards which needs to be detected on board.

The systems needs to guarantee not only ground collision avoidance functionalities, but also all other functionalities to support ground operations.

Ground collision avoidance needs to be improved compared to existing ground proximity warning systems. Such systems are greatly reducing the risk of ground collision during approach to the runway, but a typical RPAS operation will involve low level flights with much less margins.

- Airborne detect and avoid will have the following main components:
    - Traffic avoidance and collision avoidance (Gap 3.3):
        - Interoperability with ACAS;
        - Impact on delegation of separation provision;
        - Cooperative and non-cooperative sensors (when possible).
    - Other traffic information/intruders detection;
    - Terrain and obstacle information and avoidance;
    - Weather hazards - detection and avoidance;
    - Surface operations – traffic, obstacles, airport layout compatibility;
    - Other hazards (birds, wake vortex).
- Detect and avoid support by other means when practical and feasible (e.g. ground based, space based);
- Detectability of the own-ship RPAS – related to activity #4.The prototype developed will be validated and verified in simulation, demonstrations and flight tests with other traffic.

Specific focus will be given to activities needed for VFR operations outside controlled airspace:

- Integration in non-controlled airspace (detect and avoid of non-cooperative targets);
- Ability to maintain VMC (distance from clouds, visibility).

**SESAR**

This activity has impact on SESAR through:

- Delegated separation;
- Integration of RPAS in IFR environment;
- Interoperability of D&A with existing conflict detection and collision avoidance systems;
- Weather detection;
- Safety;
- Enhanced/Synthetic Vision Systems;
- Remote towers.

**Deliverables**

- Operational Services and Environment Description (OSED);
- Safety and Performance Requirements (SPR);
- Interoperability requirements (INTEROP);
- System/performance specifications;
- Prototypes;
- Verification/validation results.

**Key dependencies and pre-requisites**

The D&A system developed here must be compatible with existing ACAS used in commercial aircraft while not creating/generating confusing information for VFR traffic with no ACAS on board – where the decision is taken by pilot – usually based only on visual information

Existing regulatory framework must be strictly followed and implemented. When a new regulation is to be placed it must be carefully evaluated and impact to existing airspace user must be zero to very limited.

MIDCAS is looking to prevent mid-air collision and providing traffic avoidance advices of part of detect & avoid. The results of the project are expected to be used as a basis for further development.

**Planning elements – duration of the activity**

Start: 2013.

End: 2014 (OSED, SPR).

Effort estimation: large.

End: 2015 (INTEROP, SPS).

Effort estimation: large.

End: 2017 (validation of prototypes).

Effort estimation: large.

End: 2018 (performance assessed and validated operations and prototypes for initial integration. This concerns only the part of activities for ASBU1, the work will not be finished completely by 2018; there will be overlap towards ASBU2).

Effort estimation: large.

**Required expertise**

A close cooperation of avionics system manufacturers, air traffic control companies, RPAS end users and current airspace users is required here. A typical set of expertise required:

- Sensor (cooperative & non-cooperative);
- Sensor integration, blending, target tracking;
- System architecture and integration;
- Separation & avoidance logic, ACAS logic;
- Operations;
- Information processing in embedded on-board systems;
- Aircraft control and flight performance expertise;
- ATC expertise.

**Risks and Opportunities**

Risks: Negative impact on the target level of safety which might render in constraint to operations, non-effective co-operative and non-cooperative solutions that may create an overload for ATC, spectrum, sensor performances, integration issues, contingency, lack of requirements availability and technology solutions to cater for all RPAS.

Opportunities: Emergence of new technology common with manned aviation, remote ATS etc. Detect and avoid solutions will provide safety benefits for manned aviation. Positive effect on solutions for manned aviation.

### 4.1.6 Activity #6: 2013-2018 – BVLOS – D&A

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #6 | D&A | EC Gap 3.3 Airborne based detect & avoid<br>EC Gap 3.4 Ground based detect & avoid<br>EC Gap 3.6 Ground and obstacles avoidance<br>EC Gap 3.7 Weather detection<br>EC Gap 3.8 detectability solutions<br>EC Gap 3.10 other hazards including WAKE ref 2.4 |

**Context and objective**

Operating RPAS in Very Low Level conditions, below 400ft requires a new look at aviation as manned aircraft do not tend to operate at these altitudes. RPAS operating in this environment will be flying very close to obstacles and therefor this activity, in addition to activity 5, addresses the specific requirements for Very Low level operations.

**Description of work**

**Nature and description of work**

A detect and avoid system (D&A) is required for safe operations of RPAS in the airspace shared with conventional (manned) aircraft. The airspace which is to be used for very low level operations suggested here is not typically the airspace with a high density traffic, but there are certain segments of traffic present there – crop dusters, medical helicopter operations, or even an fixed wing aircraft training operation (engine malfunction simulation etc.) are common.

Weather detection is also important – especially cloud and other hazards detection. A flight conducted under VFR must not enter clouds and in a manned aircraft this is done by the visual recognition. Hazard like thunderstorms are of a special importance for a small RPAS as the severe weather will significantly impact the ability the ability of RPA to fly – or even lead to a crash of RPA. The same applies for icing or wind shear.

Ground collision avoidance needs to be built on different principle than the existing ground proximity warning systems. Such systems are greatly reducing the risk of ground collision during approach to the runway, but a typical RPAS operation will involve low level flights with much less margins. Also existing databases do not include all the obstacle of significant importance for light RPAS – mobile network radio must is a good example. A combination of database and suitable sensor information will probably be required here.

For conditions in visual meteorological conditions (VMC) or instrument meteorological conditions(IMC):

- Identify detect and avoid requirements for conducting flights under IMC and VMC in very low level flight;
- Airborne detect and avoid:
    - Traffic avoidance and collision avoidance:
        - Non-cooperative sensors or other non-cooperative means to have information on all flying objects.
    - Other traffic information/intruders detection;
    - Terrain and obstacle avoidance:
        - Extended terrain database requirements beyond current obstacle databases for very low level operations. Trees, small radio masts big ships etc. are not considered as obstacles by current definition but will have impact on small RPAS low level operation.
    - Weather detection and avoidance;
    - Other hazards (birds).
- Detect and avoid support by other means (e.g. ground based, space based);
- RPAS own-ship detectability – compatibility;
- Airspace awareness, ability of the pilot to be aware of the airspace classification and requirements.

The prototype developed will be validated/verified in simulations, demonstrations and flight test with other traffic.

Specific activities needed for very low level VFR/VMC operations are:

- Integration in non-controlled airspace (detect and avoid of non-cooperative targets);
- Ability to maintain VMC (distance from clouds, visibility).

**SESAR**

This activity has impact on SESAR through:

- Delegated separation;
- Interoperability of D&A with existing conflict detection and collision avoidance systems;
- Weather detection;
- Safety;
- Enhanced/Synthetic Vision Systems;
- Remote towers.

**Deliverables**

- OSED;
- SPR;
- Interoperability requirements;
- System/performance specifications;
- Prototypes;
- Verification/validation results.

| Key dependencies and pre-requisites |
| --- |
| The D&A system logic developed here must be especially compatible with existing rules of the air logic as employed by any pilot on board the aircraft. ACAS compatibility must be considered as well. Existing regulatory framework must be strictly followed and implemented. When a new regulation is to be placed it must be carefully evaluated and impact to existing airspace user must be zero to very limited.There is a direct dependency with activity 5 especially overlaps with the areas of airborne collision avoidance, ground avoidance and obstacles avoidance. |
| **Planning elements – duration of the activity** |
| Start: 2013.<br>End: 2014 (OSED, SPR).<br>Effort estimation: medium.<br><br>End: 2015 (INTEROP, SPS).<br>Effort estimation: medium.<br><br>End: 2017 (validation of prototypes).<br>Effort estimation: medium.<br><br>End: 2018 (performance assessed and validated operations and prototypes for initial integration. This concerns only the part of activities for ASBU1, the work will not be finished completely by 2018; there will be overlap towards ASBU2).<br>Effort estimation: medium. |
| **Required expertise** |
| A close cooperation of avionics system manufacturers, air traffic control companies, RPAS end users and current airspace users is required here. A typical set of expertise required:<br>• Sensor (cooperative & non-coopeative);<br>• Sensor integration, blending, target tracking;<br>• System architecture and integration;<br>• Separation & avoidance logic, ACAS logic;<br>• Operations – GA pilots and operators;<br>• Information processing in embedded on-board systems. |
| **Risks and Opportunities** |
| Risks: Negative impact on the target level of safety which might render in constraint to operations, non-effective co-operative and non-cooperative solutions that may create an overload for ATC, spectrum, sensor perfomances, integration issues, contingency, lack of requirements availiability and technology solutions to cater for all RPAS.<br><br>Opportunities: Emergence of new technology common with manned aviation, remote ATS etc. Detect and avoid solutions will provide safety benefits for manned aviation. Positive effect on solutions for manned aviation. |

### 4.1.7 Activity #7: 2013-2018 – IFR/VFR – Comms C2 data link

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #7 | Comms C2 data link | EC Gap 2.1 Secure C2 systems and links<br>EC Gap 2.2 LOS/B-LOS SATCOM infrastructures and data links<br>EC Gap 2.3 Radiobandwith management<br>EC Gap 4.1 RPAS system security threats and potential mitigation |

**Context and objectives**

This activity addresses the data link requirements for safe RPAS operations. It looks at this from a radio line of sight and beyond line of sight (SATCOM) perspective. Data links are essential for the execution of a safe flight but will also provide the ground station with essential information of the Aircraft status and other mission critical data like data on D&A.

**Description of work**

**Nature and description of work**

- The work is primarily to determine minimum C2 requirements for RLOS and BRLOS to:
  - Definition of C2 Data link General Performances;
  - Categories according those of the RPAS in general to:
    - Robustness;
    - Availability;
    - Integrity;
    - Quality of Service;
    - Continuity;
  - Latency (only BRLOS specifically for SATCOM services);
  - Cross check and liaison with GNSS services (related to gap 2.2). RPAS C2 is closely related to accurate navigation as fitted by enhanced GNSS systems;
  - Application of Software Defined Radio (SDR) techniques for secure and efficient use of allowable bandwidth;
- Safety and security aspects addressing:
  - Development of operational procedures for different scenarios, including the degradation of C2 comms. Autonomy as a last resource emergency system ;
  - Counteracting attacks to data link systems (jamming and hijacking by Radio and SW means).
- Modelling, prototyping and demonstration. All the above should be demonstrated by stepped approach from modelling and simulation to in- flight demonstration of selected cases;
- Spectrum issues.

**SESAR**

This activity has impact on SESAR through:

- Spectrum requirements;

- Latency definition;
- C2 architecture and integration with ATC communications and data link.

**Deliverables**

- Operational Services and Environment Description (OSED);
- Safety and Performance Requirements (SPR);
- Interoperability requirements (INTEROP);
- Models and prototypes;
- System/performance specifications (SPS);
- Spectrum requirements, including spectrum management issues.

**Key dependencies and pre-requisites**

Spectrum availability and allocation.

Satcom infrastructure and services availability.

Acceptable latency for ATC.

**Planning elements – duration of the activity**

Start: 2013.

End: 2015 (OSED, SPR, INTEROP, SPS and spectrum requirements).

Effort estimation: medium.

End: 2017 (validation of prototypes).

Effort estimation: large.

End: 2018 (performance assessed and validated operations and prototypes for initial integration).

Effort estimation: large.

**Required expertise**

Specifically devoted facilities for characterization of EM (Electromagnetic) environment and measurement are needed.

**Risks and Opportunities**

Risks: Secure spectrum availability for safety of life communication, cost-effective comm-service provision, cyber security/

Opportunities: Spin-off effects to manned aviation development.

### 4.1.8 Activity #8: 2014-2018 – BVLOS – Comms C2 data link

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #8 | Comms C2 data link | EC Gap 2.1 Secure C2 systems and links<br>EC Gap 2.2 LOS/B-LOS SATCOM infrastructures and data links<br>EC Gap 2.3 Radiobandwith management |

**Context and objectives**

In addition to activity 7 this activity addresses the additional requirements for secure and safe data link at very low levels beyond visual line of sight. Aspects like masking and obstacles will require additional requirements.

**Description of work**

**Nature and description of work**

Built on the requirements of activity 7 due to the nature of BVLOS operations (very low level operations) this activity will address the following:

- Determine minimum C2 requirements for RLOS and BRLOS:
    - Definition of C2 Data link General Performances. Categories according those of the RPAS;
    - Robustness. Extended use of sensor fusion for robustness of data link signal;
    - Availability, interference because of masking, close proximity to obstacles, interference with ground infrastructure (like energy sources);
    - Integrity;
    - Quality of Service;
    - Continuity, temporary loss of signal because of infrastructure or vegetation;
    - Latency (only BRLOS);
    - Cross check and liaison with GNSS services (related to gap 2.2). RPAS C2 is closely related to accurate navigation as fitted by enhanced GNSS systems;
    - Alternative navigation means (i.e. optical) for supporting GNSS or to overcome the lack of it;
    - Application of Software Defined Radio (SDR) techniques for secure and efficient use of allowable bandwidth;
    - Exploring the effect and efficiency on Comms C2 data link of multiple collaborative RPAS flight. Swarming and distributed tasks.
- Safety and security:
    - Development of operational procedures for different scenarios, including the degradation of C2 comms. Autonomy as a last resource emergency system;
    - Counteracting attacks to data link systems (jamming and hijacking by Radio and SW means).
- Modelling and prototyping. All the above should be demonstrated by stepped approach from modelling and simulation to in- flight demonstration of selected cases;
- Spectrum issues, including FM interference.

**SESAR**

This activity has impact on SESAR through:

- Spectrum requirements.

**Deliverables**

- Operational Services and Environment Description (OSED);
- Safety and Performance Requirements (SPR);
- Interoperability requirements (INTEROP);
- Models and prototypes. Flight demos related to defined scenarios;
- System/performance specifications;
- Spectrum requirements, including spectrum management issues.

**Key dependencies and pre-requisites**

Spectrum availability and allocation;

Satcom infrastructure and services availability;

Build on the work performed in the IFR/VFR C2 work.

**Planning elements – duration of the activity**

Start: 2014.

End: 2016 (OSED, SPR, INTEROP, SPS and spectrum requirements).

Effort estimation: medium.

End: 2017 (validation of prototypes).

Effort estimation: medium.

End: 2018 (performance assessed and validated operations and prototypes for initial integration).

Effort estimation: medium.

**Required expertise**

Expertise needed in the fields of RF, automatic control, GNSS Sat Navigation, as well as advanced control for denied SatNav scenarios and small vehicles, including multiple collaborative flight.

Wide TRLs range to cope from basic technologies (RF, advanced control,..) to modelling, simulation and flight demonstration.

Good ground for cooperative work from basic research (University+ Research Institutes) to industrial applications.

Specifically devoted facilities for characterization of EM (Electromagnetic) environment and measurement are needed.

**Risks and Opportunities**

Risks: Secure spectrum availability for safety of life communication, cost-effective comm-service provision, cyber security.

Opportunities: Spin-off effects for manned aviation development.

### 4.1.9 Activity #9: 2013-2016 – IFR/VFR – Airspace Access and Airport Operations

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #9 | Airspace Access and Airport Operations | EC Gap 1.1 Short term validation in current ATM<br>EC Gap 3.1 ATM interfaces in current context<br>EC Gap 6.1 Automatic take-off and landing |

**Context and objectives**

RPAS that are to operate under VFR or IFR will have to integrate into an environment which is dominated by manned aviation. RPAS will have to adapt to the existing rules and regulations. This activity addresses the main airspace and airport integration aspects like, flight planning, minimum performance requirements for IFR flights, separations criteria, surface operations and many other ATM requirements to enable RPAS integration.

**Description of work**

**Nature and description of work**

Access to the airspace and airport concerns activities to ensure smooth RPAS traffic handling, similar to other (manned) traffic in all phases of flight.

Research activities can be divided into those necessary to prepare the flight in the flight planning phase and those for executing the flight.

Flight preparation requires information management for flight planning, where all intended flights are filed to the ATC organisation. The special character of some RPAS operations (see e.g. section 2.3 of this document for typical RPAS profiles) will require assessing the airspace configuration and possible needs for (temporary) airspace modifications.

~~I~~The integration of RPAS will require assessing separation criteria; RPAS will, certainly in the early phases of ATM integration, not behave exactly the same as other aircraft, because of the latency and a different flight awareness of the crew. Specifically at airports, it may not be possible to control the aircraft at high speed towards high speed exits and to make sharp turns, because of the delay in C2 that can lead to a minimum RPAS performance requirement (Standard Rate Turns, minimum climb performance, etc.).

Finally, ATC will need awareness of RPAS activities in their control area. Activities must be pre-announced and the flight plan will need to indicate the fact that the flight is an RPAS. During flight, the air traffic controller must have some indication (e.g. through a call sign) and must have received sufficient training to understand ~~its~~ the RPAS behaviour. ATC has knowledge of contingency procedures through adequate training.

IThe impact of RPAS operations integration on the ATM Master Plan activities, which describe the current ATM systems and its evolution until 2018, including:

- Network operations;
- Airport operations – airports to be shared with other traffic;
- Integration of RPAS into existing airspace and ATM environment – considering expected kind of missions, compatibility with current airspace structures&airways. RPAS performance consideration and limitations;
- Separation criteria including wake turbulence– possible introduction of sub light category for light RPAS operating close to commercial air traffic;
- Airspace driven requirements on avionics and CNS – mandates.

Automatic take-off and landing – conformity to existing manned aircraft routes/SID/STARs or development of new RPAS routes. Compatibility with airport surface operations. Development of required equipment for take-off and landing and compatibility with legacy systems.

The outcome of these initial activities will lead into the development of:

- Minimum performance requirements for IFR/VFR operations;
- Safety requirements for IFR and VFR operations;
- ATM security requirements for IFR and VFR operations;
- RPAS specific flight plan requirements – including arrivals/departures;
- ATC additional training;
- ATC system requirements;
- Requirements for technology impact of RPAS on the ATM system;
- Surface operation procedures;
- Etc.

**SESAR**

This activity has impact on SESAR through:

- Gate to gate operations;
- SWIM;
- Trajectory management;
- Initial 4D;
- Transition in/out of different airspace classes/different mode of RPAS operations.

**Deliverables**

- Updated ATM Master Plan;
- Final work breakdown structure for RPAS integration;
- Impact assessment.

**Key dependencies and pre-requisites**

Work inside this activity will be also driven by the development status of other enablers – basically all the enablers developed will have impact on integration. The ideal workflow will be in a structured steps – the entire airspace issue cannot be resolved at once – it will be driven by different classes/types of operation.

| Planning elements – duration of the activity |
|---|
| Start: 2013.<br>End: 2014 (impact assessment).<br>Effort estimation: large.<br><br>End: 2016 (performance assessed and validated initial operational/technical recommendations).<br>Effort estimation: large. |
| **Required expertise** |
| A close cooperation of RPAS end users, air traffic control companies, RPAS manufactures, avionics manufactures and current airspace users is required here. A typical set of expertise required:<br>• ATC and ATM specialists – from ATCO performing the actual control of air traffic to procedure designers and other stakeholders;<br>• Operations – pilots (all kinds of operations) and manned aircraft operators;<br>• RPAS end users – pilots, payload operators. |
| **Risks and Opportunities** |
| Risks: Delay due to lack of acceptance by pilots, controllers, other airspace users or airport operators e.g. reduction of performance of the capacity of the airspace.<br>Opportunities: Early advantages beneficial to the SESAR work. |

### 4.1.10 Activity #10: 2013-2016 – BVLOS – Airspace Access and Airport Operations

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #10 | Airspace Access and Airport Operations | EC Gap 1.1 Short term validation in current ATM<br>EC Gap 3.1 ATM interfaces in current context<br>EC Gap 6.1 Automatic take-off and landing |

**Context and objectives**

In addition to activity 9 this activity addresses the unique aspects of very low level operations beyond line of sight. BVLOS operations are seen as a new paradigm in aviation as we will have aircraft operating at altitudes where "normally" no manned aircraft operate. This activity should also ensure that they will not impact existing low level operations.

**Description of work**

**Nature and description of work**

This table is strongly linked to the IFR/VFR operations in all airspace classes and airport operations, and focusses here specifically on aspects concerned with the very low level flight.

Make an impact assessment of very low level flight operations in the ATM Master Plan, taking into consideration the following aspects:

- Type of operations (IMC/VMC aspects, all phases of flight);
- Minimum performance requirements;
- Minimum flight condition (IMC/VMC)
- Airspace classification;
- Separation criteria including wake turbulence;
- Avionics – requirements – mandates;
- CNS;
- Etc.

The outcome of these initial activities will lead into the development of:

- Safety requirements;
- ATM security requirements;
- RPA specific flight plan requirements/"no flight plan recorded" operations;
- ATC system requirements and ATCo training;
- Operations at non-controlled airfields;
- Etc.

**SESAR**

This activity has impact on SESAR through:

- Transition in/out of different airspace classes.

**Deliverables**

- Impact assessment of the ATM Master Plan;
- Operational Services and Environment Description (OSED);
- Safety and Performance Requirements (SPR);
- Interoperability requirements (INTEROP);
- Further deliverables can be expected for new functionalities, technologies, procedures, etc.

**Key dependencies and pre-requisites**

Deliverables from the previous airspace access and airport operations activity, C2 and D&A activities.

**Planning elements – duration of the activity**

Start: 2013.

End: 2014 (impact assessment).

Effort estimation: small.

End: 2015 (OSED and SPR).

Effort estimation: medium.

End: 2016 (performance assessed and validated initial operational/technical recommendations).

Effort estimation: medium.

**Required expertise**

A close cooperation of RPAS end users, air traffic control, RPAS manufactures, avionics manufactures and current airspace users is required here. A typical set of expertise required:

- ATC and ATM specialists – from ATCO performing the actual control of air traffic to procedure designers and other stakeholders;
- Operations – pilots (all kinds of operations) and manned aircraft operators;
- RPAS end users – pilots, payload operators.

**Risks and Opportunities**

Risks: Delay due to lack of acceptance by pilots, controllers, other airspace users or airport operators, negative impact on airspace classification, restriction on low level operations for manned aviation, interoperability around airports.

Opportunities: Early advantages beneficial to the SESAR work.

### 4.1.11 Activity #11: 2014-2018 – IFR/VFR – Contingency

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #11 | Contingency | EC Gap 5.1 Safe and standard recovery procedures for contingencies and emergency<br>EC Gap 5.2 Safe automated health monitoring &fault detection<br>EC Gap 5.4 On-board real-time smart processing |

**Context and objectives**

The data link of an RPAS can be seen as the life line of the system. When the link is severed the RPAS will become “uncontrolled” and because of this it is essential that contingency procedures are developed. The loss of link does not constitute immediate loss of the RPA, but it will not be able to receive any additional inputs into the execution of the flight. In order to accommodate these conditions harmonised procedures will need to be established. These procedures will also have to be transparent to ATC, as it will not be possible for ATC to distinguish what type of contingency belongs to what type of RPAS. The contingency aspects will also be addressed at the RPAS system level.

**Description of work**

**Nature and description of work**

Specific detailed analysis of the RPAS contingencies mode, notably connected to loss of C2 link or lack of Detect and Avoid data and equipment, are strictly required. For the ATM Master Plan Baseline & Step 1 timeframe, it is recognized that contingencies management shall be based on consistent and dependable identification of predefined procedures. In order to manage unforeseen contingencies and emergencies, which can endanger lives in air or on ground, a flight termination system shall further be provided to RPA flying in unrestricted airspace.

The contingencies management will require a thorough evaluation of the contingency event(s), their prioritization if multiple events occur simultaneously, identification of the mitigation operations, and the execution of such operations/procedures.

For all kind of contingencies, their management will anyway require that pilot-in-command and ATC service are immediately aware of the RPAS specific condition. Pilot-In-Command, in effect, remains the responsible for the flight and shall be able to decide the procedure to be applied to optimally mitigate the contingency effects.

The contingency management, in its widest definition, is actually a hard task for R&D work, which will likely extend well beyond the ASBU 1 timeframe.

Actually, contingency conditions can vary widely both in type and level and, depending on that, also the contingency mitigation operations and their delegation to pilot or automated on-board system can equally vary. A short list of relevant topics to be taken into consideration follows:

- Extended failure mode analyses, which allows, on the base of data collected from RPAS use, to continuously upgrade the failure modes typology, their statistical relevance, and the related recovery and mitigations operations/means;
- Health monitoring systems/tools development, for the evaluation of system/subsystem/equipment degradation and the related residual system performance capabilities;
- Resilience engineering and health management system development, to support the identification of functions allocation between the pilot (or human) operating the aircraft or automation systems (e.g., strictly required in case of complete loss of command and control link);
- High detailed simulation environment and verification tools development, which allows complex scenarios reproduction and complex systems extended tests for the safe verification of contingencies management systems.

Development of contingency procedures for standardisation to cater for:

- Lost link procedures:
    - On-board decision making, including level of automation/autonomy;
    - System (graceful) degradation.
- Emergency procedures:
    - Dependable emergency recovery, including safe automated health monitoring and fault detection and on-board real-time processing capability;
    - Operational emergency procedures for all phases of flight, including flight termination;
    - Information management to ATC and SAR.
- Simulation/demonstration;
- Validation/Verification;
- Handling on system degradation;
- Health monitoring.

**SESAR**

This activity has impact on SESAR through:

- Integration of IFR;
- SWIM;
- Trajectory management;
- Initial 4D;
- Transition in/out of different airspace classes.

**Deliverables**

- Operational Services and Environment Description (OSED);
- Safety and Performance Requirements (SPR);
- Interoperability requirements (INTEROP);
- System/performance specifications (SPS);
- Demonstrators.

**Key dependencies and pre-requisites**

Relation to Trajectory/Mission planning and management, Data link Quality of Service- D&A system performance-Safety Analysis System design.

**Planning elements – duration of the activity**

Start: 2014.

End: 2015 (OSED, SPR, INTEROP and SPS).

Effort estimation: large.

End: 2017 (demonstrators).

Effort estimation: large.

| |
|---|
| End: 2017 (performance assessed and validated operations and demonstrators/prototypes for initial integration).<br><br>Effort estimation: large. |
| **Required expertise** |
| • Safety Assessment Analysis;<br>• Resilience engineering and Automation;<br>• Health management system (including FDI);<br>• Modelling simulation and verification of complex system. |
| **Risks and Opportunities** |
| Risks: Research issues not fully exploited due to complexity integrating many different systems or subsystems, implementation of standard recovery and contingency procedures fit for different kinds of RPAS categories.<br><br>Opportunities: Spin-off effects to manned aviation development. |

### 4.1.12 Activity #12: 2014-2019 – IFR/VFR and BVLOS – Human Factors

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #12 | Human Factors | EC Gap 3.5 Ground stations HMI<br>EC Gap 3.9 Roles & responsibilities observer & pilot |

**Context and objectives**

Human factors addressing all aspects of manned aviation have been studied for many years. With the emergence of RPAS, this type of operations brings along new human factors aspects that need to be addressed. These are not only from the RPAS perspective, but also from the perspective of other airspace users and all other ATM actors like ATC.

B-VLOS and VFR/IFR flight operations means that no human may have direct visual contact with the RPA or visual overview of the situation. For these operations RPAS therefore require additional on-board sensors and automation for flight safety and task performance. One objective of this research activity is to investigate design requirements for interfaces that enable the pilot to manage these additional sensors and and supervise partly autonomous functions with an acceptable mental workload. Another objective of this research activity is to investigate how the pilot and ATC can create a common situation awareness of the flight situation and RPAS behaviour during IFR flight.

The research activity complements activity #1, #3, #4, and #10 that focuses on information requirements and technical solutions for critical flight safety during B-VLOS operations and VFR/IFR flight.

**Description of work**

**Nature and description of work**

The lack of direct visual information during B-VLOS and VFR/IFR flight operations means that the pilot uses a combination of on-board sensors and automation for flight safety and task performance. However, only presenting sensor information on the pilot's interface is often insufficient for creating the desired situation awareness due to the different perspective and sensor limitations. RPAS interface design therefore requires special care to provide contextual information and perceptual contrast for critical events that facilitates the pilot's situation awareness. Furthermore, the pilot needs information of where the RPA is relative to task objectives, reference points, obstacles, and potential hazards. This research activity will develop guidelines for this interface design in typical user cases.

Task performance in B-VLOS and VFR/IFR flight operations also depends on how the pilot utilises the partially automatic functions of the RPAS. Such functions may have several levels of automation with varying amounts of authority for coping with future task demands. Since automated functions may initiate actions without pilot intervention, the pilot interface should support a common understanding and enable coordination of behaviour. Further, the interface should minimize pilot confusion regarding interface and automation modes that combine several functions or enable several task strategies. This research activity will develop interface design guidelines for RPAS autonomous functions and provide recommendations for interaction concepts that enable an efficient utilisation of autonomous automated functions.

IFR flight is particularly challenging since the RPAS must follow ATC guidance, while the pilot assess the flight situation in a potentially congested airspace and degraded visual conditions. Since RPAS should have minimum to no impact on the ATC system, the pilot has the main responsibility for configuring the RPAS according to ATC instructions and informing ATC about RPAS behaviour. However, some RPAS behaviour may be harder for ATC to comprehend than others, since RPAS may perform operations differently from manned aircraft, or may perform operations that are not being possible with manned aircraft. This research activity will therefore investigate how the pilot and ATC can maintain common situation awareness during normal, as well as contingency situations. The research activity will use task modelling techniques to investigate the necessary communication for maintaining common situation awareness during varying task requirements and operator workloads.

This research activity will also investigate personnel qualifications for B-VLOS and VFR/IFR flight operations, such as language aptitude for operations across international borders, and TRM/CRM training need for ATC interaction during IFR flight. Other topics that will be investigated are cognitive fatigue during extended operations and critical factors for public trust in these operations.

Finally, during VFR flight the RPAS may also perform joint operations with other manned aircraft. Such manned-unmanned teaming requires a common understanding of task objectives, task assignments, and task progress. Additionally, the pilot may on occasions control the RPAS from one of the manned aircraft, which may simplify the creation of a common understanding. This research activity will provide recommendations for interaction concepts and develop interface guidelines that enable manned-unmanned teaming for RPAS.

Interface design guidelines, information requirements, and CONOPS for B-VLOS and VFR/IFR flight operations are validated with demonstrators and evaluations. The CONOPS will improve the organisational understanding of the benefits and limitations of these operations.

Human-system integration requirements will address the following:

- Human machine interface;
- Human Factors engineering;
- Skill knowledge;
- Cognitive fatigue;
- Level of automation.

Human Factors and their impact on ATC operation:

- TRM/CRM;
- Training tasks and training development methods;
- Task modelling;
- Distributed teams and shared situation awareness;
- Training;
- Qualification of personnel;
- Supervision;
- Manpower mix;
- Language aptitude;
- Health and safety;
- Organisational and social;
- Roles and responsibilities;
- Workload;
- Situational awareness;
- Communication;
- Common situational awareness;
- Demonstrations/studies.

Mixed operations (unmanned-manned traffic):

- Information to manned aircraft.

**SESAR**

This activity has impact on SESAR through:

- Integration of IFR operations:
    - Operational interoperability for mixed operations;
    - System interoperability.
- Possible impact of BVLOS operations.

**Deliverables**

- OSED;
- SPR;
- Demonstrators;
- Task models;
- Validation reports;
- Generic training and qualification guidelines.

**Key dependencies and pre-requisites**

-

**Planning elements – duration of the activity**

Start: 2013.

End: 2015 (OSED and SPR).

Effort: medium.

End: 2016 (demonstrators).

Effort: medium.

End: 2017 (SPS)

Effort: medium

End: 2018/2019 (performance assessed and validated operations and prototypes for initial integration: 2018 for IFR (airspace A-C) and BVLOS, and 2019 for IFR&VFR (all airspace classes) and BVLOS)

Effort: medium

**Required expertise**

Human factors experts, IFATCA, IFALPA, RPAS operators, pilots, and experts in automation and in aircraft performance.

**Risks and Opportunities**

Risks: Inconsistent international standards, requirements or guidance material lack of empirical data.

Opportunities: Spin-offs and early benefits to manned aviation.

### 4.1.13 Activity #13: 2013-2018 – Security

| Activity ID | Activity title | Related technology gaps |
|---|---|---|
| #13 | Security | EC Gap 4.1 RPAS system & cyber security |
| **Context and objectives** | | |
| The safe execution of RPAS operations is also highly dependent on the security of the RPAS and its environment. This activity addresses all aspects of security, hardware and cyber that affect RPAS operations and its ATM environment. | | |
| **Description of work** | | |
| **Nature and description of work** | | |

- Development of RPAS security requirements.

This aspects deals with the soft side of the RPAS and cyber security:

- RPAS:
  - IT hardware integrity;
  - Software integrity;
  - Secure IT hardware maintenance;
  - Secure Software maintenance;
  - Cyber intrusion detection system;
  - Cyber intrusion prevention system;
  - Authentication and encryption of communication;
  - Resistance to GNSS Jamming and spoofing;
  - Resistance to C&C jamming;
  - Resistance to C&C spoofing.
- Ground station RPAS Equipment:
  - IT hardware integrity;
  - IT Software integrity;
  - Secure hardware maintenance;
  - Secure Software maintenance;
  - Cyber intrusion detection system;
  - Cyber intrusion prevention system;
  - Authentication and encryption of communication with RPAS;
  - Resistance to data spoofing;
  - Detection of data spoofing.

- Education, awareness and training:
    - Secure hardware maintenance;
    - Secure Software maintenance;
    - Counter Social engineering training;
    - Incident/crisis management training;
    - Information Security training;
    - Procurement procedures development to include cyber requirements.
- Integration of security into R&D activities;
- Ensure awareness of cyber security issues in decisions makers AND users:
    - Cultural change towards coop during R&D priorities regarding Cyber security;
    - Vendor;
    - Military procurement;
    - Military.

RPAS Systems and cyber security:

- Ground station:
    - Physical hijacking;
    - Cyber hijacking.
- GPS vulnerability;
- Secure communications requirements;
- Education, awareness and training.

Integration of security into R&D activities:

- Ensure awareness of security issues;
- Cultural change.

Civil military cooperation.

Personnel security.

CNS security.

Incident/crisis management.

**SESAR**

This activity has impact on SESAR through:

- Security impact on all SESAR activities.

**Deliverables**

- Security advice for R&D activities;
- Physical security requirements;
- Cyber security requirements;
- Training and awareness courses;
- Operational and Technical systems contingency requirements;
- Incident and crisis management material.

| Key dependencies and pre-requisites |
| --- |
| ATM security regulations;<br>State security regulations;<br>Incorporation of security in all ATM R&D activities. |
| **Planning elements – duration of the activity** |
| Start: 2013.<br>End: 2017 (demonstrators).<br>Effort estimation: medium.<br><br>End: 2018 (performance assessed and validated operations and prototypes for initial integration).<br>Effort estimation: medium. |
| **Required expertise** |
| Experts in cyber security, electronic warfare, physical security. |
| **Risks and Opportunities** |
| Risks: Access to some technology due to national security restrictions and/or IPRs and architecture and software design.<br>Opportunities: Synergies with other domains, potential usage of existing technology from the military side. |

### 4.1.14 Activity #14: 2013-2016 – Demonstrations of best practices

| **Activity ID 14** | **Activity title**<br>**Demonstrations of best practices** |
|---|---|

**Context and objectives**

RPAS activities are already taking place in several member States and for different types of operations. In light of the development of technical and operational documentation, the collection of best practices from among operator's service providers and national authorities are of the utmost importance when developing the harmonised rules, procedures and proposals for industry standards at European or global level. It avoids duplication of work and capitalises ~~of~~ on work successes or early maturity of developments. To bring this into the R&D activities in parallel is essential, and enhances cooperation between RPAS operators, manufacturers, ANS service providers and regulatory authorities.

It is foreseen that demonstration activities will be launched during 2013 for a period of initially 2 years to support the other activities as well as the regulatory roadmap.

**Description of work**

**Nature and description of work**

- Demonstration activities in support of RPAS and type application to enable integrations;
- Validation of operational procedures, prototypes and regulatory material such as safety assessments;
- Collection of best practices.

**Deliverables**

- Input material to OSED´s, SPR´s;
- Project progress and final reports of operational, technical and regulatory findings;
- Operational and Technical demonstrations;
- Proposals for technical and operational standards and procedures;
- Demonstration/Validation reports.

**Key dependencies and pre-requisites**

Direct dependencies with all the other R&D and regulatory activities foreseen in the roadmap.

Common understanding of all actors on integration obstacles.

Direct communication with all actors.

**Planning elements – duration of the activity**

Start: 2013.

End – until full integration is established.

Start: 2013.

End: 2013 (OSED/SPR).

Effort estimation: medium.

End: 2014 (demonstrators).

Effort estimation: medium.

End: 2015 (performance assessed and validated operations and demonstrators/prototypes for initial integration).
Effort estimation: medium.

**Required expertise and expected budget**

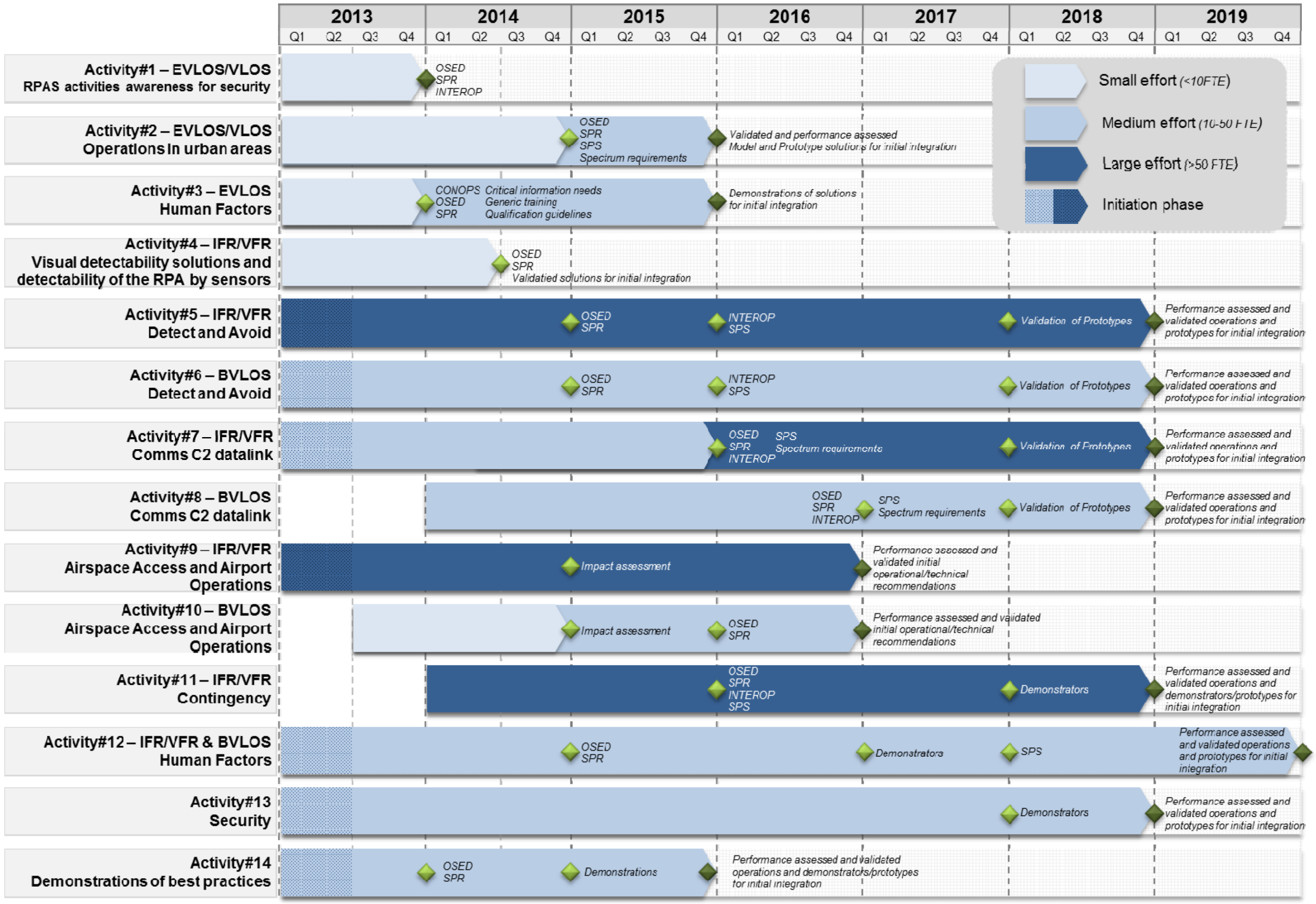
- Regulators;
- RPAS operators;
- ANSP´s;
- Manufacturers;
- Validation experts.

**Risks and Opportunities**

Risks: Diversification of activities evading to duplication of effort, lack of funding, lack of communication leading into not reaching all actors.

Opportunities: Possible identification of early innovative solutions to integration obstacles, identification of technology or procedures under development in SESAR.

## 4.2 R&D Activities Gantt chart



# 5 KEY MILESTONES AND DEPENDENCIES

## 5.1 Introduction

This section will identify the key milestones and related dependencies of the identified R&D activities that will enable RPAS to integrate into non-segregated airspace. The requirements that were listed in chapter 2 lead to the identification of required technology related to the type of operations. Chapter 3 consequently identified the areas in where gaps exist that require R&D activities either to develop technology or supporting operational procedures. Chapter 4 detailed the R&D work that needs to be undertaken. This chapter aims at using the previous chapters as a baseline to develop a matrix in where the key milestones are identified and through that the critical enablers. Typical dependency for RPA is the compatibility of a D&A system with TCAS II. It is expected that this will be further addressed with ACAS X and the RPA version ACAS Xu based on ADS-B.

## 5.2 Key milestones

The tables that are used to describe the key milestones are based on type of operations projected over a timeline that reflects the timeframes of the ATM master plan. The time available before any key milestone should be utilised to enable SMEs/SMIs to demonstrate their innovations as a possible solution or partial solution to the envisaged R&D challenge. This has been identified in the table of this chapter and indicated as data collection which continues until the year before the identified key miles stones. It encompasses activities like, but not limited to demonstrations, prototyping and validation.

**It has to be stated that the key milestones only indicate the availability of enablers that would allow a certain type of RPAS operations. It is entirely up to the States to use these enablers based on ~~N~~National requirements.**

## 5.3 Dependencies

It is the intention of this chapter also to identify the dependencies of the R&D activities from a technical nature, regulatory nature or internally with other R&D activities. These dependencies will be used to identify the critical path for the RPAS R&D roadmap.

- **R&D dependencies**

  R&D dependencies are linked to either technical or procedural aspects which have been identified in this roadmap per type of operations the dependencies that are identified will have impact on the timely enabling of operations. It is essential that the results of the R&D activities are fed back to the regulatory authorities to ensure compatibility with the set requirements.

- **Regulatory dependencies:**

  Regulatory dependencies have relevance to the EASA, JARUS and National regulations that set the requirements for the technical end product and intended operation. Essential is to link back to the R&D roadmap to provide data on the achievability of the set safety requirements in light of innovative nature of RPAS operations.

- **Complementary dependencies**

  Complementary dependencies are linked to aspects like privacy, liability and insurance. One of the dependencies that are identified in this chapter is linked to insurance aspects which impacts on all operations.

An overview of the key dependencies per roadmap and the interdependencies with the other roadmaps is provided in Appendix A.

### 5.3.1 VLOS & E-VLOS operations

As VLOS and E-VLOS operations are already conducted in many States, the only dependency is linked to the timely availability of regulation in this. The R&D activity identified for this aspect are not seen as critical although the security aspect needs attention specifically when the amount of RPAS operations expand the requirements to resolve this issue will become more stringent. It will become essential to have harmonized European regulation in support of the RPAS industry and cross border operations.

### 5.3.2 B-VLOS

B-VLOS operations are considered a new type of operations that can be conducted under specific Meteo conditions. There are several dependencies that are considered critical and essential in this. It is not foreseen to develop or alter the existing flight rules. The following dependencies are identified:

- Regulatory framework;
- Airspace assessment (linked to IMC/VMC conditions);
- Performance requirements;
- D&A ( additional requirements above the IFR/VFR requirements);
- C2;
- Human factors;
- Security.

### 5.3.3 IFR/VFR

IFR/VFR integration requires RPAS to adapt to the existing ATM system without negatively affecting manned operations. Initial IFR operations are being conducted under strict conditions and early integration efforts will concentrate on airspace class A-C, as the ATC service that is provided is able to mitigate some aspect of detect and avoid. Integrating if classes of airspace that allow VFR operations has been identified as the most challenging due the different type of aircraft and unavailability of sensors be other airspace users. The following dependencies have been identified:

- Regulatory framework;
- D&A including non-corporate targets;
- C2;
- Performance requirements;
- Human factors;
- Detectability of RPA;
- Security.

## 5.4 Early Opportunities

Based on the findings in the previous chapters the following quick wins can be identified pending the timely delivery of the relevant enabler taking into consideration that the R&D activity starts in 2013:

### 5.4.1 VLOS & E-VLOS

- VLOS and E-VLOS operations including airports by 2013.

### 5.4.2 B-VLOS

- B-VLOS operations in remote areas by 2013;
- GBSAA definition of use  limitations 2013;
- Initial BVLOS operations through the use of GBSAA as from 2013;
- Airspace assessment 2013.

### 5.4.3 IFR/VFR

- GBSAA definition of use  limitations 2013;
- Initial IFR operations through the use of GBSAA as from 2013;
- Detectability requirements for RPA 2013/14;
- ATM impact assessment 2013;
- IFR flight planning 2013;
- ACAS-II interoperability requirements 2013.

## 5.5 Opportunities

It is crucial that the R&D Roadmap is linked to the ATM Master Plan and the related R&D activities to ensure that there is no duplication of effort or conflicting activities. It has been identified that following SESAR R&D aspects could provide an unique opportunity to both manned aviation and RPAS and require further investigation;

- **SWIM**

  RPAS could be used as nodes and support SWIM demonstrations.

- **4DTrajectory based operations**

  RPAS could support the development and demonstration of 4D trajectory based operations as RPAS are through their data link provide trajectory data.

- **Remote towers**

  The use of camera in the operations of remote towers could provide a partial solution to D&A.

- **Safety**

  The solution to the D&A could bring additional benefits to manned aviation.

Through the synchronization of this R&D roadmap with the ATM master plan more opportunities might arise.

The table below provides an overview of the R&D roadmap timeline and its key milestones. There are three timelines:

- **Initial National operations**

  In here it is up to the national authorities to enable RPAS operations under certain national regulatory conditions.

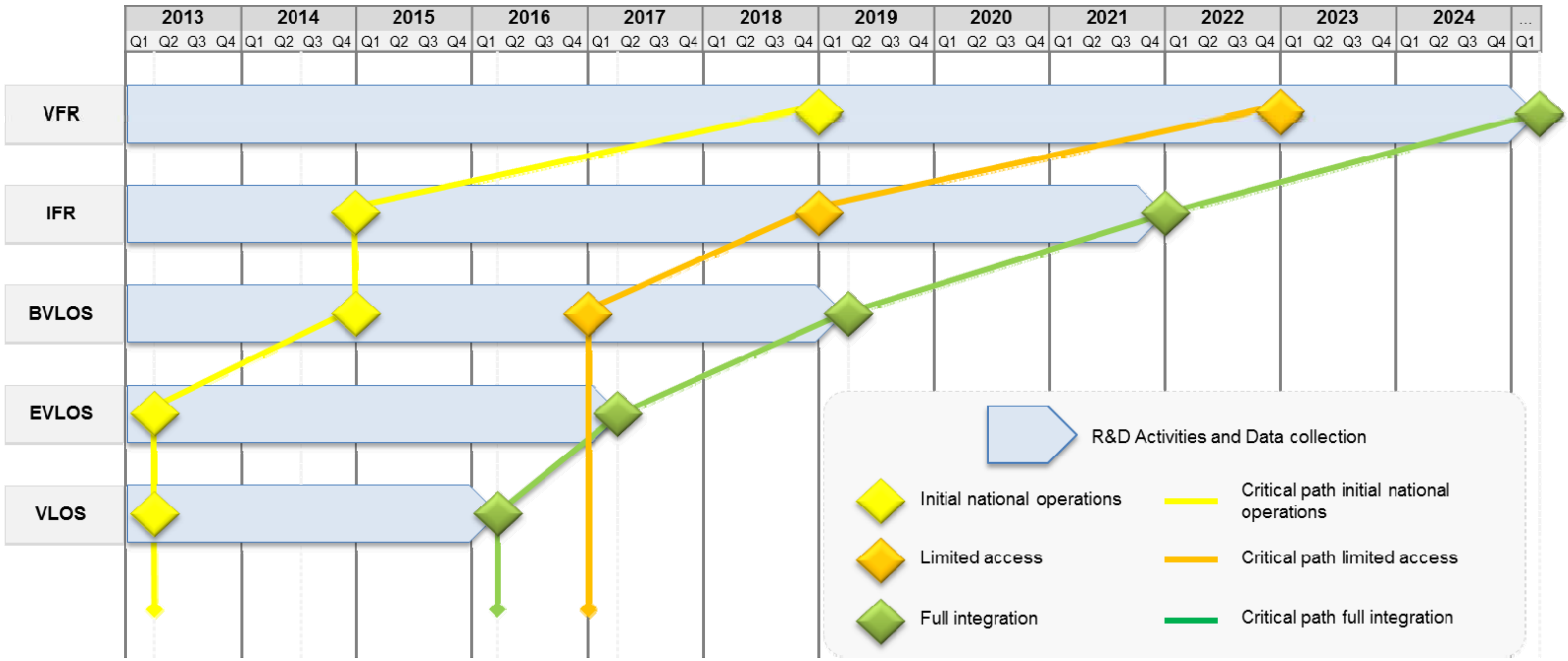
- **limited access**

  In here pan European regulation or partial regulation is already available supported by the results of R&D activities.

- **Full integration**

  In this all requirements for full integration are in place.

## 5.6 R&D ROADMAP TIMELINE



# 6 RISKS, ISSUES AND OPPORTUNITIES

## 6.1 A definition of "risk"

The first action is to agree on a definition of risk w.r.t. the roadmap within the scope of the present document. A risk may be defined as an undesired event or series of events which reduce confidence in the Roadmap and, on occurring, may represent a potential obstacle towards delivering the timely, coordinated and efficient deployment of the new technologies and procedures in line with the foreseen targets objectives, which are:

> To foster the development of civil RPAS by planning and coordinating all the activities necessary to achieve the safe integration of RPAS into the European air traffic by 2016

Problems of risks are that they usually do not warm before occurring and most often that they are coming from where they are not expected to arise. Solution is to be aware of the potential existence of risks through an extensive review and propose mitigating measures.

From another point of view, risks may also bring opportunities. The review of risks and their mitigating measures may facilitate the detection of solutions or ideas that would be beneficial to the whole process.

Two examples can be given:

- Civil-military synergies: a comprehensive approach to crisis management will bring more coherence and efficiency in operational and capability related aspects. This is particularly obvious for the current exercise on RPAS. While all RPAS will benefit from the regulatory development and technological breakthroughs produced during the implementation of the Roadmap, it is envisaged that some of the specific developments made for UCAV may also be profitable to civilian RPAS;
- Manned/unmanned aviation. The domain remains yet to be explored. Nevertheless opportunities are quite visible for combat air systems, including engines. Future systems could be composed of mixed manned and unmanned aircraft. Opportunities lie in the overall system intelligence, its reliability and the security of operations.

## 6.2 Methodology for addressing risks

A three-stepped approach is proposed:

1. The first step consists in the identification of the risks impacting the implementation of the roadmap R&D on RPAS

   In order to set a reference as a point of view for reviewing the potential risks it is proposed to put the R&D working groups at the centre of the analysis, and to segregate the risks according to their origins:

   - Internal risks to the R&D roadmap;
   - Implementation risks for the R&D roadmap;
   - External risks.

2. In a second step, the risks should be characterized according to their causality and their criticality. Therefore a Metrics should be defined so as to be able to measure the impact of the occurrence of the risk on the objective. The impact could be a delay, a supplementary cost, etc.; but in fine the quantification could be summarized into four criticalities:

   - ***Low***: low impact on the roadmap which does not justify a specific action;
   - ***Moderate***: the impact is noticeable, but can be addressed through a corrective action;
   - ***Major***: the impact is sufficiently important to justify an action plan to come back on track;

- ***Critical***: such an impact would make the realisation of the objective impossible. Its correction can only be made by a substantial investment and could lead to the correction of the objectives.

3. As the above paragraph makes it clear, the third step consists in defining a list of mitigating actions aimed at preventing the risks to occur. All recorded risks must be tackled or have to be still treated through mitigation action plans. Each mitigation action identifies dedicated ownership and a target date in order on one hand to reduce the likelihood of the event materialising and on the other hand to reduce the possible impact, thus increasing confidence in the "R&D Roadmap on RPAS" and encouraging decision-making.

## 6.3 Identification of risks

The first step of the methodology for identifying the risks was realized through a brainstorming session.

The result is the following:

**1) Internal risks**

These risks may hinder the elaboration of a sound roadmap by the team itself:

- Potential risk of having conflicting views due to the presence of an interdisciplinary team with different interests (industry, agencies, institutions, regulators, etc.);
- Regulatory requirements might not be precise enough or not set quickly enough to launch the necessary developments to address them.

**2) Implementation risks**

These risks are specific to the execution of the roadmap itself:

- Timely execution. 2016 is coming very quickly, therefore it is important to determine what milestones need to be determined in between. The regulatory Roadmap shows the expected milestones in terms of integration from 2016, nonetheless a better clarification about the level of integration would clarify the ambition of the roadmap;
- Risk that the available technologies will not be able to meet the safety requirement with the current technology state of the art;
- Besides technological risk, the risk linked to the human interaction and performance is essential to be taken into account;
- A risk is directly linked to the availability of sufficient funding to ensure the implementation of the roadmap;
- The implementation of the roadmap will require an appropriate governance structure. Risk may occur that this governance structure is not optimal. Inadequate coordination with other RPAS programmes like the JIP RPAS from EDA may also bring risk to the light;
- Linked to the coordination with other programmes, the problem of IPR and possible limitation exchange of information needs to be considered;
- There is also a risk that the technical management approach does not enable the Programme to ensure the overall coherence of the future system;

**3) External risks**

Some risks may occur from outside the scope of R&D activities; nevertheless their realization could make the implementation of the roadmap highly problematic, or even impossible:

- Competition with another regulatory framework (US) that could impose standards;
- Risk of divergence or incompatibility between the three roadmaps from regulation, R&D and complementary measures. Will the calendars be compatible? This risk will continue even during the roadmap implementation. This risk can be understood under the generic regulatory and standardisation risk;
- A not well defined interface between regulation and technology development will lead to a constant mismatch between performance and safety objectives. This is also a risk linked to regulation and standardisation;
- Risk of over regulation. Need to a change in philosophy; regulation shall not continue to do as if there were a pilot on board (i.e. necessity of a physical communication channel between ATC and the RPAS is useless). This is identified as a regulatory risk, for which the regulatory needs would be unable to support the implementation phase;
- Fragmentation of work and/or regulation. The harmonization of rules not falling under the remit of EASA might be controversial and some nations might not support the process, this is the case for state aircraft. On another side some works might be done in duplication, for instance when taking into account the developments launched for military applications. This can jeopardise interoperability and global harmonisation.

## 6.4 Risk assessment and mitigation plan

As defined by the second step of the methodology, the causality and criticality of risks due to their impact on the project objective are quantified. For each risk a mitigation action is proposed.

This gives the following table:

| Risk Item | Label | Performance objectives affected by the risk | Consequences / Impact | Criticality | Mitigation measure |
|---|---|---|---|---|---|
| 1 | Conflicting views within the stakeholders, IPR issues | Priorities for setting up the milestones, availability of project results | Milestones could be defined in an inappropriate order. Conflict between necessary protection of industrial know-how and disclosure of information in order to foster innovation | Medium | - Problem solving through the Integration team<br>- Define an adequate IPR regime supporting and strengthening the European Defence and technical Industrial Base (EDTIB) |
| 2 | Timely execution, and follow-up of business objectives | - The Roadmap provides the baseline for future implementation of first RPAS R&D roadmap.<br>- Coordination with the JIP RPAS of EDA | - Insufficient commitment for the implementation phase<br>Delay / de-synchronisation of implementation plans related to first RPAS results<br>- Performance objectives are not met<br>- Negative impact on the EU economy, employment, mobility and environment | critical | - Establish a steering group to monitor the implementation of the roadmap for further action to the appropriate forum<br>- Implement the Roadmap according to the stakeholders plans<br>- Identify, stabilise and ensure proper implementation of the roadmap |
| 3 | Investment to support the implementation phase | Projects delayed or cancelled | - Insufficient commitment, financial resources and investment for the implementation phase<br>- Delay / de-synchronisation of implementation<br>- Performance objectives are not met<br>- Severe negative impact on the EU economy, employment, mobility and environment | critical | - Prepare for the implementation of the roadmap (business cases, linked performance improvements).<br>- Ensure that financial and operational incentive mechanisms are defined and implemented to facilitate the roadmap implementation.<br>- Ensure consistency between the stakeholders' roadmaps in the RPAS Master Plan and their respective investment plans. |
| 4 | Governance | The future deployment governance structure will be | - Lack of accountability between | major | - Develop all guidance material necessary to establish the deployment governance structure |

| | | | | | |
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| | structure | capable of ensuring a successful implementation of the roadmap. | the various actors.<br>- Delay / de-synchronisation of implementation<br>Performance objectives are not met<br>- Severe negative impact on the EU economy, employment, mobility and environment | | through common projects.<br>- Define and implement appropriate implementation governance mechanism to ensure an effective execution of the RPAS master plan. |
| 5 | Available technologies cannot meet requirements | The RPAS Master Plan should ensure the integrity and consistency of the entire R&D and validation process, from inception to industrialisation, where implementation-oriented R&D constitutes the backbone. This should be a continuous, dynamic and collaborative process aiming to achieve the RPAS performance requirements. | - An interruption in the planning and monitoring of this process, at any stage, will substantially compromise the successful and coherent insertion of RPAS in airspace.<br>- Lack of clarity on the continuation of the R&D activities beyond 2016, in scope and means, and on the "ownership of the RPAS Master plan would seriously undermine the capacity of RPAS SG to meet the performance require-ments with a negative impact on the industrialisation processes and consequently on synchronisation of deployment. | critical | - Carry out the necessary evaluation for planning and co-ordinating future RPAS R&D and validation activities and for the execution and maintenance of the RPAS Master Plan.<br>- All stakeholders need to coordinate their activities in order to ensure that the needs to address technological innovation to support evolving performance requirements and necessary funding are assessed in a timely manner, and sufficiently in advance of the short-term deadlines.<br>- Ensure the adequate documentation of all relevant R&D output and the identification and storage of all results, necessary to ensure continuity of Research and Development and deployment planning activities supporting the execution of the RPAS Master Plan |
| 6 | Overall coherence of the future system | Consistency and coherence within & between the work packages of the implementation plan | Consistency and synchronisation between the projects cannot be guaranteed | major | - Assign Programme priorities based on critical path analysis for the main roadmap components<br>- Ensure compliance of projects with quality criteria related to content definition and validation and proper content integration processes through the effective use of transversal activities<br>- Ensure that transversal activities deliverables |

| | | | | | |
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| | | | | | are fit for purpose and strongly coupled with programme priorities<br><br>- Further improve system engineering reviews, with detailed performance criteria and targets for the RPAS roadmap. |
| 7 | Human performance factor, competency and change management issues | - Human Factors not integrated in concepts, development and validation (with operational staff), including applying minimal standards and unrealistic assumptions (especially human workload and automation)<br><br>- Lack of appropriate Competency (Training and Assessment) regulatory, certification, training and assessment framework<br><br>- Lack of verified and competent Human Resources to support operations in a new technological environment (timely and in sufficient numbers)<br><br>- Absence of appropriate Social and Change Management processes and Social Dialogue structures at European, national and local levels.<br><br>- Lack of an integrated and consistent approach (consistency between regulatory and working | - Without addressing these risks it will not be possible to fully achieve its roadmap objectives.<br><br>- Risk of additional safety hazards | critical | - Ensure that operational staffs are included in development and validation activities.<br><br>- Issue regular recommendations and activity plans for Human Performance in the area of R&D, regulation, standards, and management at industry level.<br><br>- Monitor all RPAS oriented R&D and validation phases regarding Human Performance standards, methods and requirements.<br><br>- Examine staffing implications of all deployment activities for all groups of operational aviation staff and publish results and related recommendations.<br><br>- Ensure appropriate coordination between all stakeholders concerned to ensure consistency between initiatives related to Human Factors, Competency and Social Dialogue |

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| | | bodies). | | | |
| 8 | Competition or desynchronization with another regulatory framework | - Regulation could change during the execution of the implementation plan.<br>- Different regulations developed by Nations | - Implementation plan will have to be amended according to the changes in requirements and take into account the evolution of National regulations.<br>- Discrepancies between national regulations could put overall safety at risk when systems have to comply with all regulations. | critical | - Keep up to date information about progress made outside Europe and react quickly.<br>- Organise consultations with European stakeholders |
| 9 | Regulatory and standardisation risks | Identification of the necessary standardisation and regulatory activities to support the implementation of the roadmap. | - Delay / de-synchronisation of implementation<br>- Potential for regulatory fragmentation leading to increased costs for the Programme<br>- Compromise to the delivery of enhanced performance due to the reliance on "workarounds" to secure regulatory approval<br>- Results of implementation phase of RPAS roadmap are not applicable<br>-Inappropriate regulation, regulation not in line with ICAO requirements or end-user expectations | major | - Strengthen current engagement of the standardisation bodies in the development phase to prepare for deployment<br>- Fully leverage the current mechanism to capture, in particular for RPAS Master Plan essential operational changes , the regulatory and standardisation needs out of the R&D activities<br>- Strengthen current engagement of the regulatory authorities in the development phase to prepare for deployment |
| 10 | Fragmentation/duplication of work/regulation | Not taking properly into consideration the interests of civil and military airspace users | - Rework required resulting in delays in development and increased development costs<br>- Compromise on | major | - Work towards complementary and coordination of regulation.<br>- Ensure global interoperability |

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| | | Similar works undertaken by different organisations | interoperability performance goal<br>- Delayed deployment Reduction of the magnitude of the deployment of the Programme | | |

## 6.5 Initial assessment of the roadmap risk

Although a risk analysis can be made only on a real and running project, a preliminary analysis of the technical risks from the activities detailed in Chapter 4 was performed, with a focus on technical risks.

For each of the 14 activities, risks have been identified and listed. The table below recalls the technical risks, the activity effort and the connection with the general matrix list:

| **Activity** | **Risk** | **Connection with general risk matrix** |
|---|---|---|
| Activity #1: 2013 – EVLOS/VLOS – RPAS activities awareness for security | - Involvement of state authorities;<br>- Lack of guidance related to cyber security issues, underestimation of the importance of the activity. | 1; 3 |
| Activity #2: 2013-2015 – EVLOS/VLOS – Operations in urban areas | - Spectrum availability;<br>- GNSS spoofing;<br>- Contingency due to loss of signal;<br>- Dependency to activity 1 and 13. | 5; 10 |
| Activity #3: 2013-2015 – EVLOS – Human Factors | - Inconsistent international standards requirements;<br>- Lack of empirical data. | 9 |
| Activity #4: 2013-2014 – IFR/VFR – Visual detectability solutions | - Negative impact on the target level of safety which might render in constraint to operations.<br>- Non-effective co-operative and non-cooperative solutions that may create an overload for ATC. | 9 |
| Activity #5: 2013-2018 – IFR/VFR – D&A | - Negative impact on the target level of safety which might render in constraint to operations.<br>- Non-effective co-operative and non-cooperative solutions that may create an overload for ATC;<br>- Spectrum;<br>- Sensor performances;<br>- Integration issues;<br>- Contingency;<br>- Lack of requirements availability and technology solutions to cater for all RPAS. | 5;8;9 |
| Activity #6: 2013-2018 – BVLOS – D&A | - Negative impact on the target level of safety which might render in constraint to operations.<br>- Non-effective co-operative and non-cooperative solutions that may create an overload for ATC;<br>- Spectrum;<br>- Sensor performances;<br>- Integration issues;<br>- Contingency; | 5;8;9 |

| | | |
|---|---|---|
| | - Lack of requirements availability and technology solutions to cater for all RPAS. | |
| Activity #7: 2013-2018 – IFR/VFR – Comms C2 data link | - Secure spectrum availability for safety of life communication;<br>- Cost-effective communications-service provision;<br>- Cyber security. | 5 |
| Activity #8: 2014-2018 – BVLOS – Comms C2 data link | - Secure spectrum availability for safety of life communication;<br>- Cost-effective communications-service provision;<br>- Cyber security. | 5 |
| Activity #9: 2013-2016 – IFR/VFR – Airspace Access and Airport Operations | - Delay due to lack of acceptance by pilots, controllers, and other airspace users or airport operators e.g. reduction of performance of the capacity of the airspace. | 1;4;7 |
| Activity #10: 2013-2016 – BVLOS – Airspace Access and Airport Operations | - Delay due to lack of acceptance by pilots, controllers, other airspace users or airport operators, negative impact on airspace classification;<br>- Restriction on low level operations for manned aviation;<br>- Interoperability around airports. | 1;4;7 |
| Activity #11: 2014-2018 – IFR/VFR – Contingency | - Research issues not fully exploited due to complexity integrating many different systems or subsystems;<br>- Implementation of standard recovery and contingency procedures fit for different kinds of RPAS categories. | 3;8;9;10 |
| Activity #12: 2014-2019 – IFR/VFR and BVLOS – Human Factors | - Delay due to lack of funding;<br>- Inconsistent international standards;<br>- Lack of empherical data. | 3,8,9,10 |
| Activity #13: 2013-2018 – Security | - Access to some technology due to National security restrictions or IPR, hardware architecture and software design. | 1;3 |
| Activity #14 : 2013-2016 – Demonstrations of best practices | - Diversification of activities leading to duplication of effort;<br>- Lack of funding;<br>- Lack of communications;<br>- Not reaching all involved actors. | 1;2;3;5;7;8 |

# Appendix A Operational requirements and technology gaps tables

| | |
|---|---|
| (green) | **Done** |
| (yellow) | **Underway** |
| (orange) | **Under development** |

| Timeframe | Affected KPAs | Type of Operations | REQUIREMENTS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Airspace access and Airport operations | Comms C2 data link | D&A | Human Factors | SESAR compatibility | Contingency | Security |
| **ATM Master plan Baseline & Step 1** ***(Present – 2013 )*** | **Safety** **Security** | **VLOS** **EVLOS** | VLOS operations at surface | Additional requirements for urban areas | Minimum meteor conditions | Role between observer and pilot | | Lost link recovery | Pilot |
| | | | | | Visual detectability requirements, if any | | | | Jamming |
| | | | | | | | | | Hijacking |
| | | | | | | | | | Flight planning |
| | **System gaps** | | | Gap EC 2.1 Secure C2 systems and links ***Activity #2*** | | Gap EC 3.9 roles & responsibilities observer & pilot | | | Gap EC 4.2 RPAS activities awareness ***Activity #1*** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ***Activity #3*** | | | |
| **ATM Master plan – Step 1;**<br>***(From 2014 until 2018)*** | | **IFR** | ATM impact assessment | UVS data link requirements | Minimum requirements | Human system integration requirements | MAP ATM Master Plan requirements | Transparent contingency procedures | Ground station/Hijacking |
| | | | Impact on Network Operations | (Integrity, Availability, Continuity of service) | Visual detectability RPAS | Impact on ATC ops | Trajectory management for RPAS | Loss link procedures | GPS vulnerability |
| | | | Airport operations | Latency | Interoperability with ACAS | Mixed operations | Initial 4D operations | | Secure COM requirements |
| | | | Performance requirements for IFR operations | Spectrum requirements | Ground Based Detect & Avoid requirements | | SWIM | | |
| | | | Modify CNS requirements | | | | Delegated separation | | |
| | | | Flight Planning | | | | | | |
| | **System Gaps** | | Gap EC 3.1 ATM interfaces in current context ***Activity #9***<br>Gap EC 6.1 Automatic take-off and landing ***Activity #9***<br>Gap EC 1.1 Short term validation in current ATM ***Activity #9*** | Gap EC 2.1 Secure C2 systems and links ***Activity #7***<br>Gap EC 2.2 LOS/B-LOS SATCOM infrastructures and data links ***Activity #7***<br>Gap EC 2.3 | Gap EC 3.3 Airborne based detect & avoid ***Activity #5***<br>Gap EC 3.4 Ground based detect &avoid ***Activity #5***<br>Gap EC 3.6 Ground and obstacles avoidance | Gap EC 3.5 Ground stations HMI ***Activity #12***<br>Gap EC 3.9 roles & responsibilitie s observer & pilot ***Activity #12*** | Gap EC 1.2 long-term validation<br>Gap EC 3.2 ATM interfaces in the SESAR context | Gap EC 5.2 dependable emergency recovery ***Activity #11***<br>Gap 5.3 Safe automated health monitoring & fault detection ***Activity #11***<br>Gap EC 5.4 | Gap EC 4.1 RPAS system & cyber security ***Activity #13*** |

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|---|---|---|---|---|---|---|---|---|---|
| | | | | Radiobandwith management<br>***Activity #7*** | ***Activity #5***<br>Gap EC 3.7 Weather detection<br>***Activity #5***<br>Gap EC 3.8 detectability solutions<br>***Activity #4***<br>***Activity #5***<br>Gap EC 3.10 other hazards including WAKE ref 2.4idance<br>***Activity #5*** | | | On-board real time processing<br>***Activity #11*** | |
| | | **VFR** | Impact on GA Operations | UVS data link requirements | Minimum requirements | Human system integration requirements | | Transparent contingency procedures | Ground station/Hijacking |
| | | | Flight Planning | (Integrity, Availability, Continuity of service) | Visual detectability RPAS | Impact on ATC ops | | Loss link procedures | GPS vulnerability |
| | | | Integrated Airport Operations requirements | Latency | Ground Based Detect & Avoid requirements | Mixed operations | | | Secure COM requirements |
| | | | | Spectrum requirements | | | | | |
| | **System Gaps** | | Gap EC 3.1 ATM interfaces in current context | Gap EC 2.1 Secure C2 systems and | Gap EC 3.3 Airborne based detect & avoid | Gap EC 3.5 Ground stations HMI | | Gap EC 5.2 dependable emergency | Gap EC 4.1 RPAS system & cyber security |

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| | | | ***Activity #9***<br><br>Gap EC 6.1 Automatic take-off and landing<br>***Activity #9***<br><br>Gap EC 1.1 Short term validation in current ATM<br>***Activity #9*** | links<br>***Activity #7***<br><br>Gap EC 2.2 LOS/B-LOS SATCOM infrastructures and data links<br>***Activity #7***<br><br>Gap EC 2.3 Radiobandwith management<br>***Activity #7*** | ***Activity #5***<br><br>Gap EC 3.4 Ground based detect &avoid<br>***Activity #5***<br><br>Gap EC 3.6 Ground and obstacles avoidance<br>***Activity #5***<br><br>Gap EC 3.7 Weather detection<br>***Activity #5***<br><br>Gap EC 3.8 detectability solutions<br>***Activity #4***<br>***Activity #5***<br><br>Gap EC 3.10 other hazards including WAKE ref 2.4idance<br>***Activity #5*** | ***Activity #12***<br><br>Gap EC 3.9 roles & responsibilitie s observer & pilot<br>***Activity #12*** | | recovery<br>***Activity #11***<br><br>Gap 5.3 Safe automated health monitoring & fault detection<br>***Activity #11***<br><br>Gap EC 5.4 On-board real time processing<br>***Activity #11*** | ***Activity #13*** |
| | | **B-VLOS (very low level)** | Flight planning | UVS data link requirements | Minimum requirements | Human system integration requirements | | Transparent contingency procedures | Ground station/Hijacking |
| | | | CNS requirements | (Integrity, Availability, Continuity of service) | Visual detectability RPAS | Impact on ATC ops | | Loss link procedures | GPS vulnerability |

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| | | | Airspace assessment | Latency | Ground Based Detect & Avoid requirements | Mixed operations | | | Secure COM requirements |
| | | | Urban specific | Spectrum requirements | Terrain database requirements | | | | |
| | | | Performance requirements | | | | | | |
| | | | Type of flight rules applied | | | | | | |
| | **System Gaps** | | Gap EC 3.1 ATM interfaces in current context<br>***Activity #10***<br>Gap EC 6.1 Automatic take-off and landing<br>***Activity #10***<br>Gap EC 1.1 Short term validation in current ATM<br>***Activity #10*** | Gap EC 2.1 Secure C2 systems and links<br>***Activity #8***<br>Gap EC 2.2 LOS/B-LOS SATCOM infrastructures and data links<br>***Activity #8***<br>Gap EC 2.3 Radiobandwith management<br>***Activity #8*** | Gap EC 3.3 Airborne based detect & avoid<br>***Activity #6***<br>Gap EC 3.4 Ground based detect &avoid<br>***Activity #6***<br>Gap EC 3.6 Ground and obstacles avoidance specific to VLL<br>***Activity #6***<br>Gap EC 3.7 Weather detection<br>***Activity #6***<br>Gap EC 3.8 detectability solutions | Gap EC 3.5 Ground stations HMI<br>***Activity #12***<br>Gap EC 3.9 roles & responsibilitie s observer & pilot<br>***Activity #12*** | Gap EC 3.2 ATM interfaces in the SESAR context | Gap EC 5.2 dependable emergency recovery<br>***Activity #11***<br>Gap 5.3 Safe automated health monitoring & fault detection<br>***Activity #11***<br>Gap EC 5.4 On-board real time processing<br>***Activity #11*** | Gap EC 4.1 RPAS system & cyber security<br>***Activity #13*** |

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| | | | | | ***Activity #6***<br><br>Gap EC 3.10 other hazards including WAKE ref 2.4idance ***Activity #6*** | | | | |
| **ATM Master plan – Step 2;**<br><br>***(From 2019 until 2023)*** | | **IFR** | Flight planning | UVS data link requirements | Minimum requirements | Human system integration requirements | MAP ATM Master Plan requirements | Transparent contingency procedures | Ground station/Hijacking |
| | | | CNS requirements | (Integrity, Availability, Continuity of service) | Visual detectability RPAS | Impact on ATC ops | Trajectory management for RPAS | Loss link procedures | GPS vulnerability |
| | | | Airspace assessment | Latency | Interoperability with ACAS | Mixed operations | Initial 4D operations | | Secure COM requirements |
| | | | Urban specific | Spectrum requirements | Ground Based Detect & Avoid requirements | | SWIM | | |
| | | | Performance requirements | | | | Delegated separation | | |
| | | | Type of flight rules applied | | | | | | |
| | **System Gaps** | | Gap EC 3.1 ATM interfaces in current context<br><br>Gap EC 6.1 Automatic take-off and landing | Gap EC 2.1 Secure C2 systems and links<br><br>Gap EC 2.2 LOS/B-LOS | Gap EC 3.3 Airborne based detect & avoid<br><br>Gap EC 3.4 Ground based detect &avoid | Gap EC 3.5 Ground stations HMI | Gap EC 1.2 long-term validation<br><br>Gap EC 3.2 ATM interfaces in the SESAR | Gap EC 5.2 dependable emergency recovery<br><br>Gap 5.3 Safe automated | Gap EC 4.1 RPAS system & cyber security |

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| | | | Gap EC 1.1 Short term validation in current ATM | SATCOM infrastructures and data links<br><br>Gap EC 2.3 Radiobandwith management | Gap EC 3.7 Weather detection<br><br>Gap EC 3.6 Ground and obstacles avo<br><br>Gap EC 3.10 other hazards including WAKE ref 2.4idance | | context | health monitoring & fault detection<br><br>Gap EC 5.4 On-board real time processing | |
| | | **VFR** | Flight planning | UVS data link requirements | Minimum requirements | Human system integration requirements | MAP ATM Master Plan requirements | Transparent contingency procedures | Ground station/Hijacking |
| | | | CNS requirements | (Integrity, Availability, Continuity of service) | Visual detectability RPAS | Impact on ATC ops | Trajectory management for RPAS | Loss link procedures | GPS vulnerability |
| | | | Airspace assessment | Latency | Interoperability with ACAS | Mixed operations | Initial 4D operations | | Secure COM requirements |
| | | | Urban specific | Spectrum requirements | Ground Based Detect & Avoid requirements | | SWIM | | |
| | | | Performance requirements | | | | Delegated separation | | |
| | | | Type of flight rules applied | | | | | | |
| | **System Gaps** | | Gap EC 3.1 ATM interfaces in current | Gap EC 2.1 Secure C2 | Gap EC 3.3 Airborne based | Gap EC 3.5 Ground | | Gap EC 5.2 dependable | Gap EC 4.1 RPAS system & |

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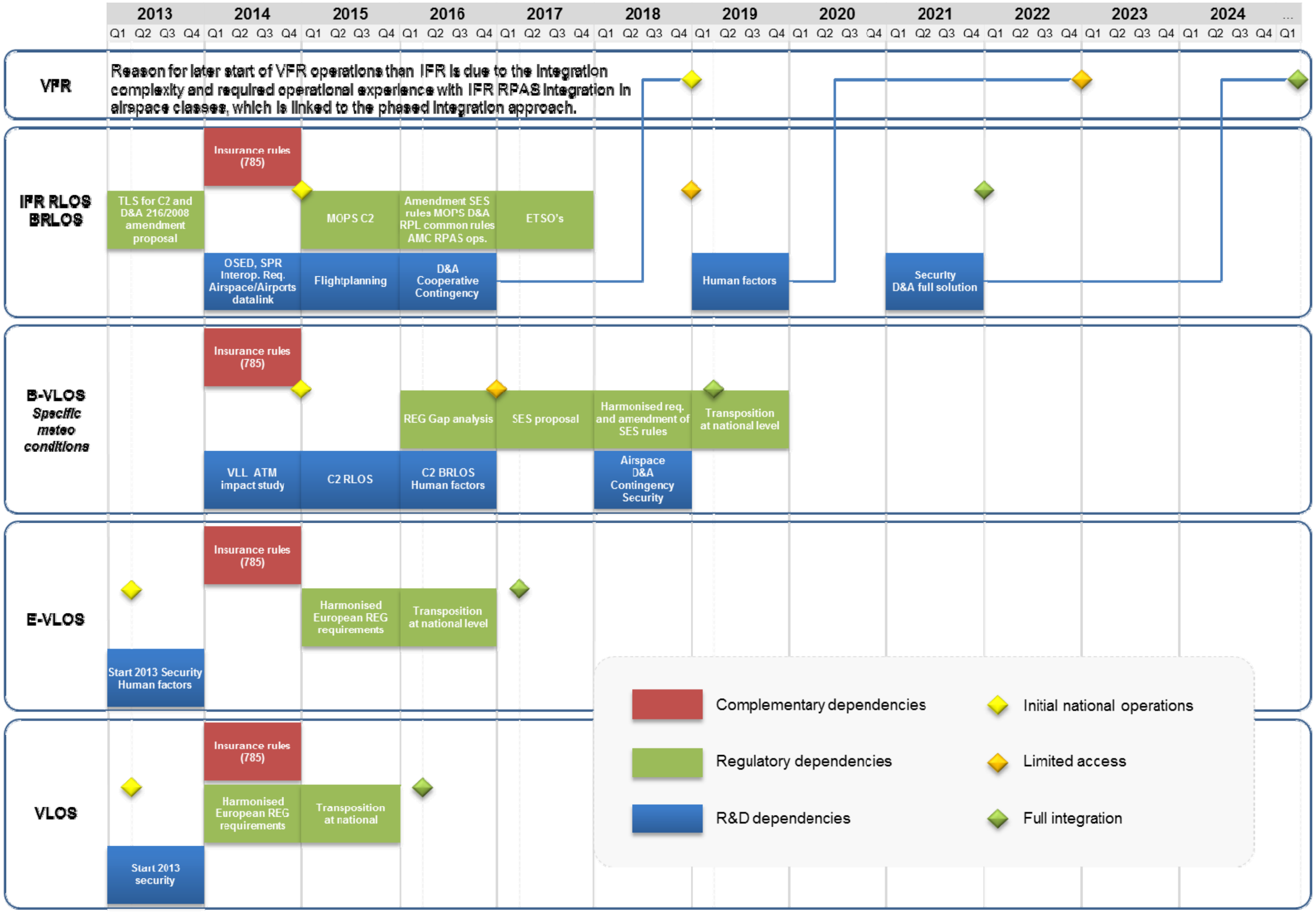
| | | | context<br>Gap EC 1.1 Short term validation in current ATM | systems and links<br>Gap EC 2.2 LOS/B-LOS SATCOM infrastructures and data links<br>Gap EC 2.3 Radiobandwith management | detect & avoid<br>Gap EC 3.4 Ground based detect &avoid<br>Gap EC 3.7 Weather detection<br>Gap EC 3.6 Ground and obstacles avoidance<br>Gap EC 3.10 other hazards including WAKE ref 2.4 | stations HMI | | emergency recovery<br>Gap 5.3 Safe automated health monitoring & fault detection<br>Gap EC 5.4 On-board real time processing | cyber security |
| | | **B-VLOS** (very low level) | Flight planning | Integrity | Minimum requirements | Human Machine interface | TBD | Development of Transparent contingency procedures | Ground station |
| | | | CNS requirements | Availability | Conspicuity issues | Impact on ATC ops | | | Jamming |
| | | | Airspace assessment | Continuity of service | Interoperability | Mixed operations | | | |
| | | | Urban specific | Loss Link | Ground Based Solutions | | | | |
| | | | Performance requirements | Latency | Terrain database | | | | |
| | | | Type of flight rules | Spectrum | | | | | |

| | | | applied | requirements | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **System gaps** | | Gap EC 3.1 ATM interfaces in current context<br>Gap EC 6.1 Automatic take-off and landing<br>Gap EC 1.1 Short term validation in current ATM | Gap EC 2.1 Secure C2 systems and links<br>Gap EC 2.2 LOS/B-LOS SATCOM infrastructures and data links<br>Gap EC 2.3 Radiobandwith management | Gap EC 3.3 Airborne based detect & avoid<br>Gap EC 3.4 Ground based detect &avoid<br>Gap EC 3.7 Weather detection<br>Gap EC 3.6 Ground and obstacles avoidance specific to VLL<br>Gap EC 3.10 other hazards including WAKE ref 2.4idance | Gap EC 3.5 Ground stations HMI | Gap EC 3.2 ATM interfaces in the SESAR context | Gap EC 5.1 dependable emergency recovery<br>Gap 5.2 Safe automated health monitoring & fault detection<br>Gap EC 5.3 On-board real time processing | Gap EC 4.1 RPAS system & cyber security |

# Appendix B R&D, regulatory and complementary dependencies and milestones



# Appendix C Terminology

| *Term* | *Definition* |
|---|---|
| **ACAS** | Airborne collision avoidance system |
| **ADS-B** | Automatic dependent surveillance - broadcast |
| **ASBU** | Aviation System Block Upgrade |
| **ATC** | Air Traffic Control |
| **ATI** | Air Traffic Insertion |
| **ATOLS** | Automatic Take-off and Landing Systems |
| **BRLOS** | Beyond Radio Line of Sight |
| **BVLOS** | Beyond Visual Line of Sight |
| **D&A** | Detect And Avoid |
| **E4U** | EREA for RPAS |
| **EADS** | European Aviation Defence and Space |
| **EDA** | European Defence Agency |
| **EFC** | European framework cooperation |
| **EO/IR** | Electro-Optical/InfraRed |
| **EPS** | European Framework Cooperation for Security and Defence |
| **EREA** | Association European Research Establishments |
| **ERGS** | European RPAS steering group |
| **ESA** | European Space Agency |
| **EVLOS** | Extended Visual Line of Sight |
| **FLAME** | Flexible Airspace Modelling Environment |
| **GBD&A** | Ground-Based D&A |
| **GBSAA** | Ground based sense and avoid (USA) |
| **HMI** | Human machine interface |
| **IAP** | Initial approach point |
| **ICAO** | International Civil Aviation Organisation |

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|---|---|
| **IDEAS** | Integrated Deployment of RPAS in the European Airspace Using Satellites |
| **IFR** | Instrument Flight Rules |
| **IOC** | Initial Operational Capability |
| **ITU-R** | International Telecommunication Union-Radiofrequencies |
| **LOS** | Line of sight |
| **MIDCAS** | MIDair Collision Avoidance System |
| **OSED** | Operational Service Environment Description |
| **PBN** | Performance based navigation |
| **pMS** | Participating Members States |
| **RPA** | Remotely Piloted Aircraft |
| **RPAS** | Remotely Piloted Aircraft System |
| **S&A** | Sense & Avoid |
| **SES** | Single European Sky |
| **SARPS** | Standards and recommended practices |
| **MASPS** | Minimum Aviation System Performance Standar |
| **MOPS** | Minimum Operation Performance Specification |
| **SID** | Standard Instrument Departure |
| **STAR** | Standard Arrival Route |
| **SIGAT** | Study on military spectrum allocation required for the Insertion into the General AirTraffic of the unmanned aircraft systems |
| **SINUE** | Satellites for the Integration in Non-Segregated Airspace of RPAS in Europe |
| **SPR** | Safety Performance Requirements |
| **SWIM** | System Wide Information Management |
| **TAWS** | Terrain Awareness Warning System |
| **TMA** | Terminal Airspace |
| **RPAS** | Unmanned Aircraft System |
| **UAV** | Unmanned Aircraft Vehicle |
| **VFR** | Visual Flight Rules |

| | |
|---|---|
| **VLL** | Very Low Level |
| **VLOS** | Visual Line of Sight |

# Appendix D References

## D.1 General references

- ICAO - Circular 328;
- EASA - Policy Statement Doc # E.Y01301Airworthiness certification of RPAS (Unmanned Aircraft Systems);
- SESAR – ICONUS study performed by the ATM FUSION consortium.
- JARUS- Certification Specification for Light Unmanned Rotorcraft Systems (CS-LURS);
- EUROCONTROL – Set of deliverables as defined in D2;
- EUROCAE – WG 73 deliverables of the several sub groups (OSED, roadmaps, etc.);
- EUROCAE – WG 93 deliverables of the several sub groups (OSED, roadmaps, etc.);
- EC – INOUI.

## D.2 References to planned, on-going or finalized studies and/or other R&D activities

### D.2.1 Air4All Roadmap

***Scope:***

The purpose of the project was to develop a detailed route-map and plan that outlines the way to the routine use of RPAS within European airspace by 2012 for military and experimental RPAS, paving the way for state and civil RPAS by 2015 in airspace A, B and C in a first step. Additional work packages were performed as an extension to the Air4All roadmap study contract to cover all airspace classes and also to cover VFR operation.

***Performed by:***

The Air4All Consortium under EDA Contract.

***Status (not yet on-going/on-going/finalized):***

Finalized in July 2009.

***Outputs from the study (finalized or expected to be finalized as the case may be):***

The focus of this study was to develop a high level plan, involving all key stakeholders across the participating member states, setting the recommendations and a joint European agenda for future common RPAS activities. This would provide the rationale and justification for a more significant investment that will ultimately place Europe at the forefront of RPAS airspace integration.

Most of the studies which are currently proposed as part of a potential R&D programme dedicated to RPAS air traffic integration are direct results from the Air4All Roadmap.

***To be found at:***

*EDA (upon request).*

### D.2.2 E4U

***Scope:***

The European Framework Cooperation for Security and Defence (EFC) was launched in 2009 by the European Defence Ministers with the purpose to ensure synergies of Defence R&T investment by the

European Defence Agency (EDA) with research investments for civilian security and space made by the European Commission (EC) and by the European Space Agency (ESA).

***Performed by:***

*EREA Consortium.*

***Status (not yet on-going/on-going/finalized):***

Finalized in 2012.

***Outputs from the study (finalized or expected to be finalized as the case may be):***

- A series of three open workshops for EFC and non-governmental experts to discuss RPAS ATI in Europe for defense applications;
- Recommendation on the prioritisation of technical topics, necessary for air space insertion;
- Development of a RPAS programmes business case relating to the technical topics of the study.

***To be found at:***

*EDA (upon request).*

## D.2.3 EC UAS Panel

Considering the emergence of RPAS, EC launched in 2011 a broad stakeholders consultation, EC UAS panel process" to foster the development of civil RPAS applications in Europe. The EC UAS panel organised a series of five thematic workshops from July 2011 to February 2012: UAS industrial market, UAS insertion into airspace, UAS safety, societal impacts and R&D.

On 9 February 2012, the Commission organised the fifth workshop of the UAS Panel Process aiming at preparing a R&D strategy for RPAS in Europe. After a series of four workshops respectively dedicated to RPAS industry and market, RPAS insertion into air traffic and radio frequencies, safety of RPAS and the societal dimension of the use of RPAS for civil applications, this last workshop addressed the technology needs to develop RPAS civil applications and their safe insertion into the airspace and Discussed the general research framework for RPAS in Europe.

The workshop highlighted the existence in the EU of a large number of research initiatives related to the development of RPAS platforms and derived civil application showing the high interest of pMS and industry in this emerging sector. The workshop took then a closer look at the technology requirements to achieve a safe insertion of RPAS into the airspace. The technology readiness levels of isolated technologies are high, the problem being mainly their integration into functioning systems meeting the safety requirements for their insertion into civil air traffic. The workshop identified a clear need to progress on the development of the safety regulatory framework and to set-up at European level a plan combining both the research and regulatory aspects. It also identified areas where more R&D is needed to allow RPAS to fly safely in non-segregated airspace. It concluded on the need to exploit and capitalize on the knowledge and progress already achieved in the defence sector when developing civil RPAS.

## D.2.4 SIGAT (EDA)

***Scope:***

The SIGAT study has been initiated to support the identification of an appropriate spectrum for the integration of RPAS and to define and promote European interests in the perspective of the ITU-R World Radio-Communications Conference planned in 2012.

***Performed by:***

The Air4All Frequency Group Consortium under EDA Contract. It started in January 2009.

***Status (not yet on-going/on-going/finalized):***

Finalized in 2010.

***Outputs from the study (finalized or expected to be finalized as the case may be):***

- SIGAT has studied airworthiness and safety constraints attached to the communication link for C2, ATC and S&A, and subsequently proposed a set of optimized safety targets;
- Hypotheses for military RPAS density and scenarios for RPA Air Traffic Integration have been defined for the period 2015 – 2030, both in OAT and GAT;
- Innovative techniques of data transmission and system architectures have been proposed;
- Analysis of Radio-Frequency spectrum availability and potentially usable RF bandwidths and characteristics have been studied;
- Compatibility and potential interferences with other frequencies have been analysed;
- A set of potentially usable RF frequencies have been defined;
- Finally, SIGAT significantly supported the preparation of the 2012 World Radio communications Conference in the frame of ITU-R Agenda 1.3, which successfully concluded to a new allocation of frequencies for the terrestrial link (CS to RPA) in C Band, while existing current frequencies are recognized as satisfactory for the satellite link (L and C).

***To be found at:***

EDA (upon request).

## D.2.5 RPAS C3 Channel Saturation Study (EUROCONTROL)

***Scope:***

Identification of C3 spectrum requirements in support of C3 and D&A based on present bandwidth technology.

***Performed by:***

QinetiQ and NATS.

***Status (not yet on-going/on-going/finalized):***

*F*inalized.

***Outputs from the study:***

The study undertook modelling and analysis of these multiple RPASRPAS operational scenarios so as to:

- Assess the overall RPAS spectrum requirement and communication performance (such as latency and reliability) and associated rules of use which would be required to support unconstrained RPAS operations into the medium to long term (2020, 2030 and 2050);
- Assess the ability of the EUROCAE WG73 defined RPAS~~RPAS~~ C3 spectrum requirement to fulfil the C3 data transmission requirements for the modelling scenarios used within this study.

The fast time model used was the FLexible Airspace Modelling Environment (FLAME) model which generated all the manned and RPA traffic within the volume of interest based on realistic traffic patterns.

Following traffic creation the simulated area will generate a communication load based on operations occurring within the area and simulated timeframe. Once all communication traffic for each of the scenarios, the communication model, FLAMENCO, was used to assess the communication requirement against three possible technology implementation options to assess channel saturation and generate a global spectrum requirement.

***To be found at:***

*EUROCONTROL (upon request).*

### D.2.6 Unmanned Aircraft Systems – ATM Collision Avoidance Requirements

***Scope:***

A major goal in the development of Unmanned Aircraft Systems operations is access to non-segregated airspace. In order to achieve this, RPAS must have a Detect & Avoid function analogous to the See & Avoid function of manned aircraft.

In order to determine the ATM Collision Avoidance Requirements for RPAS operating in non-segregated airspace EUROCONTROL have commissioned the CAUSE study, Phase 1 of which is reported here.

The study uses results from previous EUROCONTROL safety studies of ACAS to demonstrate that there is a need for RPAS to have a collision avoidance capability comparable to that delivered by ACAS on manned aircraft.

The required performance capability is derived for a range of airspace regimes.

The study also investigates to what extent carriage of ACAS by RPAS might deliver this capability and the issues involved.

***Performed by:***

EUROCONTROL.

***Status (not yet on-going/on-going/finalized):***

Finalised 2009-12-14.

***To be found at:***

EUROCONTROL (upon request).

### D.2.7 Functional Hazard Assessment *(FHA) Report for Unmanned Aircraft Systems*

***Scope:***

The EUROCONTROL Agency, in executing its responsibilities associated with the management of the pan-European ATM network, must ensure that RPAS do not negatively impact overall levels of ATM security, safety, capacity and efficiencies.

This work will result in the development of an ATM safety assessment for RPAS that will identify a set of ATM safety requirements, over and above existing ATM regulatory safety requirements, which, if implemented, will ensure that the integration of RPAS into non-segregated airspace will be acceptably safe.

The primary aim of this task is to develop an ATM safety assessment for RPAS so as to identify a set of ATM safety requirements, over and above the existing ATM regulatory safety requirements, which, if implemented, will ensure that the introduction of RPAS into non-segregated airspace will be acceptably safe. The safety assessment is to consider two defined RPAS operating scenarios in order to provide a realistic context into which RPAS will be operated.

- Scenario 1 – covers RPAS operations in Class A, B or C en-route airspace flying Instrument Flying Rules (IFR) beyond the visual line of sight of the pilot-in command;
- Scenario 2 – covers RPAS operations in Class C – G airspace operating under;
- Visual Flying Rules (VFR) and the pilot-in-command has direct visual line;
- Sight of the RPA.

***Performed by:***

EUROCONTROL.

***Status (not yet on-going/on-going/finalized):***

Finalised September 2009.

***To be found at:***

EUROCONTROL (upon request).

## D.2.8 RPAS simulation report 2008

***Scope:***

The EUROCONTROL Agency let a contract to Swedavia to execute a real-time air traffic control simulation for an initial, exploratory operational assessment of the integration of unmanned aircraft systems (RPAS) into the ATM network. Swedavia performed this in cooperation (consortium) between LFV-group (ANS Provider) and Saab AB (Publ.), Saab Aerosystems (Aircraft manufacturer), based on an existing close cooperation between LFV and Saab, specifically in the area of joint RPAS and ATM interests.

The companies have recently (2006) performed three joint real-time simulations/workshops internally, which served to facilitate this work.

RPA exist in a wide range of shapes and sizes, from micro RPA to quite large RPA, close to the size of a B737. They can be fixed wing aircraft, or rotorcraft (helicopters). In order to integrate RPAS in controlled airspace, the RPA must be able to follow current procedures and rules in order to maintain safety and efficiency. Three potential problem areas are identified:

- Flight performance of the RPA;
- Communication to the RPA;
- Ground operations.

The project stated four main objectives:

- Assess the impact on ATC of RPAS communication link (voice and data), latency (including failure situations);
- Assess the impact on ATC of RPA flight performance;
- Assess the impact on ATC of light RPA in the aerodrome environment;
- Assess the impact on ATC of RPAS sense of traffic;
- A fifth expectation was also expressed: Identify and assess any relevant findings expressed by ATC relative to RPA in controlled and non-segregated airspace.

***Status (not yet on-going/on-going/finalized):***

Finalised 2008.

***To be found at:***

EUROCONTROL (upon request).

## D.2.9 Human Factors Case for the RPASRPAS – ATM Integration

***Scope:***

Part I: RPAS IFR Operation in Classes A, B, C En-route Airspace.

Part II: RPAS VLOS Operation in Classes C and F/G Airspace.

Part I describes the Human Factors (HF) Case for the Integration of RPAS into the European Air Traffic Management (ATM) System in Scenario 1. This scenario includes RPAS operations under Instrument Flight Rules (IFR) in Classes A, B, and C enroute airspace. The HF Case was carried out in four steps: (1) the Fact Finding, (2) the HF Issues Analysis, (3) the HF Action Plan, and (4) the Action Implementation. The key outcome of the HF case is a set of HF requirements for the RPAS-ATM integration.

Part II describes the Human Factors (HF) Case for the Integration of RPAS into the European Air Traffic Management (ATM) System in Scenario 2. This scenario is concerned with RPAS operation in Visual Line of Sight (VLOS) in uncontrolled airspace (Class F/G) or – if operation takes place in the CTR - in controlled airspace (Class C). The HF Case was carried out in four steps: (1) the Fact Finding, (2) the HF Issues Analysis, (3) the HF Action Plan, and (4) the Action Implementation. The key outcome of the HF case is a set of HF requirements for the RPAS ATM integration.

***Status (not yet on-going/on-going/finalized):***

August 2009.

**To be found at:**

EUROCONTROL (upon request).

## D.2.10 SINUE and IDEAS

***Scope:***

To investigate the feasibility of a demonstration mission integrating RPAS~~RPAS~~ and satellites for the purpose of satisfying end-user needs and for insertion into non-segregated airspace.

***Performed by:***

EDA and ESA initiated in close coordination two parallel feasibility studies (SINUE and IDEAS), contracted in 2010 to 2 consortia working independently from each other.

***Status (not yet on-going/on-going/finalized):***

Finalized in September 2010.

***Outputs from the study (finalized or expected to be finalized as the case may be):***

- There is a potential for sustainable services in particular for some applications like maritime surveillance services, where RPAS complemented by satellites can offer unique capabilities and can also contribute to significant savings of operational expenditures;
- Many users and stakeholders (in particular in the aviation regulation and safety community) are interested in a demonstration of RPAS supported by satellites. Some users have expressed an urgent need for RPAS based services for specific applications;
- It is feasible to demonstrate the potential of the utilization of satellites complementing RPAS already within the current regulatory framework and utilizing the currently available technologies;
- The most suitable scenario for demonstrating a RPAS service in the short term is based on a maritime surveillance service, because of the high interest of end-users, the reduced risk of flying over water, and the capabilities to demonstrate critical issues for inserting RPAS into non-segregated airspace;
- Progress in the regulations will be stimulated and helped by the demonstration of safety related aspects for the Air Traffic Insertion, as well as by a clear interest from end-user communities;
- Future investments in RPAS based services will notably be depending on the decisions to be taken by the competent organizations regarding critical regulatory issues, related for example to the assignment of spectrum for C2 communications via satellite;
- The definition of a communication architecture (C2, payload and ATC) addressing mobility, security and scalability issues can provide relevant inputs to regulators on the approach to be adopted.

***To be found at:***

*EDA and ESA (upon request).*

### D.2.11 ESPRIT

***Scope:***

The goal, through the ESPRIT study is to focus on the provision of communication capacity for Command & Control ($C^2$) links to RPAS flying through civilian airspace. The aim is to study solutions at both spectrum and system levels.

***Performed by:***

ESA contracted the study to a consortium.

***Status (not yet on-going/on-going/finalized):***

The project is currently on-going.

***Outputs from the study (finalized or expected to be finalized as the case may be):***

- The importance of satellite communications is unanimously acknowledged due to the operations performed by RPAS, by nature very often beyond the radio horizon, including for small RPAS in the near future;
- It is well recognized that today's satellite solutions cannot satisfy the need as such. This point is thus identified as one of the barriers to be overcome with the highest priority. ICAO requires the use of frequency bands allocated to civil aviations (AMS(R)S);
- World Radio Conference 2012 has confirmed the use of the already allocated bands, namely the L band AMS(R)S and the 5GHz band AMS(R)S, while for the LOS, a new bandwidth has been allocated in the 5 GHz band;
- Several systems are today operating or are planned in the AMS(R)S L-band. However, this use is likely to be possible only for the preliminary phase during which some additional procedures will be deployed and the operations limited. In addition, L-band systems suffer from the lack of spectrum (10MHz only to be shared with other applications) and won't be able anyway to cover the overall need that is envisaged once the market expands;
- The 5GHz band appears to be a good candidate for future development and would lead to strong synergies with the LOS counterpart. This band allows meeting stringent availability requirements and would offer a high capacity, while enabling additional aeronautical use of the band. The 5GHz solution would provide a global and unified Command & Control capability for both line-of-sight and beyond-line-of-sight conditions;
- Another option that is today envisaged, in the frame of WRC 2015, is the use of FSS systems (Ku and Ka band). However, this leads to several issues, to be analyzed in the frame of WRC-15 preparation.

***To be found at:***

ESA (upon request).

### D.2.12 DeSIRE

***Scope:***

Following the completion of the parallel feasibility studies (SINUE and IDEAS), for reducing the risks linked to technical and regulation issues, it was decided to organize the follow-on demonstration activities in two successive elements.

The first demonstration element, entitled "Demonstration of the use of satellites complementing Unmanned Aircraft Systems (RPAS) addresses the capability of RPAS supported by satellites to make use of safe and secure data links for RPAS and ATC communications, with a suitable balance between safety and security, to allow RPAS Air Traffic Integration. It specifically addresses and demonstrates safety challenges, issues and required capabilities.

The main objectives of this activity are twofold:

- Demonstrate the capability of safe integration of RPAS in non-segregated airspace using satellites, identify issues and required procedures, and provide early inputs to regulatory bodies;
- Demonstrate to the user community that RPAS, supported by satellites and flying in non-segregated airspace, can fulfil their needs.

***Performed by:***

ESA contracted the study to a consortium.

***Status (not yet on-going/on-going/finalized):***

The project is currently on-going and scheduled for completion in 2013.

***Outputs from the study (finalized or expected to be finalized as the case may be):***

The demonstration will include flying in non-segregated airspace (class A, B or C) under instrumental flight rules (IFR) for analysing and verifying a list of topics for Air Traffic Insertion, including:

- The switch over between LOS and BLOS communication;
- The ability to follow ATC instructions including several areas of responsibility (e.g. between air traffic control zones, cross border flights) ;
- The evidence of data link(s) latency;
- The quality of the Data Link in terms of Availability and Reliability.

***To be found at****:*

*ESA (upon request).*

## D.2.13 MIDCAS (EDA)

***Scope:***

The on-going MIDCAS project addresses the most critical items identified as 'Technical Challenges" in the Air4All Roadmap: Separation and Collision Avoidance.

The MIDCAS mission is to "demonstrate the baseline of solutions for the Unmanned Aircraft System Mid-air Collision Avoidance Function" acceptable by the manned aviation community and being compatible with RPAS operations in non-segregated airspace by 2015. The project addresses this in an iterative approach, where requirements and standards are progressed in parallel with solutions development, and finally with flight testing using manned and unmanned air vehicles.

Most of MIDCAS results are public and the aim is to:

- Reach a consensus among European stakeholders on Detect and Avoid;
- Define the basis for a Detect and Avoid Standard through demonstration of performances on simulation and flight test.

***Performed by:***

On behalf of 5 Nations (France, Germany, Italy, Spain and Italy), EDA contracted MIDCAS in 2009 to a consortium of 13 European industries.

***Status (not yet on-going/on-going/finalized):***

On-going.

***Outputs from the study (finalized or expected to be finalized as the case may be):***

Outputs of MIDCAS will be constituted by an important number of reports and presentations to the EDA and to the European stakeholders, describing and justifying the main results, selected options and performance obtained from simulation tests, system integration and flight tests on board a surrogate aircraft and a real RPAS.

3 Workshops have already been organized, during which were presented current status of:

- Encounter concepts and avoidance Conops;
- System safety analysis;
- Potential future system architecture;
- Target system performances.

3 Future Workshops will address definition of future system, results of simulation and finally results from flight tests.

***To be found at:***

*EDA and midcas.org website (public access)*

## D.2.14 NATIONAL CONTRIBUTIONS

Several national studies exist. Most of these activities are believed to have contributed into the detect and avoid efforts above and are reflected in the outcome:

- ASTRAEA (UK) with enlarged objectives to Autonomy, Human-System interfaces and Communications;
- OUTCAST (NL);
- S&A TD ( SE),
- Busard (FR);
- WASLA-HALE (DE);
- and more.

All such studies results have not necessary been made public and are not available.