Task 1 Report -
General Approach and Safety Assessment Method Definition

MALE RPAS Accommodation Study

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Document History

Issue	Date	Reason for change
01	30th April 2018	Initial Release
02	08th May 2018	To incorporate customer and stakeholder feedback and review comments resulting from the Safety Assessment Method Definition Gate review.
03	30th June 2018	Updates to improve coherence between Safety Case Methodology and subsequent Scenario and Simulation approaches so as to 'tell a complete and consistent story' on the development of MALE RPAS Generic Accommodation Scenarios to Implementation Scenarios leading towards Integration approaches. Additional consideration has also been made on ATM aspects of the Safety Case and its importance alongside platform and operational aspects.
04	24th July 2018	Inclusion of minor typos and restructuring of contents to correctly insert ATM Safety Case as subordinate to the generic Safety Case as agreed with EDA at SRR meeting.

Number of pages: 68

1 Introduction

1.1 Document Purpose

This document is an update of the Milestone deliverable report for Task 1 of the MALE RPAS Accommodation Study (Ref: 17.CPS.OP.017) let by the EDA to Team SIRENS at the Project Launch Workshop held at EDA HQ in Brussels on January 11th 2018. This 'General Approach and Safety Assessment Method Definition' report may be decomposed into two distinct sub-topics comprising a summary of current methods used to enable initial MALE-type RPAS operations in Europe as well as a recommended safety assessment methodology that will be used to underpin the study and explore the path towards future MALE RPAS integration in all classes of airspace. The proposed safety assessment methodology will be described and supporting rationale provided to explain how it will be applied to support MALE-type RPAS operations in European countries planning to conduct such operations in the 2020-2025 epoch.

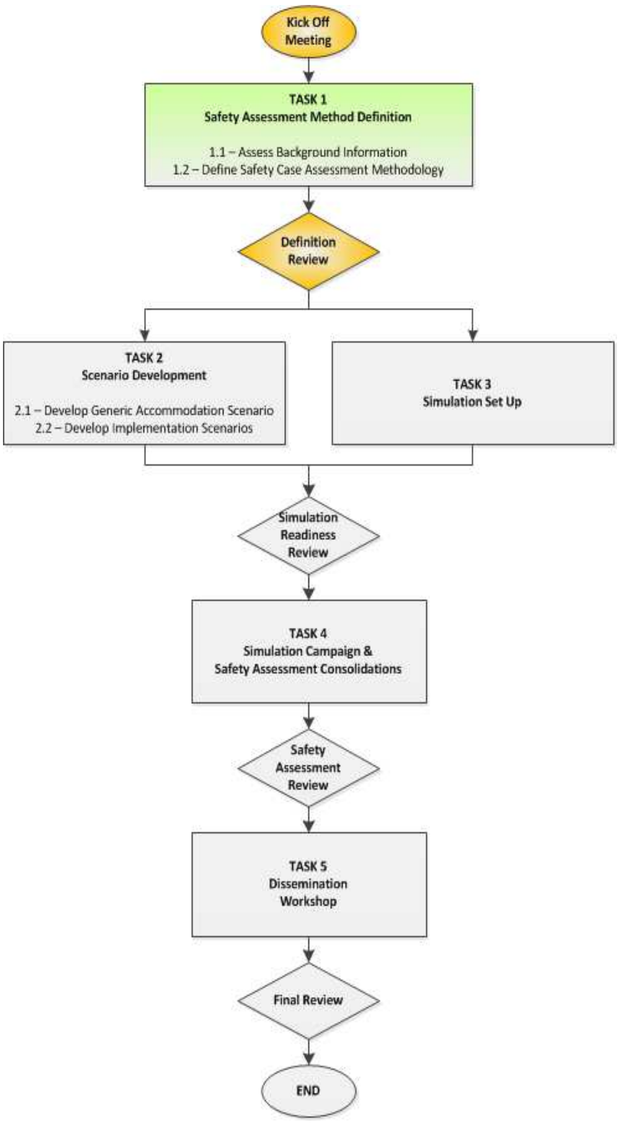

Figure 1 – Project Process Flow Illustrating Task 1

This updated document will be submitted to the EDA and disseminated to the wider stakeholder community in response to comments received by stakeholders and especially those regarding clarity of ATM aspects of the safety assessment. The document also provides an illustrative and textual explanation of linkages and supporting rationale between the application of the safety methodology and the scenario selection for simulation and discussion at the Simulation Readiness Review (SRR).

1.2 Study Overview

This study will deliver an enhanced Aviation Safety Case Assessment Methodology for RPAS by assimilating and consolidating current best practice across both manned and unmanned aviation, testing this methodology through simulation and developing a consolidated version of the generic RPAS Accommodation scenario to allow all aspects of aviation hazard analysis to be exercised for MALE-type RPAS integration into European skies alongside manned aviation.

Figure 1 illustrates the planned flow of activities to be undertaken during this study programme and the position of Task 1 within that structure. Successful completion of the Safety Assessment Method definition review will enable subsequent tasks to progress in cognisance of outcomes and actions agreed with stakeholders and the EDA.

1.3 EDA RPAS Capability Development

The EDA have embarked on a long-term strategy to enable the integration of RPAS into European skies alongside manned aviation and this study forms an important part of the initial work programme aimed at achieving that goal – more information may be found at:

https://www.eda.europa.eu/what-we-do/activities/activities-search/remotely-piloted-aircraft-systems---rpas/

1.4 Task 1 – Conduct

1.4.1 Overview

The following diagram (Figure 2) illustrates the flow of activities and proposed primary data sources for Task 1. Sections 1.4.2 to 1.4.5 inclusive, describe how Task 1 was actually performed including source background information taken into account. The Definition Review will provide opportunity for stakeholders to comment on outcomes of Study Task 1 and for agreed changes to be introduced into the final document prior to final release so as to underpin subsequent simulation and scenario development exercises.

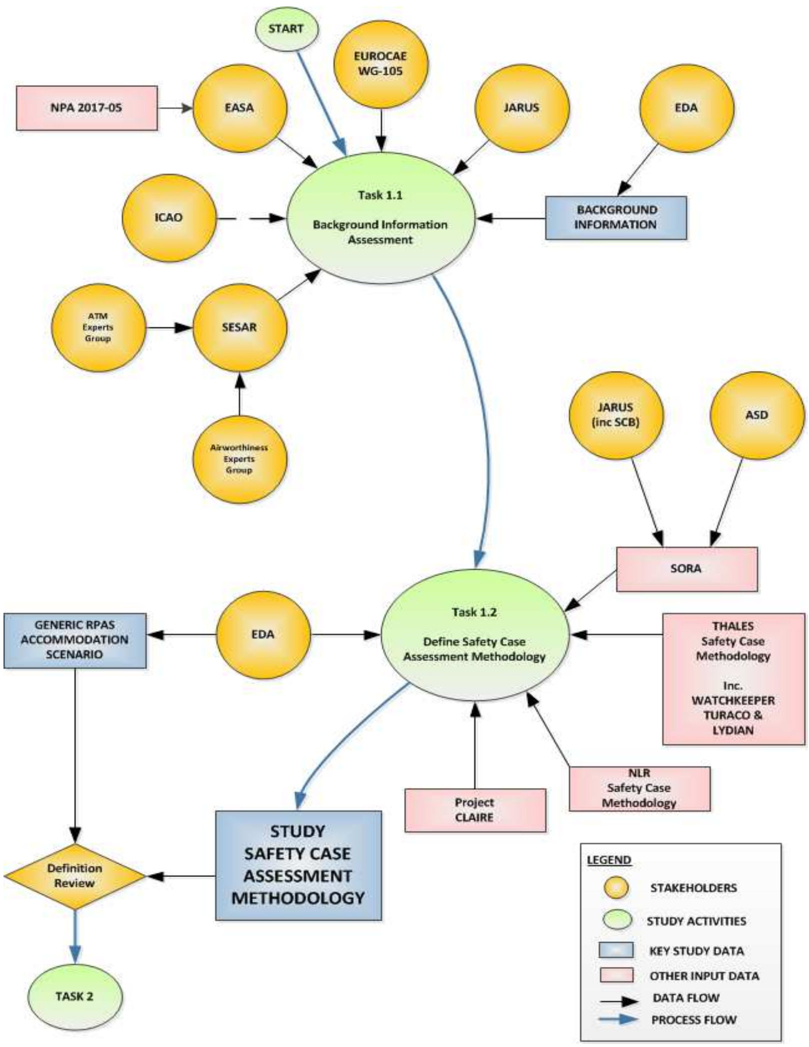

Figure 2 – Task 1 Process Flow

1.4.2 Task 1.1a – Background Information Review

Task 1 began by conducting a review of the documentation supplied as background information with the call for tender as well as useful supplementary information identified by team SIRENS and the EDA. This documentation set is detailed in Annex B and is summarized in Figure 3 below:

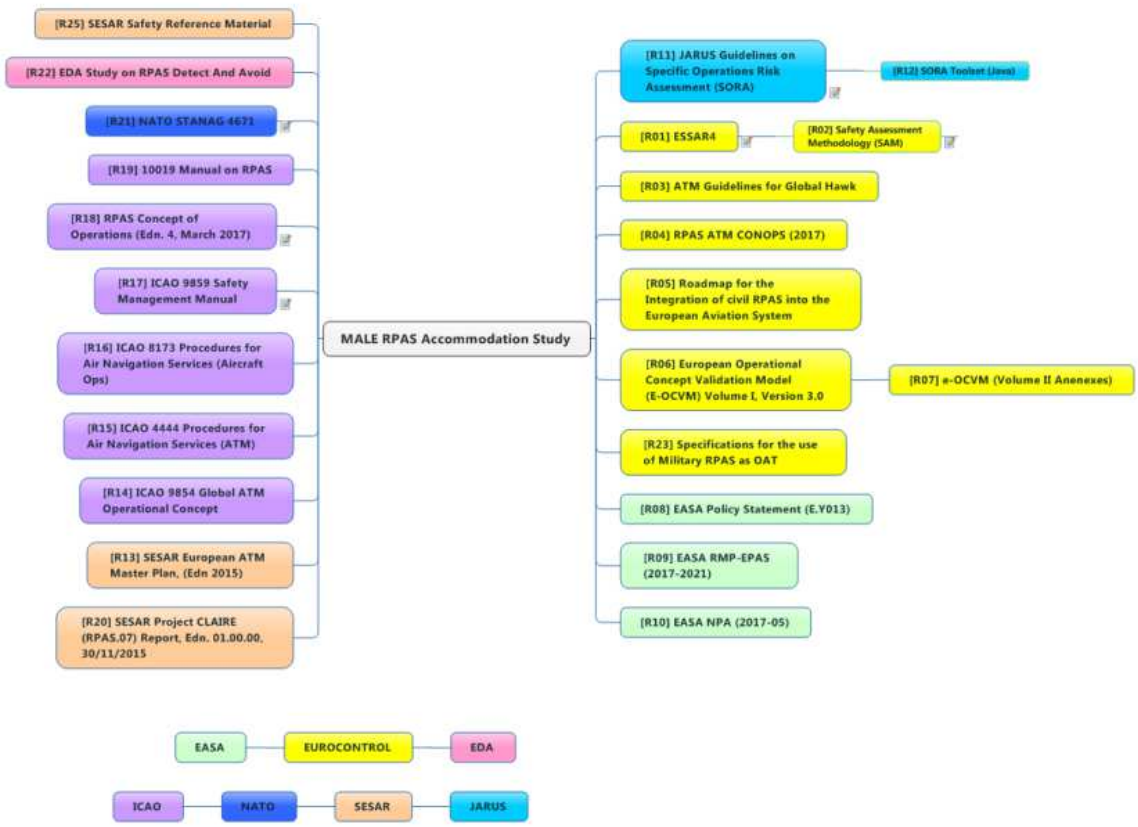

Figure 3 – Background Information Diagram

The results of this review are detailed in ***Section 2 - Background Information Review***.

1.4.3 Task 1.1b – State-of-the-Art on Accommodation

In parallel, Task 1 continued with a review of the current 'state-of-the-art' regarding the 'Accommodation of MALE-type RPAS in Europe' - the results of this review may be found in ***Section 3 - State of the Art on Accommodation.***

1.4.4 Task 1.2 - Safety Case Assessment Methodology

Although the process shown in Figure 1 showed the sub-tasks being conducted in series, Task 1 actually began identifying candidate Safety Case Assessment Methodologies from the start of the project.

Task 1.2 reviewed and compared existing methodologies seeking to identify current 'best practice' before combining them together in the methodology proposed ***Section 4 - Safety Case Assessment Methodology.*** This section also includes a justification of the rationale behind the methodology.

1.4.5 Task Conclusion/Output

The Task 1 output (deliverable) is this report. This document shall be presented for approval at the Safety Assessment Method Definition review gate. It is noted that successful completion of this review (i.e. acceptance of the documentation by EDA) is a pre-requisite for permission to proceed with the rest of the study – however, some of the activities will be started in parallel in order to maintain timescales and to ensure sufficient flexibility in stakeholder engagement is retained. Please refer to the 'Definition Review' activity shown in Figure 2.

Over the course of the project, team SIRENS will generate individual Task Reports that stand alone but may be combined into a single Project Report covering the entire project. The illustration below summarises the study methodology and linkages between the various tasks so as to develop a logical flow (based on application of the safety assessment methodology, implementation scenarios and simulation exercises) to mature a top-level MALE RPAS Accommodation Scenario towards a future Integration Scenario. The principles, assessment methods and toolsets will define a robust and consistent application baseline necessary to expand the scope of the study using additional implementation scenarios to support future thinking and emergent challenges necessary to achieve integration in the future.

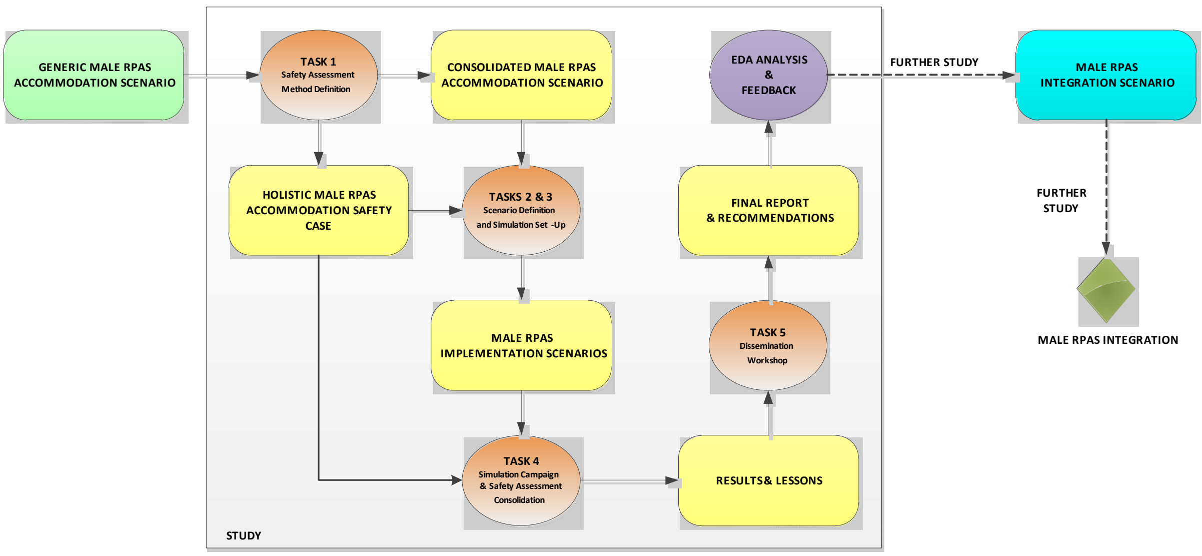

Figure 4 – Study Linkage Diagram

2 Background Information Review

2.1 Summary

The background information to this study, as illustrated in Figure 3, was reviewed by Team SIRENS and the key points are summarised below:

Further details of this review by the team may be found in Annex B.

2.2 Conclusions

The following is a brief synopsis of the key points emerging from the review of background information, relevant to this study:

a) The subject of RPAS accommodation is long-standing, well-researched and comprehensively documented but not well understood. There are numerous players all driving towards the same goal using broadly similar terminologies, processes and procedures.
b) SORA is a valuable reference methodology and provides a robust set of processes but has yet to be implemented and validated, future iterations are currently in progress. This study aims to propose a concise and easy to follow, in-depth methodology for Safety Case Assessment that will be used and developed throughout Tasks 1 – 4 and those outcomes may provide useful experience and feed-back into SORA should JARUS decide to adopt them.
c) The Global Hawk flights in Europe were clearly a step in the right direction and although not a direct 'read-across' there are significant lessons to learn from the exercise. The high-altitude, cross-border flight profiles were carefully planned and agreed amongst multinational stakeholders (via workshops) though the different operating concepts and performance capabilities of HALE and MALE-type platforms need to be taken into consideration (see section 3.2).
d) The EUROCONTROL ESSAR & SAM documents provide a detailed approach to ATM risk assessment and mitigation as well as an associated safety assessment methodology. The documents are thorough and have a lot to offer, many of the lessons identified are incorporated in the Safety Case Assessment Methodology proposed in Section f).
e) E-OCVM is a framework for carrying out R&D rather than a strict set of rules - essentially another way of 'managing' the Systems Engineering process required to develop a system from expression of need, through development, to delivery, deployment and disposal (and draws heavily on INCOSE) and is focused on the validation process using maturity levels and transition criteria. Another key factor is the Business Case which presents a balanced synthesis of the critical issues from the other cases (Safety, Human Factors etc.).
f) 'Accommodation' will need to be enabled by the introduction of equipment such as Detect & Avoid, revised ATM training (for the ATCOs to understand RPAS limitations and performance 'nuances') as well as regulatory frameworks, standards, operating practices and procedures. The introduction of DAA equipment will itself need to be handled iteratively using both

cooperative and non-cooperative technologies but to be successful such equipment will need to be cost-effective and proportionate.

g) The adoption of system wide information management principles is to be encouraged as it incorporates findings and recommendations from the accommodation of Global Hawk and is a logical move given that RPAS Control Stations are generally (at least currently) land-based.

h) ATM CONOPS are constantly evolving under EUROCONTROL, SESAR & ICAO etc. and have for some time now included consideration of the effect the introduction of RPAS will have upon them. The accommodation risks are expected to be mitigated by a combination of regulation (e.g. EASA NPA 2017-5 which proposes the introduction of an RPAS regulatory framework), standardisation (e.g. STANAG 4671) and equipment provision (such as DAA) but the overarching principle is that RPAS have to fit into the extant ATM system and not that the ATM system should be adapted to accommodate them.

i) The European Union has also released Regulation 2017/373 which describes a number of common requirements for providers of air traffic management; air navigation services and other air traffic management network functions. In order to ensure a harmonised approach to certification and oversight, the measures are intended to be coordinated across Member States, functional airspace blocks and all persons providing the necessary infrastructure for flight operations.

j) There is an underlying assumption that accommodated and integrated RPAS will fly under IFR, which are rules that allow properly equipped aircraft to be flown under instrument meteorological conditions (IMC), i.e. when flying and navigation based on outside visual reference is not safe or possible. IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signals.

k) Some degree of accommodation (albeit of a Tactical UAS) has already been achieved through SESAR's Project CLAIRE – which is covered in more detail in Section 3.4 - and many of these lessons identified are relevant to the further development of the Generic Accommodation Scenario and into the Implementation Scenarios planned for later in this study

l) EUROCONTROL have proposed a harmonised set of specifications which can be used by the Member States for the implementation of UAVs flying as OAT in non-segregated airspace, including cross-border operations. In particular, they propose reversion to autonomous flight in the event of loss of data-link. A similar scheme is proposed with regard to traffic avoidance and collision avoidance so that where ATC is not available to separate an RPA from other airspace users; the pilot-in-command (PIC) will assume that responsibility using available surveillance information and technical assistance in the form of a DAA system. The DAA will also initiate last-ditch autonomous collision avoidance should circumstances warrant it. Clearly this leads to the requirement to develop a set of stringent DAA equipment safety requirements before such equipment can robustly function in this role and, given that the introduction of DAA equipment needs to be both cost-effective and proportionate, these apparently mutually exclusive requirements will need careful management.

m) SESAR Safety Reference Material (SRM) has been developed to provide a clear, complete, coherent and integrated approach to safety assessment that meets the need of the SESAR work programme aligned to the European Operational Concept Validation Methodology (E-OCVM) V1-V4 maturity model [Ref. 6]. The key novelty of the approach is the simultaneous use of both ***success-***based and ***failure***-based approaches to aviation safety. The success-based safety approach is used to show that a concept is intrinsically safe in the absence of failure, whereas EC regulations (CR 1035/2011) currently only requires a failure-based approach to identify hazards and risks and propose mitigations or barriers to them.

n) SRM aims to improve the historical approach, whereby safety assessments have tended to assess how reliable the ATM system need to be (as a combination of equipment, procedures and human resources organised to perform a function within the context of ATM) to ensure that the system is adequately protected against internal failures. This restricted view of safety has been sufficient since ATM systems have gradually evolved and it has been adequate to rely on the assumption that ATM system is intrinsically safe when no failure occurs. Given the nature of SESAR concepts, the development of new technologies and the increasing use of automation this assumption is no longer valid.

o) The accommodation of MALE-type RPAS into controlled airspace is a clear example of such a novel concept and, given the alignment to E-OCVM, SRM is clearly a significant source of guidance to the Safety Case Assessment Methodology under development in this study.

3 State of the Art on Accommodation

3.1 Accommodation Vs Integration

There are many activities being conducted worldwide under the auspices of a number of bodies (EDA, SESAR, ICAO etc.) whose common aim is to effect the full and seamless integration of RPAS alongside manned aviation '**as if'** the RPA was conventionally manned, thus with no significant impact on normal air traffic management or other airspace users. In order to realise this objective a number of significant technological, regulatory and societal barriers must be overcome – an interim solution is the use of special procedures to enable 'constrained' RPAS operations to accommodate platforms in shared traffic environments. A number of definitions have been developed with the premise that 'accommodation' is a series of steps that may lead to full integration subject to suitable enablers and safety mitigations being established and agreed with regulatory bodies.

Integration may be defined as the state where RPAS and conventionally manned aviation are considered, managed and controlled in the same way, without ATM being impacted by the difference or carrying any additional workload burden. Team SIRENS believes, that RPAS will need to be distinguished from manned aviation by some type of notification (e.g. flight plan or unique call sign) so that ATCOs are aware of the difference in pilot situational awareness (the RP being remote without the possibility of exhibiting intuitive behaviours nor looking out of the window[1]) and in the potential mitigation response to a lost-link hazard event resulting in compromised situational awareness[2].

RPAS **Accommodation** is defined by the International Civil Aviation Organisation (ICAO) as "*the condition when an RPAS can operate along with some level of adaptation or support that compensates for its inability to comply within existing operational constructs".* The "existing operational constructs" are not adapted to RPAS operation and until new operational constructs are in place, including the regulatory framework and required technology, all RPAS operations in European airspace will have a certain degree of **segregation** from other manned and unmanned aircraft. Regulatory frameworks and operating procedures will be required to support routine RPAS operations (possibly as enablers to accommodation) - these will be developed so as not to disrupt nor add additional burden to manned aviation. Some recommendations and procedures may have a minor impact on manned aviation though this has yet to be fully assessed.

The ERSG Regulatory Roadmap definition of Accommodation is:

'Accommodation' means limited RPAS access to non-segregated airspace via special procedures and mitigations. These include permits to fly, restricted airworthiness certification processes and the use of airspace to segregate RPAS operations from manned operations. Such operations are considered on a case-by case basis to ensure that today's non-standardized RPAS performance and operational

[1] Unless a forward-looking camera system is installed on the RPA and even these have limitations, currently.
[2] Some RPAS climb to try to re-acquire the C^2 link others may return to a previous 'good' position. Team SIRENS recommends that these behaviours become 'normalised' through regulation to reduce the burden on ATM.

features do not adversely affect safety or efficiency. As RPAS research, rulemaking, and policy developments enable an increase in integrated operations, the need for accommodation will decline significantly

The diagram below (Figure 4) illustrates a potential overall roadmap for MALE-type RPAS Accommodation from full segregation, through a number of accommodation steps to full integration where RPAS are treated in the same way as 'normal', manned aviation (notwithstanding the discussion above).

Accommodation also encompasses (starts with) full segregation, which is the current approach in most European nations. However, this imposes severe restrictions for operations and training purposes and there are therefore several on-going initiatives to enable a more flexible accommodation scenario to be defined, particularly the use of an iterative approach to enable RPAS to operate under Instrument Flight Rules (IFR) in non-segregated airspace in specific flight phases of the operation.

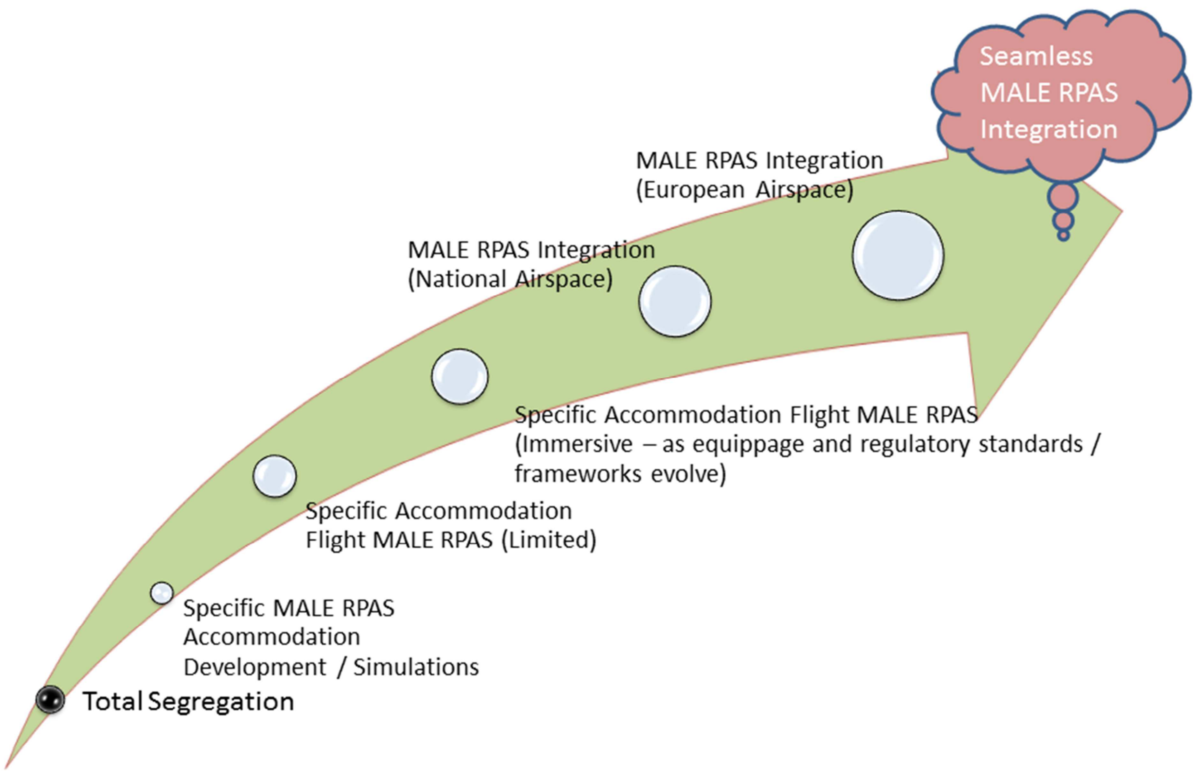

Figure 4 – MALE-type RPAS Accommodation roadmap

Military operators are currently the main stakeholders involved in RPAS operations in the conventional ATM system[3] (i.e. excluding U-Space and small RPAS operations at very low level). Military RPAS are expected to be amongst the early adopters of IFR[4] RPAS operations involving civil Air Traffic Control and, as such, they are expected to pave the way to enable these kinds of operations between 2020 and 2030. Opportunity was given to discuss operational experience and lessons learnt by the French Air Force who have acquired a wealth of knowledge in MALE-type tasks over several years, some noteworthy highlights are described below.

3.2 Armée de l'Air Française Expérience flying MALE-type RPAS

The French Air Force (Armée de l'Air Française) has many years' experience of flying MALE RPAS in French air space where control of the airspace is coordinated between military and civil authorities (DSNA). They have been flying the AIA / AIRBUS HARFANG (on the basis of HERON) and the GA REAPER out of Cognac Airbase to different training areas and operational sites. Lately, they have run some experimental flights through Bordeaux ATC to operational test areas over the Atlantic Ocean and in south west France before returning via Bordeaux airspace to Cognac.

GAT: insertion in unsegregated airspace

Two flights were conducted under the SESAR programme in January 2017 and several are planned for 2018 using Reaper, flying military RPAS at medium and high altitudes in unsegregated airspace under civilian ATC using IFR. A key part of the SESAR project work (phase 1) developed CONOPS and performed a security study to accommodate the HARFANG MALE RPAS. The MALE followed a pre-planned flight path complying with 1nm divergence and 200ft altitude separation criteria on a circular route form/to Cognac through Bordeaux approaches. Three flights were conducted under IFR rules with no NOTAM: the first with no chase aircraft; the second and third flights using cooperative air traffic to simulate IFR/VFR crossing and these flights were simulated by DSNA.

Phase 2 involved operational MALE-type RPAS (HARFANG) flights under DSNA control for the transit phases with representative military operations conducted in segregated airspace. The flight plan flew from Cognac to Bordeaux then to Toulouse and Carcassonne (where a simulated approach was conducted) before returning to Cognac via Bordeaux. A 'lost link' exercise was also performed when operating in the Carcassonne approach area. This phase was characterised by performing a large number of practice exercises including an extensive series of emergency procedure coverage. Due to the flight altitude, the en-route control centre was not part of the experimentation.

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[3] However team SIRENS believe that commercial freight organisations are, or will also be, key stakeholders in this area alongside other commercial and governmental operations such as agricultural surveying; homeland security; maritime surveillance; environmental monitoring; and numerous other potential applications.

[4] Instrument Flight Rules (IFR) are rules which allow properly equipped aircraft to be flown under instrument meteorological conditions (IMC), i.e. when flying and navigation based on outside visual reference is not safe or possible. IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signals.

The third phase is planned for the summer of 2018 and intends to add negotiations with DSNA for flights above FL190/FL200 and will conduct some short flights in and around Cognac. It is also planned to undertake some longer flights incorporating both operational and training flights with the MALE-type RPAS (REAPER) being 'accommodated' in French airspace by air traffic controllers. The key questions to be addressed are: how to coordinate IFR RPAS flights with ATC and how operating at vastly different altitudes impacts the way the MALE-type RPAS can be accommodated by the ATCOs.

HARFANG typically flies at FL130 whereas the Reaper flies at FL200 where much more air traffic is encountered.

The experiments were conducted iteratively whereby at the beginning there were only RPAS allowed in the airspace incrementally incorporate additional RPAS so that now they can accommodate both. Another outcome is that a generic system safety study has been performed from which the RPAS Accommodation Study could benefit. Although not essential accommodation requirements, the flight pragmatically avoided very busy traffic conditions (rush hours) and flying over densely populated urban areas.

The operations were conducted without DAA (either airborne or ground based) using Mode C transponders and ATC instruction to retain minimum separation criteria and used landline phone connections as a back-up, fall-back mechanism

OAT: from segregation to insertion through smart segregation

France is promoting the concept of a network of unmanned air traffic corridors across French airspace that can accommodate all types of unmanned air traffic flying at medium altitudes (e.g. FL120/FL130). Those corridors are used for OAT since the RPAS is integrated in unsegregated airspace in GAT within the air route system.

The success of this overall project and the approach pioneered was illustrated by the flight of a MALE-type RPAS over Paris as part of the Bastille Day celebrations.

Some of the issues encountered include: the MALE-type RPAS turning back unexpectedly, another is the navigational accuracy of the drones is not as good as advertised/required.

They adopted French Military requirements to accept RPAS; drones not equipped with DAA equipment and adapted these regulations to accommodate drone operations at airfields (e.g. Base aérianne 709 Cognac-Châteaubernard). One of the key criteria used through these experiments was that other air traffic can avoid the drones under ATC control – thus negating the need for DAA...

3.3 Accommodation of Global Hawk HALE into European Skies

This section is included for background information purposes <u>only</u> and does not form part of the MALE RPAS Accommodation Study

The EUROCONTROL Air Traffic Management Guidelines for Global Hawk in European Airspace document (Ref. 3), aimed to establish a set of minimum ATM requirements for Global Hawk (GH) /

EuroHawk (EH) flight in European airspace, with the primary purpose of enabling GH/EH operators to use them as the basis for negotiating access to national airspace within Europe. The Guidelines envisaged the isolation of GH/EH from other airspace users by requiring it to climb-out and recover in segregated airspace and to fly IFR/OAT[5] in the cruise in non-segregated airspace at high altitudes that are typically above or away from those occupied by manned aviation.

When these guidelines were used and the Northrop Grumman Global Hawk HALE RPAS was operated in European airspace, the basic accommodation scenario was '*isolation*'. GH used segregated airspace for take-off & climb out and for recovery & landing, and it cruised and conducted missions above FL510 i.e., above all other manned aviation. ATM was provided by the same air traffic control units that provided military manned aviation and each flight was meticulously planned with particular attention paid to the selection of suitable airfields in case diversion or emergency recovery became necessary.

Hazards were further mitigated as GH deemed '*predictable'* insofar as it will do what it has been programmed to operate in a certain manner should a malfunction occur. GH does not have the kind of flight management system (FMS) common to manned aviation and is instead flown through a mission computer which is loaded with a mission plan before each flight. Indeed, if required, GH can fly a mission entirely automatically, from take-off to landing, a capability which makes it very predictable but is slow to respond to ATM commands. Malfunctions apart, and in the absence of intervention by the Pilot In charge (PIC), GH will therefore do - very precisely - what it is programmed to do.

The PIC had/has a copy of the mission plan with details of all planned eventualities that he/she could use in discussion with ATC on how best to resolve situations safely and pre-arranged telephone numbers were set-up to ensure continuous and consistent communications were possible in the event of the loss of radio communications[6]. Although a mission plan cannot be changed once GH is airborne, the PIC can manually fly the aircraft at any time, whether in response to ATC instructions or to accommodate ad-hoc tasking or for any other reason. Having thus intervened, the PIC can thereafter return GH to its programmed route[7].

EUROCONTROL considers that UAS integration into European airspace will be an incremental process and so the introduction of GH therefore forms an important and essential initial step in the successful accommodation and safe operation of this rapidly-emerging technology. However, because GH lacks some of the performance capabilities of manned aviation, a number of specific ATM arrangements tailored to its operation are required, which the Guidelines at Ref. 3 seek to address and which help to inform this study going forwards.

[5] Operational Air Traffic flights are all flights which do not comply with the provisions stated for General Air Traffic (GAT) and for which rules and procedures have been specified by appropriate national authorities. GAT flights are all movements of civil aircraft, as well as all movements of State aircraft, when these movements are carried out in accordance with the procedures of ICAO.
[6] This again is an emerging recommendation for accelerating 'Accommodation'
[7] However, this is not always going to be possible for other RPAS and must therefore be discounted as a generic hazard mitigation activity

A qualitative safety assessment was performed which assessed the GH concept, in a European operational environment, to be extremely low risk under normal working conditions due to the following two aspects of the design of GH operations:

1) the use of segregated airspace for the climb and descent phases of GH operations; and
2) the fact that the cruise phase takes place at an altitude at which no General Air Traffic (GAT) will be present and only a limited amount of Operational Air Traffic (OAT) traffic is present

In addition, a set of performance safety objectives were identified that were designed to ensure that, under normal working conditions (i.e. in the absence of failure), the risk of an accident due to GH operations is reduced as far as reasonably practicable.

The assessment also identified a further set of safety performance objectives that aimed to reduce the risk of an accident in the event of a system-generated failure by mitigating the consequences of such failures as far as reasonably practicable.

This high-level, generic safety assessment for GH was not able to achieve the specification of quantitative safety integrity requirements for the frequency of occurrence of the causes of system-generated failure. Therefore, it was not been possible to demonstrate generically that GH operations were/are at least as safe as those for manned OAT operations in non-segregated airspace. This has been left to the operating authorities for GH to demonstrate for their specific GH operations.

Clearly, the accommodation of Global Hawk into European skies was a major step forwards towards the eventual integration of RPAS alongside manned aviation but the approach is insufficient for MALE-type or Tactical RPAS since they are unable to fly high enough in cruise and are expected to be tasked to perform missions at much lower altitudes as well.

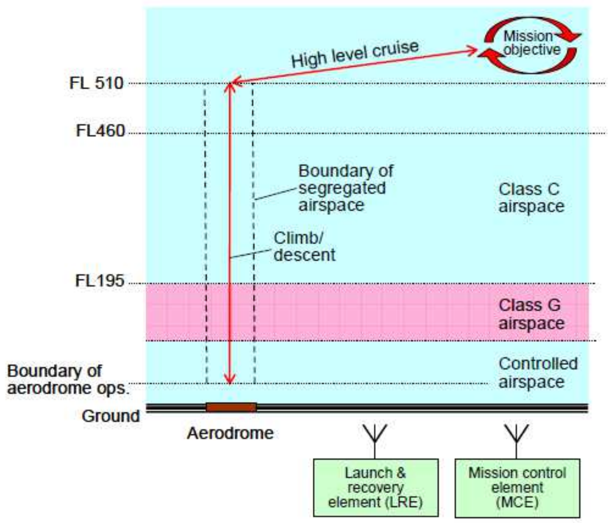


Figure 5 – Generic Global Hawk Flight Profile in European Skies[8]

[8] See Ref.3

The GH operations described above were/ are flown by the military, and are therefore classed as Operational Air Traffic (OAT). The Guidelines accordingly follow the same basic ATM principles as the EUROCONTROL Specifications for the Use of Military UAS as OAT, namely that:

a) UA operations should not increase the risk to other airspace users.
b) ATM procedures should mirror as much as possible those applicable to manned aircraft.
c) The provision of air traffic services to UAS should be transparent to ATC controllers.

Notwithstanding the above, there is a necessary degree of compromise in the Guidelines. Global Hawk was not originally designed with ATM in mind, so there are features of the UAS which are not readily compatible with how manned aircraft file and fly. This needed to be recognised and accepted in order to allow Global Hawk to operate in European airspace, though they were mitigated as much as possible. An example of such mitigation was in restricting Global Hawk to airspace where - other than in *extremis* - it was/is isolated from other traffic.

3.4 Tactical UAV Accommodation (Project CLAIRE)

This section is included for background information purposes only and does not form part of the MALE RPAS Accommodation Study

However, the integration of ATM Safety, RPAS Platform Safety and Organisational Safety have influenced the approach planned for the MALE-type RPAS Safety Assessment Methodology under development in this study

3.4.1 Objectives

Project CLAIRE was aimed at examining the issues regarding ATM and flying operations associated with the introduction of RPAS into civil airspace. The Project was undertaken by Thales, NLR and NATS as a series of complementary and incremental demonstration exercises, to validate safety case assumptions and develop procedures and mitigation actions based on their findings:

- Simulation, ground and TMA RPAS operations based on a mixed-traffic medium-sized airport including contingency operations
- Simulation, en-route (only) RPAS operations in controlled airspace including contingency operations
- Live RPAS flights in non-segregated (Class A) airspace using the UK Watchkeeper UAS

The demonstrations exercises allowed the investigation and assessment of:

- Suitability of standard ATM procedures to manage unmanned RPAS operations
- Interaction between RPAS Pilot and ATCOs
- Interaction (hand-over procedures) between ATM sectors for RPAS operations as well as GCS control hand-over
- Contingency management safeguards, processes and procedures for RPAS
- RPAS and ATCO workloads under a variety of conditions

These exercises were complemented with studies related to RPAS operations: safety, capacity, efficiency, airport integration & terminal airspace throughput, security, regulatory and collision avoidance.

3.4.2 Methodology used to 'Accommodate' an RPAS

The scope of Project CLAIRE was designed to 'push the boundaries' with a declared objective to operate a certified unmanned aircraft in non-segregated mixed traffic airspace environment. Air traffic controllers successfully interacted with RPAS pilots in a remote ground control station with normal voice communications using standard VHF radio relayed via the air vehicle. It was also a key requirement to integrate the RPAS within controlled airspace which was relatively busy and occupied by manned aircraft under ANSP (in this case UK NATS) control. An existing airway which carries regional and oceanic traffic over South Wales was used due to its representative traffic density and proximity to the West Wales trials area complex which is one of the operating bases for Watchkeeper flights in the UK.

An extensive, and very informative, programme of high-fidelity simulation exercises was undertaken to verify ATM procedures and unexpected behaviours associated with the approach and landing of RPAS in a mixed traffic environment and also flight of RPAS in mixed traffic non-segregated airspace. Scenarios exercised both normal operations and contingency (emergency) situations with findings used to optimise ATC and RPAS operating processes as well as de-risk live RPAS flights.

To ensure that the overarching safety objective ***("UAS should be no more hazardous than the equivalent manned aircraft operating in the same airspace")*** was achieved; a significant amount of effort was expended working with the civil and military regulatory authorities (CAA & MAA). It was necessary to develop an acceptable Safety Case for both Watchkeeper flight in non-segregated airspace as well as for provision of ATC separation assurance services within the airspace itself. NATS were responsible for airspace safety assurance which was applied using the NATS ATC Safety Analysis process as well as issuing Temporary Operating Instructions (TOI), which were approved by the UK CAA. Draft ATM processes and procedures were refined and optimised in the simulation facilities to mitigate any procedural gaps, hazards or risks associated with RPAS operations.

The Thales Flight Operations Organisation (FOO) is responsible for operating Watchkeeper on a Military Flight Test Permit (MFTP) for development purposes. Similarly, a revised Trials Risk & Hazard Assessment (TRHA) process[9] was undertaken (and approved by the Type Airworthiness Authority) to address the additional complexities of flying in non-segregated airspace. The assessment process covered aspects such as ATC interaction; aircrew licensing and platform CNS equipment. The process included the generation of a Waiver (approved by the MAA) to meet Regulatory Articles (RA) associated with the current non-availability of an approved RPAS detect-and-avoid system without recourse to an on-board safety pilot.

[9] The TRHA augments the air systems safety case and flight operations risk register as explained in Section f)

Flights were authorised subject to:

- Provision of a full ATC service at all times and ATC separation for IFR operation
- No flight in non-segregated uncontrolled airspace, even in the event of catastrophic failure
- Establishment of a Temporary Danger Area, below the airway, with ANSP controlled access to mitigate against air vehicle descending out of Class A airspace in emergency situations

A number of significant challenges were successfully overcome in areas such as securing acceptable insurance premiums and developing new Instrument Rating (IR) approvals for RPAS pilots operating in non-segregated controlled airspace. The feedback was encouraging with evidence assimilated to show that that it will be possible to safely integrate and control RPAS in non-segregated airspace from an ATM perspective. There is still much work to be completed but there is potential for safe, more routine and economically viable unmanned flight using larger and more capable platforms within emergent regulatory frameworks and institutionalised operating standards.

For more information on Project CLAIRE and/or for greater detail, please refer to Reference 20.

3.4.3 How does this advance the concept of Accommodation?

Project CLAIRE advanced the concept of RPAS Accommodation by covering the following points:

- Route definition approaches, avoidance of complex airspace and flight over significant population and/or national infrastructure
- Scenario Definition – malfunction testing and contingency management
- Airport surface operations – exploring potential disruptions and ATC handling procedures
- Live flight planning & flying approvals
- Requisites to access to non-segregated airspace – permissions and access control
- Air traffic control sector hand-over
- Risk assessment safety methodology

The following table summarises the demonstration objectives covered by Project CLAIRE and the success criteria employed which can be used to further inform the development of the Generic RPAS Accommodation Scenario (albeit limited to a Tactical UAS not a MALE-type) and to help shape the Simulation exercises during the next stages (Tasks 2-4 inclusive) of the project:

Table 1 – Project CLAIRE Demonstration Objectives and Success Criteria

Objective	Demonstration Objective	Success Criterion
001	Preparation and de-risking of live flight	No additional risks identified or clear mitigation approach
002	Clarification of regulatory requirements for RPAS flight in non-segregated airspace	Training and assessment plan complete
		Regulatory approval for live flight achieved

<table>
<tr><td>003</td><td>Confirm procedures to be used during live flight</td><td>All participants agree to progress live flights</td></tr>
<tr><td>004</td><td>Development of Emergency Procedures</td><td>All participants clear on actions required in an emergency</td></tr>
<tr><td rowspan="9">005</td><td rowspan="9">Fly RPAS in multi-agency, mixed traffic non-segregated environment</td><td>High level CONOPS for UAS flight in controlled airspace incorporating:
• Contingency Procedures for Lost Link
• Radio Comms Failure Procedures
• Transponder Failure Procedures
• Emergency Procedures</td></tr>
<tr><td>RPAS flies in segregated airspace</td></tr>
<tr><td>RPAS flies in controlled airspace (A-E)</td></tr>
<tr><td>RPAS flies in uncontrolled airspace (F-G)</td></tr>
<tr><td>RPAS is handed over from one ATC agency to another</td></tr>
<tr><td>RPAS demonstrates lost-link contingency procedures</td></tr>
<tr><td>RPAS demonstrates radio communications failure procedures</td></tr>
<tr><td>RPAS operates with transponder failure</td></tr>
<tr><td>RPAS demonstrates emergency procedures</td></tr>
<tr><td rowspan="2">006</td><td rowspan="2">RPAS operates at a medium-sized airport</td><td>High level CONOPS for UAS airfield operations incorporating:
• Contingency Procedures for Lost Link
• Radio Comms Failure Procedures
• Transponder Failure Procedures
Emergency Procedures</td></tr>
<tr><td>RPAS takes off from non-segregated runway</td></tr>
<tr><td>007</td><td>RPAS operates in a mixed-traffic, non-segregated environment</td><td>RPAS operations are all in a mixed traffic environment.</td></tr>
<tr><td>008</td><td>RPAS Taxiing Capability Investigated</td><td>RPAS taxis from parking area to runway under ATC instruction.</td></tr>
<tr><td>009</td><td>Identify security threats to RPAS ground operations</td><td>Security requirements clearly identified.</td></tr>
<tr><td>010</td><td>Assess the impact of inbound/outbound RPAS flight operations in the TMA on air traffic management procedures, safety and controller workload</td><td>RPAS inbound/outbound flight operation impact assessment performed</td></tr>
</table>

011	Quantify minimum RPAS flight performance requirements without impacting airport throughput significantly for departure and arrival RPAS flight operations	Performance requirements quantified
012	Assess the impact of RPAS runway vacation procedures including interaction with other departing & arriving traffic	Performance requirements quantified
013	Assess the impact of RPAS start-up and take-off procedures for airport surface operation management and airport capacity	Start-up and take-off procedures impact assessment performed
014	Assess the impact of D&A for RPAS TMA operations taking into consideration wake turbulence and meteorological conditions	D&A impact assessment performed
015	Define and assess impact of RPAS lost link procedures on airspace management procedures, safety, and controller workload	RPAS lost link procedures defined and impact assessment carried out.
016	Assess and demonstrate RPAS trajectory exchange with ATC for optimizing inbound traffic flow	RPAS – ATC trajectory exchange assessed
017	Assess the impact of RPAS re-routing procedures to avoid bad weather on airspace management, safety, and controller workload	Impact assessment of RPAS TMA re-routing procedures established
018	Raise awareness regarding SESAR activities and objectives to stakeholders	Demonstration sessions to stakeholders given.
019	RPAS operation in mixed traffic, non-segregated ground environment	Impact to other traffic is identified.
		Loss of control procedures are tested
		Loss of Comms procedure demonstrated
020	RPAS taxi from landing point to parking area	RPAS taxis from runway to parking stand under ATC instruction
021	The successful take off, transit and landing of a MALE/HALE platform from one country to the next.	High level CONOPS for cross border operations prepared

		Successful take off of the RPAS from a non-segregated airport.
		Successful transit of RPAS in Class A airspace
022	Assess the handover procedures and processing between ATC sectors, FABs and GCS	RPAS handover procedures between sectors and FABs prepared
		Identification of issues and approaches associated with RPAS transit between sectors and FABs
		Identification of issues and approaches associated with handover from one GCS to another
023	RPAS transition from En-route to TMA operations	Successful routing through the airspace to TMA and subsequent landing

3.5 Detect & Avoid

ICAO defines RPAS Detect and Avoid (hereafter referred to as DAA) as "the capability to see, sense or detect conflicting traffic or other hazards and take appropriate action". In general terms the concept of DAA comprises two components, these are often referred to as the secondary and tertiary layers of separation assurance in addition to strategic procedural separation assurance (planning and airspace structure);

- **Safe Separation** – is the ability to reduce the probability of collision by ensuring aircraft remain 'well clear' of each other (tactical separation assurance)
- **Collision Avoidance** – is the ability to perform 'last ditch' manoeuvres immediately prior to the closest point of approach to prevent collisions in instances where safe separation is lost

In essence DAA capabilities may be delivered by a variety technical solutions as well as operational procedures, whatever mitigation approaches are applied it is widely recognised that DAA will be a key enabler for RPAS integration into non-segregated airspace. However, despite a number of well publicised and highly beneficial demonstrations of enabling technologies and procedural measures, there remains a lack of certified on-board RPAS capability to ensure safe separation and reliably detect and avoid other airspace users in cognisance of an harmonised set of aircraft equipage standards. Other related challenges, that also need to be considered include (but are not limited to), a harmonised regulatory and certification approach, agreed policies and procedures on safety-level requirements and ATC interaction as well as equipage, training and licencing requirements.

Current DAA systems employ a number of sensing approaches to detect the presence and position of intruders as well as predict their speed and trajectory. Advances in both co-operative techniques (such as equipment miniaturisation and fidelity of transmitted data using Automatic Dependant Surveillance Broadcast (ADS-B) technologies) and non-cooperative sensing (using both passive and active sensing combined with multi sensor fusion) have resulted in improved detection performance;

a decrease in false alarm rates and a reduced computational processing burden. Advanced mathematical algorithms are now able to generate optimal avoidance manoeuvres based on host platform performance thresholds as well as changes in intruder position, bearing and velocity.

As work continues to define and standardise a DAA solution, the RPAS Accommodation Study will assume that no such capability will be generally available for larger platforms operating in mixed traffic environments during the agreed study lifecycle. However, alternative means of ensuring safe separation are possible to enable specific RPAS flights in specific operating environments – it is recognised that more elaborate and sophisticated risk mitigation approaches will be available as technology develops and operating standards evolve.

In the absence of a DAA capability, a number of alternate approaches to enable RPAS operations (subject to conditions imposed in granting a waiver or exemption), have been authorised based on the generation and acceptance of a suitable safety case whereby the risks of non-compliance are mitigated. Restrictions may vary from a regulatory body insisting on flight within the operators' visual line of sight; using manned aircraft to tail the RPAS or occupancy of very quiet / non-complex airspace etc. For example, in 2005 the FAA announced initial policy regarding domestic RPAS flights in the national airspace underpinned by mitigation measures such as the introduction of a reversionary system to ensure the aircrafts safe recovery in the event of a 'lost-link' situation. In Europe RPAS operations below 150kg are subject to a set of national regulations which are typically sub-divided into a number of categories based on MTOW, equipage standards and operational thresholds – flying restrictions are applied according to various parameters including RPAS operating distance; pilot training/qualifications and certification (COA) etc.

Initial BVLOS operations are already being conducted in several European nations (for experimental, training and operational purposes) using a variety of methodologies and risk-based approaches. In addition to the Global Hawk transit flights in Europe and MALE RPAS operations carried out in France (as described within the body of this document) notable examples include;

- **Switzerland** – who has developed its own set of national airspace regulations for both military and civilian operations based on the former Joint Airworthiness Authority (JAR 23 and JAA VLA), adapted to accommodate RPAS (specifically Ranger) operations – provisions included flight-critical system redundancy and emergency parachute. In the absence of DAA the Swiss Air Force presently conducts day time operations with a chase plane in non-segregated airspace, night time operations are conducted without a chase plane. The current system will be replaced by the Hermes 900 MALE platform by circa 2020.
- **United Kingdom** – has undertaken several BVLOS flights in non-segregated airspace as part of the SESAR RPAS experimental programme using the WKPR TUAS to demonstrate ATC interaction; develop contingency management procedures; address RPAS equipage and pilot licencing requirements and safety case approval. Flights were restricted to en-route phases in controlled airspace with some temporary 'buffer zones' established to safeguard against intrusion into adjacent uncontrolled airspace. Future MALE operations will be undertaken in designated airspace likely to be assigned to support accommodation approaches, details pending further MOD assessment.

- **Italy** – is operating RPAS from a number of vehicle test ranges including the recently announced facility at Taranto-Grottaglie airport which has been authorised by ENAC (Italian CAA) to conduct unmanned systems flight testing in airspace to be managed by NOTAM instructions. Suitable low-traffic density airspace and ground infrastructure has been established over land and sea to support a number of military and civilian UAS research programmes and initiatives. The Italian Air Force operates MALE RPAS to support several Intelligence, Surveillance, and Reconnaissance (ISR) missions in Italy, over the Mediterranean, and in support of NATO operations and was amongst the first nations in Europe to have achieved RPAS airworthiness certification for specified operations.

3.6 Future Need for MALE-type RPAS Accommodation

Throughout Europe, EU Member states are already operating or are planning to operate MALE-type RPAS soon and so the need for Accommodation leading to Integration is becoming ever more urgent. Current initiatives are widespread and include;

- UK, France, Spain, Netherlands all plan to procure variants of the General Atomics Predator-B
- France, Germany, Spain and Italy are all collaborating to develop the Euro MALE
- UK & France are collaborating to develop a UCAV (Unmanned Combat Air Vehicle) Technical Demonstrator which, if taken forward into production may present an additional complication to RPAS Integration due to specific design elements that might make it difficult to detect and track using conventional ATM radar systems.
- Air Forces in France and Italy already operate the GA-ASI Predator or Reaper and Germany has been operating the IAI Heron 1s moving to Heron TP in the near future

3.7 The Generic Accommodation Scenario

3.7.1 Starting Point

The preliminary Generic RPAS Accommodation scenario is defined (in the original call for tender) as:

The RPAS operates a transit in peacetime from a military airfield to a zone of operations or designated training area. Both areas (airfield and operations or training areas) are segregated airspace volumes. The transit takes place in a non-segregated airspace under a civil air traffic control (for example in airspace A to C).

The ground risks are evaluated for BVLOS operations over a sparsely populated environment (over-flown areas uniformly inhabited) and away from critical infrastructures.

The air risks are evaluated for flight plans that avoid high-density and complex airspaces, the following assumptions will apply:

- *Operations away from very busy corridors and always above a minimum flight level (FL)*

- *Operations away from major airways and aerodrome traffic patterns, and*
- *Operational time restrictions to avoid air traffic density peaks.*
- *Terminal and mission areas are segregated.*

The scenario indicates target air traffic densities and assures all other elements are in place to reduce the overall operational risk.

Lower altitude operations (i.e. the mission area) and terminal operations, including the main portion of the descent, is performed in a segregated airspace. In addition, in terminal operations there is a barrier identified: the RPAS is supported with extended and sufficient primary surveillance in terminal areas.

Therefore, the assessment of the initial operations of military RPAS IFR in the Accommodation phase is focused on the following particularities of RPAS operations:

- *Loss of safe separation and*
- *Degradation (potentially 'loss') of the Command and Control link*

The probability of a loss of safe separation is reduced by different means.

- *First, the transit in non-segregated airspace is carried out under ATC control in class C airspace. In this situation, the ATCO is responsible for provision of separation assurance services, and no non-cooperative air traffic is expected.*
- *Second, this probability is further reduced by operating in low-density airspaces (time, less congested airways, and altitude restrictions).*

Thus, no specific or single barrier is currently envisaged to mitigate the threat of loss of safe separation.

Concerning the data-link degradation threat, data-link performance requirements are mainly driven by the Required Performance Communication between the Remote Pilot and ATCO. Ground based communications are currently being evaluated as the main enabler to ensure Remote Pilot to ATC communication when the primary data-link is degraded. When the degradation of the data-link performance starts affecting the RPA command and control, other solutions - mainly those based on automation and development of link loss emergency procedures - should be developed and implemented.

The generic accommodation scenario flight profile is illustrated below:

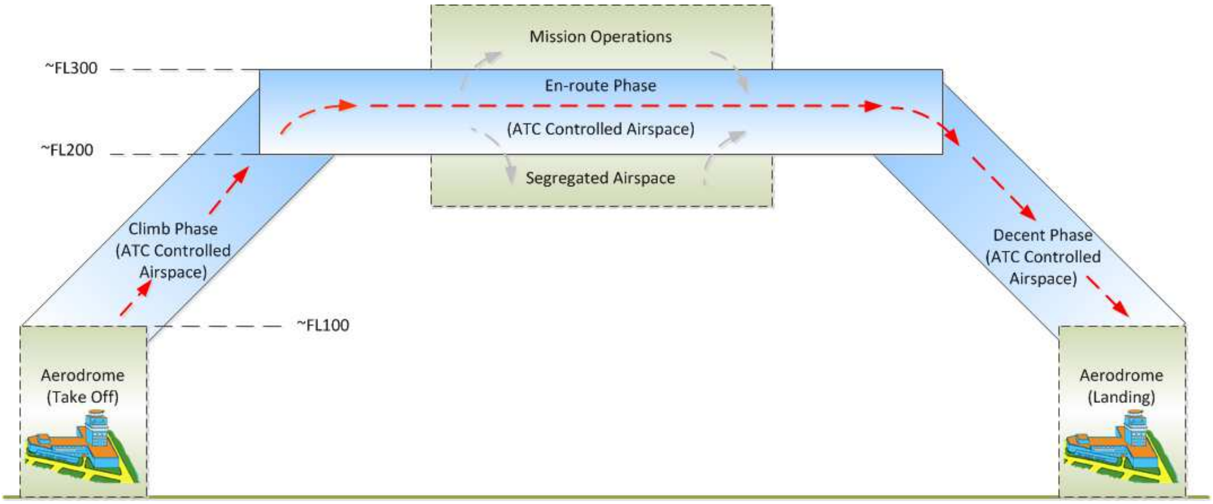


Figure 6 – Flight Profile for the Generic RPAS Accommodation Scenario

3.7.2 Development & Enhancement

The generic accommodation scenario requires the use of segregated airspace under the control of ATM/ATCO and is a good start point to explore the issues of ground and air risk. In order to develop the concept of 'Accommodation' further it is necessary to find ways to allow MALE-type RPAS to share controlled airspace with manned aviation and progressively fly over more densely populated areas and occupy more complex airspace.

In general terms, air risk relates to dangers to or from other air traffic and ground risk relates to danger to people, property, infrastructure and/or the environment on the ground caused by a malfunction in the air.

In Task 2, the generic accommodation scenario will be developed by introducing elements of complexity to form the 'consolidated' generic accommodation scenario, elements of which will be selected for implementation scenarios to be simulated. Examples of complexity elements may include but are not limited to;

- Including the use of Civilian aerodromes
- Relaxing the limitations placed upon air traffic assumptions by including operations in non-segregated airspace – such as complex airspace structures and areas of heightened traffic densities
- Developing the assessment of Ground risk to include flight over more densely-populated areas and closer to critical infrastructures
- Widening the operational time windows to include peak times and uncertain traffic flows
- Demonstrating the ability to cope with environmental impacts such as adverse weather
- Including a Statement of Assumptions relating to regulation and certification (of people, systems, equipment and support services)
- Adding an analysis of the use of platform equipage options (such as Detect and Avoid and CNS items)

3.7.3 Assumptions

The following is a current set of identified Assumptions emerging from the analysis of the Generic Accommodation Scenario. The initial assumptions list is not exhaustive but provides the basis for quantitative analysis to be undertaken in order to undertake a risk assessment. Other assumptions may be introduced into the assumptions register to support this approach – these may include factors such as platform performance data; applicable flight rules, ATC interaction and more complex encounter types:

a) RPA is certified as Airworthy
b) Remote Pilot is trained /Suitably Qualified & Experienced Personnel (SQEP) and licenced/approved
c) Mission Objective Operations take place in Segregated Airspace
d) SATCOM is used for BLOS/BVLOS
e) Ground communications are in place for back-up between ATCO and GCS however routine communications will be via normal VHF radio
f) RPAS execute a standardised & will always exhibit predictable protocol for lost-link behaviour. Note: This is an emerging recommendation designed to help meet assumption f)
g) Use of SERA (Standardised European Rules of the Air) to support the implementation of functional airspace blocks and principles of SES necessary to enable the free the movement of aircraft and RPAS cross-border operations
h) RPA is capable of supporting the operating requirements of the proposed flight profiles in terms of Performance, Communications and Visibility to ATC. Necessary equipage includes availability of Mode-S Transponder; VHF Radio (relay) as well as mandatory CNS equipage
i) RPA is able to comply with the Rules of the Air
j) DAA capability is not available due to immature enabling technologies and non-availability of CONOPS and performance standards

4 Safety Case Assessment Methodology

4.1 Introduction

Team SIRENS proposes a Safety Case Assessment Methodology based upon current best practice. The baseline is drawn from Tactical UAS operations in the UK and can therefore be seen in action with a military RPAS. There was significant input to this methodology from a civil aviation perspective as one of its key authors had spent several years working for a commercial airline in a flight safety role. This methodology has been adapted (made more generic) in order to be applicable to MALE-type RPAS in both military and civilian domains. In general terms the MALE RPAS Accommodation Safety Case will comprise three principal tenets namely Organisational / Operational; Platform (inc. Equipage) and Air Traffic Management (ATM). As illustrated below, these contributing elements are equally important. are intrinsically linked and should not be regarded as separate exercises.

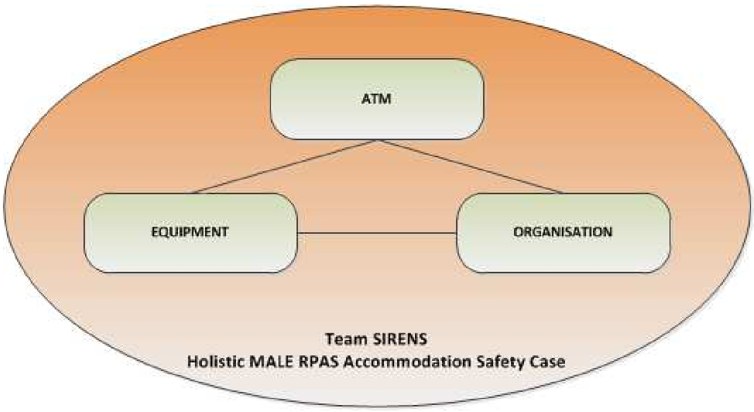


Figure 7 – Key Tenets of MALE RPAS Accommodation Safety Case

This baseline will be modified and enhanced as the study progresses in consultation with stakeholders and wider communities of interest

4.2 Safety Case

The Safety Case methodology currently adopted within the UK Military Air Environment (MAE) and endorsed by the Military Aviation Authority (MAA) utilizes an ***Air System Safety Case (ASSC)*** which is underpinned by a body of evidence and thus acknowledges that the UAS is 'Safe To Operate' and demonstrates the airworthiness for flight and approval to conduct the intended flight operations. The principles of this approach are largely shared with other member states and its generic application; in terms of airspace management and regulatory frameworks, is considered feasible by the study team. The suggested methodology has been successfully applied to underpin current RPAS flights in a 'real-world' and operationally representative environment. The UK regulatory process is jointly governed by the MAA and the CAA who are proactive members of European and Global regulatory communities including ICAO UAS WG; EUROCAE WG's and JARUS which safeguards alignment notwithstanding individual member state rights and responsibilities.

One of the evidence artifacts is the Flight Operators Risk Register (FORR) which identifies and mitigates identified Risks to Life (RtL) to a level which is at least ***As Low As Reasonably Practicable (ALARP***) and Tolerable (see Table 2) for the intended operation. Other evidence artifacts for the ASSC would be Certificates of Airworthiness (CofA), Records of qualification for Operators (Aircrew) and Maintainers, a Design Safety Case (DSC). It is worth noting at this stage that the ASSC is not a formal or complete DSC - it is best regarded as a collection of safety artifacts which support a particular operational requirement. It is important that safety related evidence is sourced from a variety of contributors so as to underpin the ***Air System Safety Case (ASSC)*** for a particular type of mission underpinned by a robust operational risk assessment.

An airspace safety assessment is considered through the Quantitative assessment of Risk to life via the ALARP and Tolerable arguments that are identified. An assessment of risk tolerability for the given task should be sympathetic with a success-based approach identified within the SRM Methodology (see Section 2.2.m and Annex B.25). With this, if the tolerability falls into the intolerable region the success criteria have not been met.

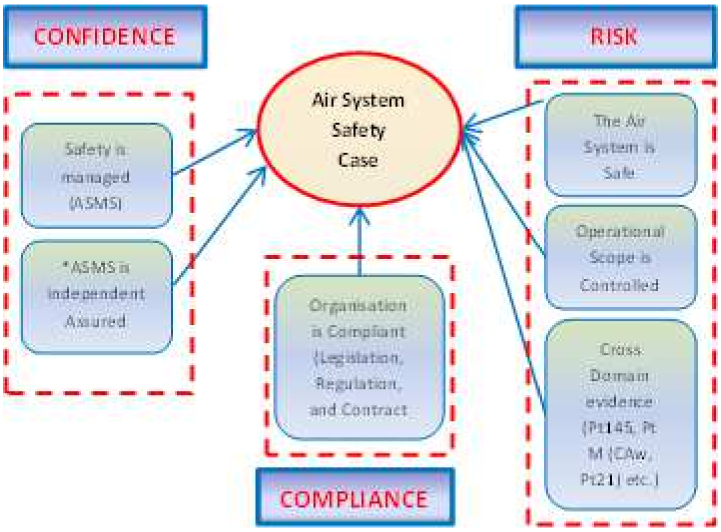
The impending scenario and simulation phases will aim to identify the success criteria and tolerability argument methodology which will allow accommodation of MALE RPAS to fly in controlled airspace.

The assessment of risk will be consistent with manned aviation however, taking into account the alternate complexities associated with unmanned aviation. Demonstration of this methodology will be taken place throughout the simulation phase in Task 3 & 4 of this project.

The process carries out an independent assessment on the Risks to Life (RtL) of UAS operations, this independence is assured by a suitably qualified individual (safety assessor) who has been granted organizational independence and is solely responsible the accountable manager so as to safeguard against any conflict of interest. The process of determining RtL is designed to cover all aspects of activity conducted with the RPAS with the overall output of the hazard identification and risk assessment being an Air Safety Statement, certified by the Accountable Manager[10], which is supported by an ASSC.

The ASSC is a structured Claim, Argument, Evidence (CAE) safety argument which is supported by a series of evidences, demonstrating that the aviation operations are at least ALARP and Tolerable with respect to RtL. This is focused around Confidence, Risk & Compliance. A high-level depiction of a generic ASSC is given below.

[10] The single individual who is designated as the person responsible to the regulatory authority in respect of the functions which are subject to regulation and safety of an air system



*ASMS – Air Safety Management Plan

Figure 8 – Generic ASSC

There are three main facets to be addressed within an ASSC:

a) Description of how confidence is gained so that the true RtL is known and that it continues to be managed;

b) Description of the operating risks and how they are being managed to an acceptable level; and,

c) Assurance that the flying organization and risk management is compliant to the necessary requirements be they statutory, contractual or adoption of 'good practice' standards.

The ASSC facets form the arguments of which evidence must be identified. A typical ASSC will have all artifacts which support the top level claim that the UAS is safe and the Operator is sufficiently competent to operate the system. This supports Acceptable Means of Compliance (AMC) or Alternative Acceptable Means of Compliance (AAMC) to relevant legislation, regulation & standards. Below (**Error! Reference source not found.**) is an example of a typical ASSC CAE diagram showing the top level claims and arguments for which evidence artifacts must be produced to support (Note: It also identifies the context in which the Top level claim is placed). Essentially the ASSC details all of the underpinning safety artifacts which have been detailed as required for authority to carry out operational flying.

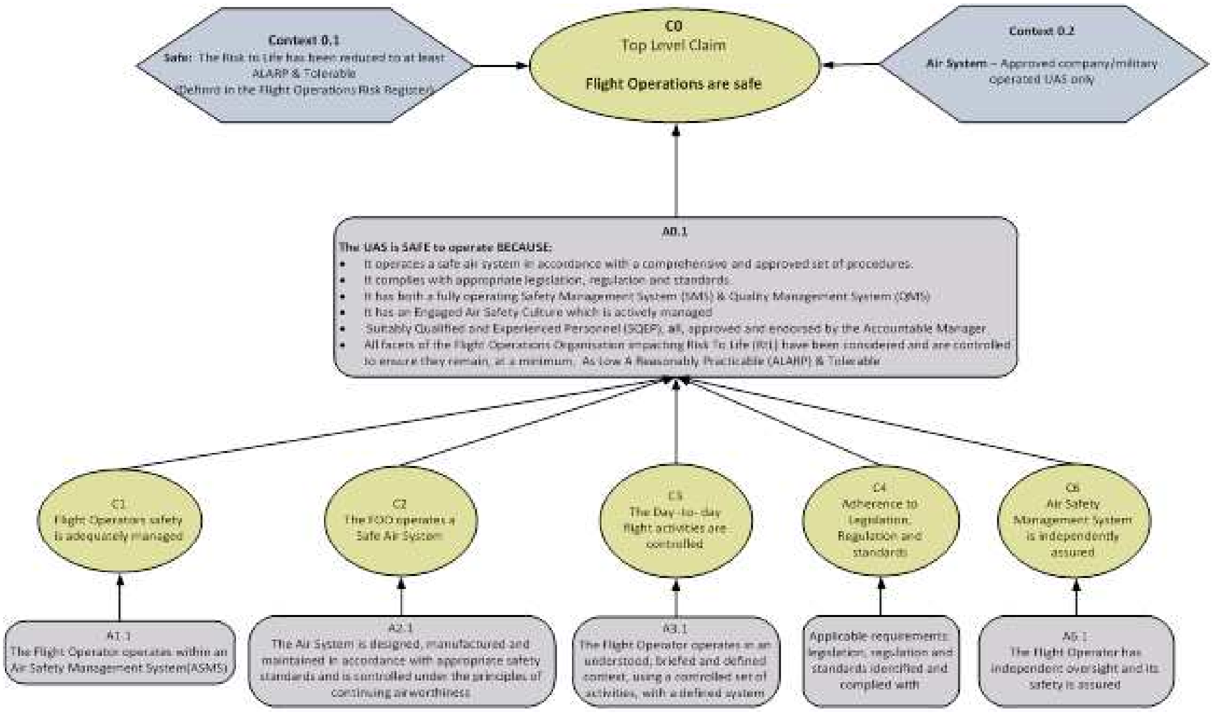


Figure 9 – Example ASSC

4.2.1 Assessing Risk - Methodology

The study ASSC is predicated upon use of a Flight Operators Risk Register (FORR), which is the record of all operational hazards, in the form of a BowTie analysis, identified within the operation of the UAS which have an effect on Risk to Life (RtL). Regulations & policy detail the regulatory requirements for Owning and Managing RtL and the requirement of operators to maintain and update on a regular basis. It provides an agile approach that can be quickly reassessed to support changes to the CONOPS, mission plans and countries of operation as directed by the tasking authority.

This analysis must be carried out by a Suitably Qualified & Experienced Person (SQEP), from all disciplines (Design, Engineering/Maintenance, Training, Operating Crew and Safety etc.) in order to ensure a credible Risk Register is in place to support Flying Operations.

In the example case the analysis has been carried out using a Risk Management BowTie XP software tool, supplied by CGE Risk Management Solution, which allows hazards & risks to be assessed and ultimately understood. It also allows an assessment of risks to ensure that they remain ALARP & Tolerable:

a) BowTie XP allows assessment of Risks/Hazards using a barrier methodology. Threats are identified which could cause the Top Level Event (TLE) to occur, which in turn will lead to the Hazard. Barriers (or controls) are identified which serve to mitigate and protect against the threats which could result in the increased Risk to Life. Consequences are also identified to understand the level of RtL which could result from Hazard. **Error! Reference source not found.** below illustrates the visual representation of the BowTie methodology.

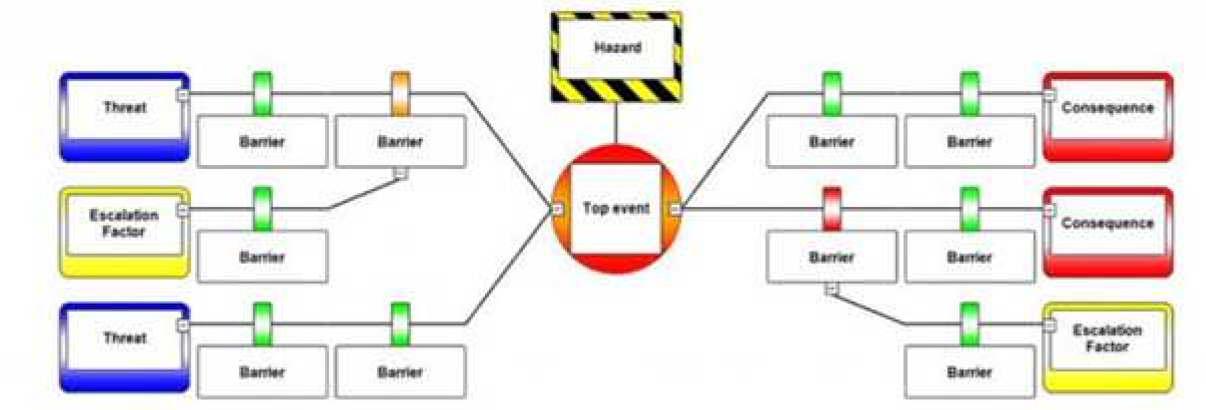


Figure 10 – Bow Tie Methodology (Framework)

b) The BowTies are analysed using a semi-quantitative analysis approach whereby Layers of Protection Analysis (LOPA) is used for analysing and assessing risk of Barriers & Controls. It uses an order of magnitude technique to evaluate the adequacy of existing or proposed layers of protection against known hazards in particular looking at event frequency, consequence of severity and the likelihood of failure. This allows determination of:
   a. If there are sufficient layers of protection against an accident scenario; and,
   b. Are additional independent protection layers required?

All hazards & TLE's identified are to be assessed using the BowTie methodology during the latter phases of this study.

4.2.2 Management

The FORR will be managed on behalf of the Accountable Manager, as detailed in an Air Safety Management Plan, and used as an artefact for the ASSC in order to provide assurance that the Risks to life have been mitigated to ALARP & Tolerable.

Typical Top Level Events (TLE's)/Risks to Life (RtL) are split between Ground and Airborne events (Note: these are not exhaustive but demonstrate a range of TLE's that may be considered):

Ground:

a) Uncontrolled Air Vehicle (AV) on the Ground
b) Runway Incursion
c) Unrestrained AV
d) Propeller damage or FOD (Foreign Object Damage)
e) Radio Hazards (RADHAZ)
f) Exposure to Lasers

Airborne:

a) Loss of Separation with the Ground - Emergency Landing

b) Loss of Separation with the Ground – Controlled Flight into Terrain (CFIT)
c) Loss of separation with the ground – Uncontrolled descent
d) Debris falling from AV during flight
e) Exposure to Lasers
f) No-Comms due to irrecoverable Loss of Data Link/Satellite Comms
g) Loss of Separation with Other Air Users – Mid-Air Collision (MAC)

Threats will be identified that could cause the top level events to occur. Barriers will be identified in order to mitigate the likelihood of the Threat leading to the TLE occurring. Please note that the Barriers are sympathetic with the Tactical mitigations used within SORA and other, similar methodologies.

4.2.3 Safety Risk Assessment Process

The overall process (**Error! Reference source not found.**) aims to show the progression from a starting position of no flying operation risk knowledge (on the left hand side of the diagram) to a fully substantiated risk argument facet (in the middle) to an ASSC allowing Accountable Manager approval of an Air Safety Statement and hence permitting the activity (lower right corner). The process aims to demonstrate the processes of Hazard ID, Safety Risk Management, the ASSC & Air Safety Statement[11] approval and certification. This process provides the Safety & Risk Management baseline for the UAS being operated.

[11] Air Safety Statement – Following the provision of supporting ASSC safety artefacts and completed FORR the Air Safety Statement provides the final approval to conduct flying operations from the Accountable Manager.

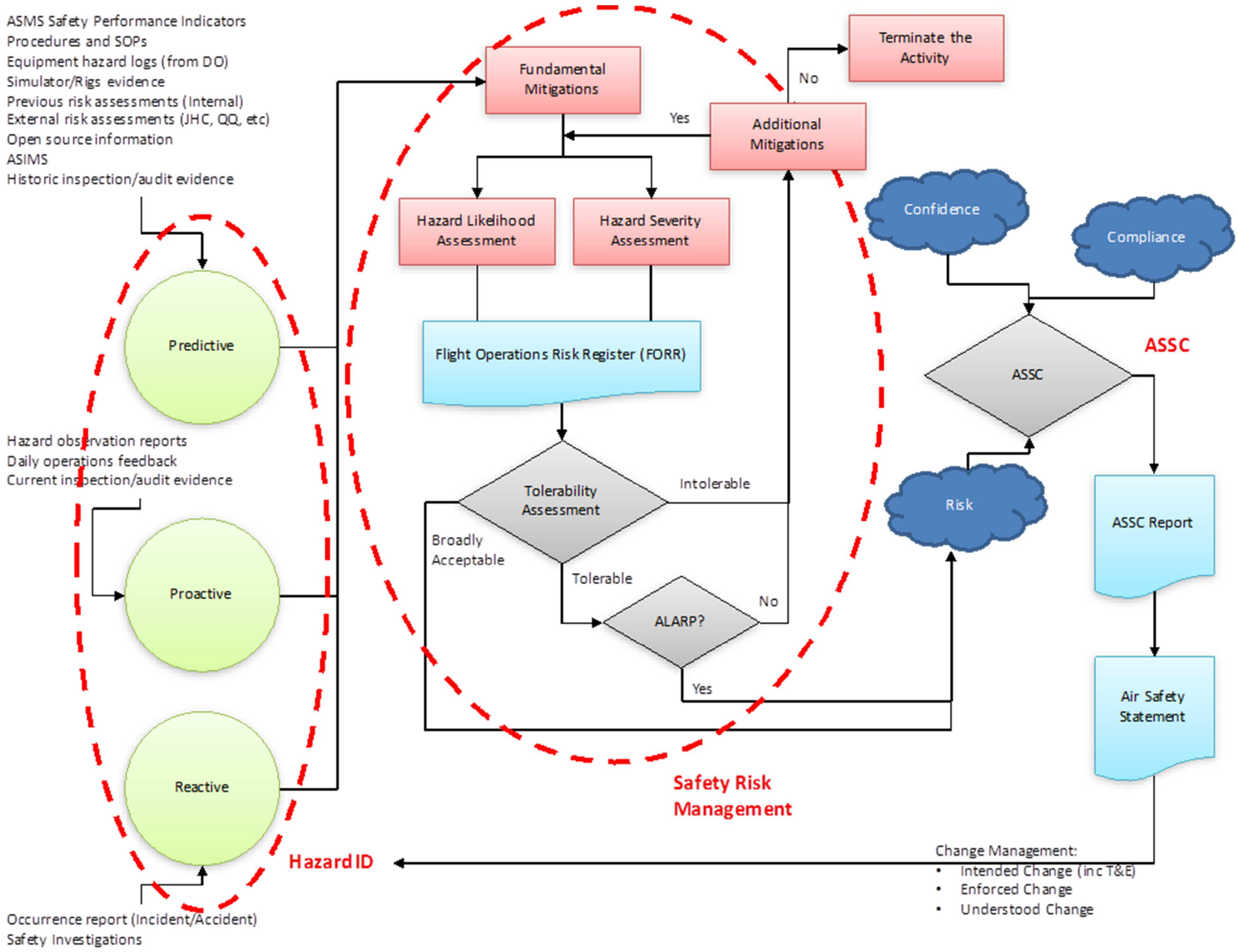


Figure 11 – Safety Risk Management

The basic logic steps for Figure 11 are listed and expanded below:

Hazard Identification:

The use of predictive, proactive, reactive identification techniques and information from other sources to understand the hazards the activity poses.

Safety Risk Management: Identification and understanding of RtL associated with operating the UAS:

Flight Operator Risk Register: Likelihood and severity assessment of the identified hazards to understand the residual risks posed to 1st, 2nd and 3rd parties[12] by the flying operation. Fundamental mitigations, such as basic aircrew training & proof of Airworthiness, are taken as having been applied at this stage. At this point the risk has been understood to be credible and is to be entered in the FORR. Further FORR detail is populated during the remainder of the process.

[12] **1st parties** - Aircrew (Pilots) **2nd Parties** - Other personnel working on aircraft, or ground crew, or flying as duty passengers **3rd parties** - The general public and personnel who do not fall within the categories of 1st & 2nd parties

Tolerability Assessment: Understanding whether the risk is broadly acceptable without further mitigation, whether the risk is tolerable and an ALARP argument is required, or whether the risk is intolerable without further mitigation. This aspect can become iterative with Risk Understanding until the risk can be tolerated or must be terminated.

ASSC Support to Air Safety Statement: The provision of the safety artefacts which provide a robust base level of assurance to support operation of the UAS. Once complete, and endorsed by the Accountable Manager, the ASSC is discussed along with the detailed FORR in order to provide the Accountable Manager sufficient assurance to approve the flying activity via an Air Safety Statement.

Review and feedback:

ASSC Maintenance and Feedback: Regular reviews to ensure that the ASSC remains ALARP & Tolerable and valid for the intended operation through routine and non-routine, reviews of the Safety artefacts and FORR for legitimacy. Steady state flying activity still requires feedback through the routine occurrence reporting channels in order that new risks are identified and existing risks are maintained.

4.2.4 Risk Mitigation

For each Single Risk, mitigations in the form of barriers are identified and recorded in the FORR aimed at bringing the risk to a level that is at least ALARP and Tolerable. The process of mitigation and risk boundary assessment may be iterative if the risk is initially assessed as intolerable or not ALARP.

The most common risk mitigation strategies are:

a) **Terminate:** Decide if this risk is justified, if not, the activity should be terminated. [Intolerable, or Tolerable but cannot be made ALARP]
b) **Transfer:** Escalate understanding of the risk if it requires additional resource to mitigate to ALARP, including production of ALARP argument. [Tolerable]
c) **Treat:** Mitigate the risk to ALARP and Tolerable, including production of ALARP argument. [Tolerable]
d) **Tolerate:** Decide if the residual risk is tolerable without further mitigation. [Broadly Acceptable, or ALARP and Tolerable]

4.2.5 Risk Assessment Assumptions

A set of assumptions will be required in order to provide a baseline for the LOPA calculations for each of the barriers. The list below is an example of assumptions that may be required (note this list is not exhaustive):

a) Total Air Vehicle Flying Hours & number of Flights
b) Average Annual Flying Hours & number of Flights

c) Average flight hours per flight

d) Time per take-off & Landing roll

e) Population densities of over-flight areas- there is a potential for injuries to people on the ground, risk levels may be assessed depending on appropriate flight planning considerations and the reversion modes of the RPAS following technical failure

f) Air traffic densities of occupied airspace – there is the potential for injuries to people in the air and on the ground resulting from collisions and/or necessary avoidance action and so risk levels will be assessed depending on appropriate flight planning considerations

g) Design assurance levels

h) Standard Human error rate

A generic example of how these will be used in a qualitative assessment may be as follows:

Top Level Event: Uncontrolled AV on the ground

Threat: Environmental Conditions on Landing and Take-off - The threat could cause the UAV to skid off the runway. (An environmental condition means primarily wind in this case. Wind unexpectedly exceeds limits on landing)

Quantitative analysis:

No known occurrences in 704 fights carried out equating to 1254.44 flying hours

Assume 1 event in per 1000 flying hours = 1.0E-3 pfh.

Time at risk to be added to the calculation for both take-off and landing:

- Take-off and Landing assumed to be 20 seconds each;
- Average sortie length equals 2.1 hrs

Therefore 40 seconds/ (2.1hrs x (60x60)) = 5.3E-3

Multiply 'Time at risk' by 'per flying hour rate' - 1.0E-3 x 5.3E-3 = **5.30E-6**

4.2.6 Risk to Life and Tolerability

Within the BowTies, each of the TLE's are to be assessed against the consequences of the event happening. Consequences will be identified and assessed against the RtL or injury to 2nd & 3rd parties (1st parties not assessed due to the 'Flight Deck' being located on the ground within a Ground Control Station (GCS)) and further assessed within the HRM (refer to section 4.2.7) risk classification and subsequent identification of ownership level for the Risks[13].

[13] 1st party means flight crew or passengers on-board, 2nd party means other personal involved in operating the system or other airspace users and 3rd party means members of the general public

The Accountable Manager needs to understand the overall RtL presented by the operation. The overall risk presented is to be stated in two ways (a) The highest aggregated single RtL presented, and (b) the highest combined RtL presented for 1st, 2nd and 3rd parties. These calculations are also to consider the ground population density on the flight route.

The highest (worst case) single RtL; is defined as the combination of the highest likelihood (worst case) for a TLE (see Bow-ties) classified as having the highest accident outcome of Catastrophic or Critical (see Table 3).

The highest combined RtL: is defined as the sum of the probabilities of the TLEs with Catastrophic/Critical accident outcomes minus the probability of these TLEs occurring at the same time for a party i.e. 1st, 2nd and 3rd parties. This methodology assumes that all single risks are independent. For a party this is presented mathematically:

(Probability (TLE1) + Probability (TLE2) +…. Probability (TLEn)) - Probability (TLE1+TLE2…+TLEn)

The referral of the overall identified risk after mitigation has been applied allows the Accountable Manager to determine if the overall risk presented exceeds the Tolerable boundaries[14], presented at Table 2. It is entirely possible that risks in both 'Tolerable' and 'Broadly Acceptable' threshold categories are deemed acceptable provided they are assessed against a specific task and, importantly, are deemed ALARP. The concept of risk tolerability has been introduced to highlight standard operating practices (SOP) whereby appropriate mitigation measures are agreed for a particular operation which has, as a consequence, been deemed 'tolerable' and ALARP.

Post risk mitigation, the Accountable Manager shall ensure that the residual RtL from operation of UAS is always below the Intolerable boundary. This condition is endorsed by the declaration of safety in the Air Safety Statement (see the Safety Risk Assessment Process 4.2.3). If the current and foreseeable overall risk is determined to be in the Intolerable area, flight operations are to be stopped.

Table 2 – Risk Tolerability Boundaries

Boundary	Risk of Death per Annum for Population at Risk		
	1st Party	2nd Party	3rd Party
Intolerable	> 1 in 1000	> 1 in 1000	> 1 in 10,000
Tolerable	≤ 1 in 1000	≤ 1 in 1000	≤ 1 in 10,000
Broadly Acceptable	≤1 in 1,000,000	≤ 1 in 1,000,000	≤ 1 in 1,000,000

[14] Risk tolerability boundaries are taken from the HSE R2P2 document. HSE = Health & Safety Executive. R2P2 = Reducing Risks Protecting People.

4.2.7 Hazard Risk Matrix

The next step is to assess the risk in terms of the impact (severity) of the hazards and their likelihood of occurring. A decision is then required on whether the risk is justified when compared with the benefit of carrying out the activity. If the risk of the activity outweighs its benefit, the decision may be taken to eliminate (terminate) the activity that in turn eliminates the risk. For example, devising a high-risk training activity would not be justified if the simulation was riskier than the real activity; likewise, removing all risk from training cannot be justified if it does not prepare personnel for exposure to operating risks. If the level of risk is justified, steps should be taken to reduce it to ALARP. If the risk is both justified and mitigated to ALARP, the Accountable Manager may permit the activity to be undertaken. In the example Hazard Risk Matrix (HRM) presented in the table below the classifications (thresholds) of severity and likelihood are specified in the Military Airworthiness Authority (publication RA1210) which covers the ownership and management of risk to life using a standardised approach.

Risk classification is to be carried out using the hazard risk classification matrix (Table 3 below) and definitions of Severity and Likelihood detailed in HSE R2P2[15] document and the Tolerability Matrix (Table 2) above.

Table 3 – Hazard Risk Matrix (HRM)

		Severity			
		Minor	Major	Critical	Catastrophic
Likelihood	Frequent	M	H	VH	VH
	Occasional	L	M	H	VH
	Remote	L	L	M	H
	Improbable	L	L	L	M

The definitions of Severity & Likelihood are taken from the UK Military Aviation Authority Regulatory Article 1210 and are stated below:

Severity: The severity of a Single Risk is an assessment of the worst credible outcome that could result from the hazard. The severity categories listed below must be used.

a) **Catastrophic**. Three or more fatalities of 1st or 2nd party employees engaged in the activity in question or a single fatality of a member of the public (3rd party).

b) **Critical**. One or two fatalities of 1st or 2nd party employees engaged in the activity in question. A large number of major injuries must also be included in this category.

c) **Major**. Major injuries to any person. A large number of reportable injuries must also be included in this category.

[15] HSE R2P2 – Health & Safety Executive Reducing Risks Protecting People

d) **Minor**. Reportable injuries of any person.

Likelihood: The likelihood is assessed with respect to the likelihood of the assessed consequence of a hazard. This is based on the likelihood of a single accident resulting in harm. The appropriate category listed below must be used:

a) **Frequent**. Likely to occur at least several times a year. Taken to be a probability of greater than 2 occurrences per annum.

b) **Occasional**. Likely to occur one or more times per year. Deemed to be one to 2 times per year.

c) **Remote**. Likely to occur one or more times in 10 years. A probability range of 0.1 to 1.0 times per annum.

d) **Improbable**. Unlikely to occur in 10 years. Taken to be less than 0.1 occurrences per annum.

These definitions are in-line with both EASA and EUROCAE definitions of ***Severity*** and will therefore be used to support a common European approach throughout the remainder of the study.

4.2.8 Risk to Life Assessment Output

The output from the RtL assessments, carried out through the quantitative analysis of the BowTie assessment and further assessment against the HRM, allows an identification of the TLE's in order from highest to lowest. The table below (Table 4) illustrates the top 5 assessed risks for an example RPAS Trials & Evaluation organisation flying in segregated airspace (for clarity, mitigation approaches exist but have been excluded in this instance). In order for operations to take place the tolerability must be either Tolerable or broadly acceptable. If a Risk sits within the Tolerable boundary it would require further mitigation of action plan to identify further activity which is planned to reduce the level to broadly acceptable.

A similar table will be produced for a MALE-type RPAS operating in the implementation scenarios to be defined in the latter stages of this study.

Table 4 –Illustrative Example Top 5 Risks for RPAS

Risk Level	TLE	Name	Consequence	Severity	Likelihood	Who	*Rate p/a	Tolerable or Broadly Acceptable
1 (Highest)	TLE 003c	Loss of Separation with the Ground (Uncontrolled Descent)	**ACC 003c-3:** Fatalities to 2nd parties (Ground Impact)	Catastrophic	Improbable	2nd Party	4.70E-08	Broadly Acceptable
2	TLE 003d	Debris Falling from UAV in Flight	**ACC 003d-2** : Fatalities to 2nd parties (debris falling)	Catastrophic	Improbable	2nd Party	8.42E-08	Broadly Acceptable
3	TLE 004b	Propeller Fragments or FOD	**ACC 004b:** Fatalities to 2nd parties (Fragments or debris hitting personnel	Catastrophic	Improbable	2nd Party	6.60E-10	Broadly Acceptable
4	TLE 003b	Loss of Separation with the Ground (unintentional CFIT)	**ACC 003b--2:** Fatalities to 2nd parties (Ground impact during take-off & landing)	Catastrophic	Improbable	2nd Party	2.80E-11	Broadly Acceptable
5 (Lowest)	TLE 003c	Loss of Separation with the Ground (Uncontrolled Descent)	**ACC 003c-1:** Fatalities to 3rd parties (Debris falling to ground following a Mid-Air Collision (MAC))	Catastrophic	Improbable	3rd Party	3.24E-11	Broadly Acceptable

* Figures for Rate p/a are demonstrative of typical values achieved.

4.2.9 Summary

The Safety methodology described aims to assess the baseline Risks to Life which, in turn, supports an overarching set of safety artefacts[16], within an ASSC, which allow approval of the UAS/RPAS to be accommodated within non-segregated airspace. The methodology is a total safety system in line with published and approved methodology for current manned & unmanned military aviation in the UK and will support any type and size of UAS and any operational environment.

The described methodology provides a single point of reference for Safety artefacts which underpins the total safety assessment for the UAS operation. It also allows flexibility to manage any risk to life and modify them appropriately based on reliability programmes, outputs from occurrence reporting and emerging changes to risk profiles.

Societal Concern is a significant factor in risk management when operating unmanned aircraft particularly when there is potential for public criticism, particularly from accidents involving significant numbers of people and/or vulnerable groups. The Safety methodology allows the ability to capture and mitigate these concerns when considering the Threat Barriers, Safe operation and the need to protect and maintain public confidence.

[16] Note: The minimum requirement for safety artefacts will be set and standardised by the Approving Authorities.

The Safety Case Assessment Methodology provides the underpinning safety assessment required for the approval to operate the UAS within non-segregated airspace.

4.3 Air Traffic Management

Of similar importance to the platform and operational safety aspects, air traffic management (ATM) safety issues need to be addressed using the same methodology to ensure a robust ATM safety assessment is carried out for the accommodation of RPAS in controlled airspace. It is anticipated that the Air Navigation Service Provider (ANSP) would be largely responsible for the ATM aspects of Safety Management process and analysis of the safety issues for the accommodated RPAS operations. It is anticipated that this will follow the principles and general processes detailed herein. The outcome of this will form part of the Air System Safety Case for accommodation of RPAS into Controlled airspace.

The air traffic management safety issues will be assessed based on deviations building from a 'situation normal' benchmark, effectively the starting point against which to quantify compromises (threats) to a defined safety case – this will be achieved using a series of proposed Implementation Scenarios as described in the Task 2 Simulation Readiness Report (SRR), It should be noted that, within the boundaries of practicality and budgetary/timescale constraints, it will not be possible to simulate every conceivable risk area – however the study will demonstrate application of a repeatable safety assessment and simulation methodology that may be applied to numerous implementation scenarios in the longer term. The selection of implementation scenarios is based on discussion within Team SIRENS to produce a diverse set of informative safety risks with focus on specific RPAS challenges and air traffic impacts; these include reliance on communication links and platform performance characteristics.

In the context of ATM, an assessment of the level of RPAS autonomy and its impact on safe flight in controlled airspace will be required and should include the following areas – a number of these will be explored during the simulation studies as implementation scenarios are developed and exercised in accordance with the safety methodology described in this document:

- Contingency Procedures - including emergency recovery routes, emergency call-signs, airspace considerations, designation of recovery sites and communications protocols
- Loss of data link – including potential reacquisition and diversionary manoeuvres, ATC advisories and communications, priority changes and de-confliction procedures
- Flight termination procedures – including possible ingress into adjacent and non-permissive airspace, ground obstacles and risks, equipage and advisories
- Collision avoidance and compliance with ATC instructions

Within the context of the safety assessment, operational issues are based upon the procedures described in the ICAO RPAS Manual Doc 10019 and the requirements outlined in the EASA document: Policy Statement Airworthiness Certification of Unmanned Aircraft Systems (UAS) E.Y01301. A number of key areas will require assessment alongside ATC and Platform considerations to develop a holistic safety case, it is not the intention to develop such a document but rather to highlight issues that may merit further investigation as tie progresses – these include, but are not limited to:

- Conflict Management
- Impact of Meteorological conditions
- Data Link Security
- ATM – Communications/Navigation/Surveillance
- ATC training
- Contingency procedures
- Emergency procedures and
- RPAS Performance Characteristics

The above areas are described further:

4.3.1 Conflict Management

The process for application of conflict management is based on that application described in the ICAO Global Air Traffic Management Operational Concept. (Doc 9854)

- **Strategic Conflict Management:** This is considered the planning phase whereby issues such as flight planning, strategic flow control, NOTAMS, weather conditions, etc. are taken into account.
- **Separation Provision**: in this phase separation provision is applied by ATC utilising the CNS infrastructure and ATC procedures and best practice.
- **Collision Avoidance Phase**: Last resort actions or manoeuvres are executed to resolve conflicts when the provision of separation has been lost for whatever reason.

If required by regulations, then collision avoidance may be achieved through the use of an approved detect and avoid (DAA) system for conflicting traffic. In controlled airspace, the assumption is that only the detection of cooperative traffic would be required with controllers providing a normal level of separation assurance services.

A separate analysis (over and above what is detailed in the study scope) of risks and mitigation will be required for the following hazards:

- Conflicting traffic
- Terrain and obstacles
- Hazardous meteorological conditions (i.e. thunderstorms, icing, turbulence)

- Other airborne hazards, including wake turbulence, wind shear, birds or volcanic ash etc.

4.3.2 Weather

The susceptibility of RPAS to hazardous weather conditions will have to be assessed at a high level and also specifically at a MALE type level. Issues to address will include;

- Fragility of the platform and its capability to withstand extreme weather conditions in terms of physical integrity, wing loading, navigation and station keeping, loss of control, etc.
- Flight capabilities (in all flight phases) in weather conditions such as strong and gusting winds, turbulence, icing, precipitation, etc.
- Provision of on-board weather detection sensors for automatic weather avoidance management or to download metrological data to the RPAS pilot. Together with additional ground based weather data in order to manage the flight from a weather avoidance perspective.

4.3.3 Data Link Integrity and Security

The command and control (C2) link is the data link between the MALE-type platform and the remote pilot station for the purposes of managing the flight.

The security and integrity of the C2 link will have to be assessed in terms of the following task it will be expected to support;

- The control uplink and downlink to RPAS/remote pilot station (RPS) to manage data to modify behaviour and state of the RPAS
- The uplink and downlink to manage issues such as
    - Sensor data e.g. DAA, terrain alert, etc.
    - RPAS handover
    - Flight data recording
    - Health management data

Integrity and security of the payload data link in as much as it might impact on the safe conduct of the flight. A further consideration is related to the integrity of the command and control security link and specifically issues such as;

- Non-malicious / unintended interference
- Security threats / malicious interference

4.3.4 Air Traffic Management – Communications; Navigation and Surveillance (CNS)

4.3.4.1 Communications:

- Issues to be addressed include:
  - ATC voice and data link communications architecture and design integrity
  - Relay configuration of the voice and data to/from the RPAS
  - Specific communications requirements
  - Frequency selection and management
  - Minimum equipment configuration and performance
  - Radio or data link failure procedures
  - Latency issues

4.3.4.2 Navigation:

- Issues to be addressed include:
  - Minimum navigation equipment and performance requirements
  - Safety of the navigation system in the event of a loss of data link
  - Compatibility with the international Required Navigational Performance (RNP) standards

4.3.4.3 Surveillance:

- Safety issues associated with the provision of surveillance equipment to include:
  - ADS-B: capability to automatically transmit and receive identification and positional data via the data link
  - Secondary surveillance radar (SSR) transponder and emergency SSR codes

4.3.5 Air Traffic Control Training

Issues related to the training of Air Traffic Controllers to manage RPAS flights will include:

- RPAS performance characteristics and interaction with manned aviation
- RPAS architecture especially associated with remote pilot and data-link
- Specific ATC RPAS terminology
- Operational characteristics such as DAA, RPAS handover, etc.
- Airspace procedures and mixed traffic procedures such as hand-over between ground control stations and air traffic sector control units (ATSU)
- Loss of data link procedures, contingency/emergency procedures

- Airborne intercept procedures
- Handover procedures and cross border operations

4.3.6 Contingency Procedures

Contingency issues to be considered include:

- Provision of a back-up direct telephone communication between the RPS & the ATC unit
- Contingency procedures that are sufficient to ensure a safe, transparent and predicable outcome
- Continuation of original flight plan and actions such as;
  - Return to land at nearest appropriate and designated landing site
  - Return to departure aerodrome
  - Flight termination
  - Climb to altitude to attempt to regain the C2 link
  - Flight termination systems that permit the termination of a flight in a controlled transparent and safe manner.

4.3.7 Emergency Procedures

- Application of emergency flight recovery and termination systems
- Application of pre-programmed scenarios
- Management of pre-programmed landing sites
- Interaction with ATC of emergency flight recovery and termination procedures

4.3.8 RPAS Performance Characteristics

RPAS performance characteristics to take into account and assess in relation to the interaction with manned aircraft will include;

- Climb and descent rates and speeds
- Turning rates
- Latency of command issues

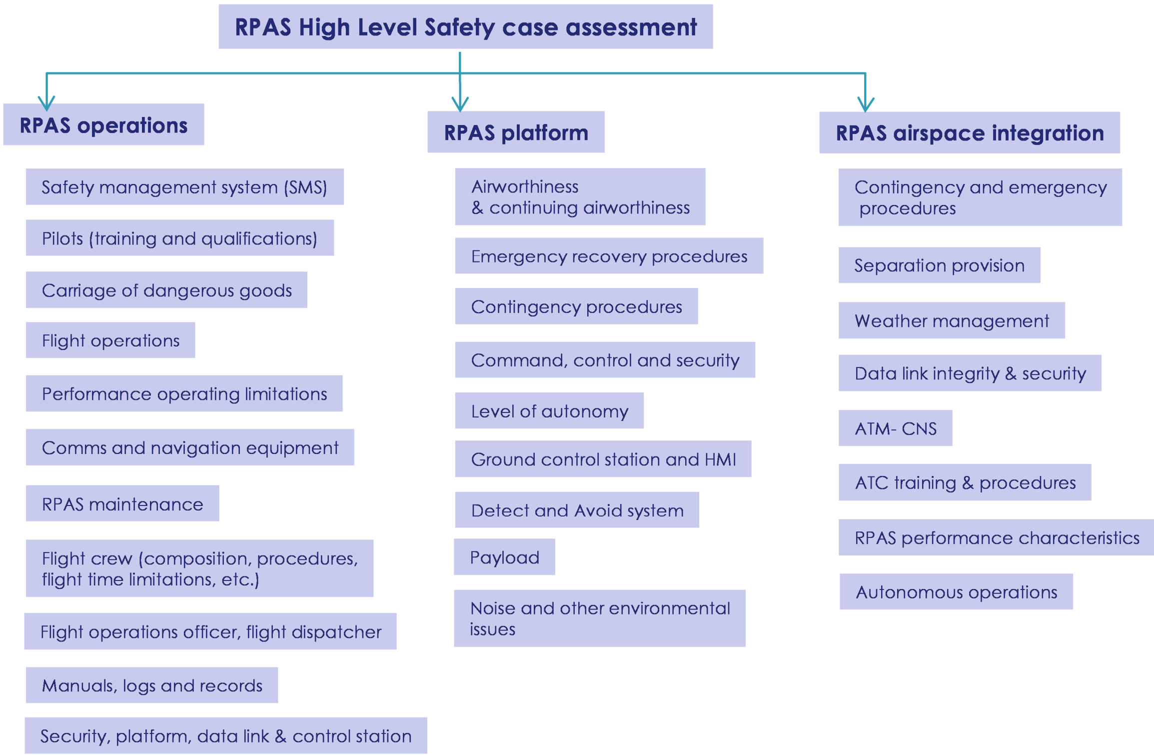


Figure 12 – Holistic Air Systems Safety Case

4.3.9 Assumptions

In the context of ATC a number of key assumptions are noteworthy;

- RPAS will have navigation and performance capability to ensure it can cruise at IFR altitudes along routes chartered in accordance with ICAO Flight Procedures Doc. 8168
- Flight Operator/Pilot is suitably qualified to plan and negotiate all phases of IFR flights in appropriate airspace.
- RPAS will be able to comply with airspace rules and procedures and associated safety requirements established by the State and/or ANSP.
- RPAS will meet the communication, navigation and surveillance (CNS) requirements for the airspace.
- RPAS operations will conform to existing airspace requirements and comply with existing ATM procedures.

5 Conclusion and Recommendations

5.1 Conclusions

The subject of RPAS accommodation is long-standing, well-researched and comprehensively documented but not well understood. There are numerous players all driving towards the same goal using broadly similar terminologies, processes and procedures. The background information provided to team SIRENS at the start of this study and supplemented by additional material identified during Task 1, has been and will be of immense value to the conduct of the study as it moves forward.

The State of the Art on Accommodation began with the way the Global Hawk HALE RPAS was accommodated in European skies, through the concept of isolation and which was a successful and necessary first step toward full integration (of RPAS seamlessly alongside manned aviation). To relax some of the constraints and to begin 'accommodation' into non-segregated airspace the generic accommodation scenario was developed which requires the use of segregated and controlled airspace under the control of ATM/ATCO and is a good starting point to explore the issues of ground and air risk. The SESAR-driven Project CLAIRE progressed accommodation by introducing a Tactical UAS into controlled airspace and many of the lessons learned will be incorporated into the consolidated Generic Accommodation Scenario to will be developed in Task 2.

In order to develop the concept of 'Accommodation' further it is necessary to find ways to allow MALE-type RPAS to share controlled airspace with manned aviation and progressively fly over more densely populated areas and occupy more complex airspace, and this will be the subject of Task 2 of this study.

In Task 2, the generic accommodation scenario will be developed by introducing elements of complexity to form the 'consolidated' generic accommodation scenario, elements of which will be selected for implementation scenarios to be simulated. Examples of complexity elements may include;

- Including the use of Civilian aerodromes
- Relaxing the limitations placed upon air traffic assumptions by including operations in non-segregated airspace – such as complex airspace structures and heightened traffic densities
- Developing the assessment of Ground risk to include flight over more densely-populated areas and closer to critical infrastructures
- Widening the operational time windows
- Environmental impacts such as adverse weather
- Including a Statement of Assumptions relating to regulation and certification (of people, systems, equipment and support services)
- Adding an analysis of the use of equipment options (such as Detect and Avoid)

The Safety methodology described (in Section f)) aims to assess the baseline Risks to Life which, in turn, supports an overarching set of safety artefacts , within an ASSC, which allow approval of the UAS/RPAS to be accommodated within non-segregated airspace. The methodology is a total safety system in line with published and approved methodology for current manned & unmanned military aviation in the UK and will support any type and size of UAS and any operational environment.

The described methodology provides a single point of reference for Safety artefacts which underpins the total safety assessment for the UAS operation. It also allows flexibility to manage any risk to life and modify them appropriately based on reliability programmes, outputs from occurrence reporting and emerging changes to risk profiles.

5.2 Recommendations

Team SIRENS recommends the Safety Assessment Methodology defined in Section f) as the most appropriate methodology for use throughout the rest of this study and as the baseline for further development/enhancement of MALE-type RPAS Accommodation.

Further recommendations emerging from Task 1 include:

- Adoption of the System Wide Information Management (SWIM) by RPAS, in particular enabling controller-pilot data link communications via ground networks, since, in the case of RPAS, the 'cockpit' (i.e. the remote pilot station) is indeed on the ground (see RI 16, Ref. 5). SWIM is an integral part of SESAR and will enable traffic and aircraft information to be shared amongst a number of actors. This will include safety related data such as contingency operations, health management and emergency routing to be disseminated and acted upon in an efficient and timely manner. Military unmanned aircraft will be OAT or GAT compliant and will be capable of being routinely integrated into the future European airspace structure as advocated by SESAR.
- The 'Normalization' through regulation/standardization of RPAS 'Lost-Link' behaviours to make them more predictable and therefore help reduce the workload and training burden for ATCOs
- Definition and agreement of a standard set of MALE-type RPAS characteristics

ANNEXES

Annex A Acronyms and Abbreviations

AAMC	Alternative Acceptable Means of Compliance
ALARP	As Low As Reasonably Possible
AMC	Acceptable Means of Compliance
ANSP	Air Navigation Service Provider
ARF	Airworthiness Regulatory Framework
ASSC	Air Systems Safety Case
ATC	Air Traffic Control/Controller
ATCO	Air Traffic Control Officer
ATI	Air Traffic Integration
ATM	Air Traffic Management
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CAA	Civil Airworthiness Authority
CAE	Claim, Argument, Evidence
CFSP	Common Foreign and Security Policy
CLAIRE	CiviL Airspace Integration of RPAS in Europe
CM	Commercial Management
CNS	Communication, Navigation & Surveillance
CofA	Certificates of Airworthiness
CS	Certification Standard
CTA	Control Area
DAA	Detect and Avoid
DARTeC	Digital Aviation Research and Technology Centre
DSC	Design Safety Case
DSNA	Direction des Services da la Navigation Aerienne
EASA	European Aviation Safety Agency
EC	European Commission
EDA	European Defence Agency

EH	EuroHawk
E-OCVM	European Operational Concept Validation Methodology
ERSG	European RPAS Steering Group
ESARR	EUROCONTROL SAfety Regulatory Requirements
FL	Flight Level
FORR	Flight Operations Risk Register
FTS/RTS	Fast /Real Time Simulation
GAT	General Air Traffic
GH	Global Hawk
HRM	Hazard Risk Matrix
ICAO	International Civil Aviation Organization
IFR	Instrumental Flight Rules
IPR	Intellectual Property Rights
ISR	Intelligence, Surveillance and Reconnaissance
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LOPA	Layers Of Protection Analysis
LOS	Line of Sight
MAA	Military Aviation Authority
MAE	Military Air Environment
MALE	Medium Altitude Long Endurance
MFTP	Military Flight Test Permit
MOD	Ministry Of Defence
MPR	Monthly Progress Reports
MRAS	MALE RPAS Accommodation Study
NARSIM	NLR ATC Research Simulator
NATO	North Atlantic Treaty Organization
NATS	National Air Traffic Services
NLR	Netherlands Aerospace Centre
OAT	Operational Air Traffic

e-OCVM	European Operational Concept Validation Methodology
PIC	Pilot In Charge
PM	Programme Management
PMO	Programme Management Office
QA	Quality Assurance
R&D	Research & Development
RBS	Risk Breakdown Structure
RM	Resource Management
RPAS	Remotely Piloted Aircraft Systems
RtL	Risk to Life
SAIL	Safety Assurance and Integrity Levels
SAM	Safety Assessment Methodology
SAME	Safety Assessment Made Easier
SCG	Stakeholder Consultation Group
SEC	SESAR Expert Community
SERA	Standardised European Rules of the Air
SESAR	Single European Sky ATM Research
SID	Standard Instrument Departure
SORA	Specific Operations Risk Assessment
SPR	Safety and Performance Requirements
SQEP	Suitably Qualified & Experienced Personnel
SRM	SESAR Safety Reference Material
STAR	Standard Terminal Arrival Route
sUAS	Small UAS
TCAS	Traffic Collision Avoidance System
TMA	Terminal Manoeuvring Area
UAS	Unmanned Aircraft System
UA	Unmanned Aircraft
UTM	Unmanned Traffic Management
VAT	Value Added Tax

VFR	Visual Flight Rules
VLOS	Visual Line of Sight
WG	Working Group

Annex B Background Information Review Notes

Ref	Title	Owner	Review Notes
1	ESSAR4 - Risk Assessment & Mitigation in ATM (05-04-2001)	EUROCONTROL	Safety regulatory requirement covering the use of Risk Assessment & Mitigation including hazard identification in ATM when introducing and/or planning changes to the ATM system. Applies to all ATM service providers for the parts of the ATM/CNS System and supporting services for which they have managerial control and covers the human, procedural and equipment (hardware, software) elements of the ATM System as well as its environment of operations. The main objective of this requirement is to ensure that the risks associated with hazards in the ATM System are systematically and formally identified, assessed and managed within safety levels, which as a minimum, meet those approved by the designated authority. The Safety Case Assessment Methodology described in Section f) aligns to this requirement, addresses the issues in much the same way and covers the main areas of safety assessment in sufficient detail to be a credible baseline for going forward in this study.
2	Safety Assessment Methodology (SAM)	EUROCONTROL	Safety Assessment Methodology prepared by EUROCONTROL to provide comprehensive and detailed guidance for the implementation of ESSAR 4 and thus to demonstrate compliance with it (ESSAR 4). It comprises a large set of documents and so a guide as to who should read which parts has also been included. The Safety Case Assessment Methodology described in Section f) is aligned with this methodology which describes a generic approach for the safety assessment and mitigation process of Air Navigation Systems in three steps: • Functional Hazard Assessment (FHA); • Preliminary System Safety Assessment (PSSA); • System Safety Assessment (SSA).

3	ATM Guidelines for Global Hawk	EUROCONTROL	These guidelines aimed to establish a set of minimum ATM requirements for Global Hawk (GH) / EuroHawk (EH) flight in European airspace, with the primary purpose of enabling GH/EH operators to use them as the basis for negotiating access to national airspace within Europe. The Guidelines envisaged the isolation of GH/EH from other airspace users by requiring it to climb-out and recover in segregated airspace and to fly IFR/OAT in the cruise in non-segregated airspace at high altitudes that are typically above those occupied by manned aviation.
4	RPAS ATM CONOPS	EUROCONTROL	Feb 2017 publication describing all types of RPAS operations in all classes of European airspace (from VLL to higher altitude airspace above FL600) with full implementation targeted for 2023. The ATM CONOPS address both civilian and military operations and has been written in cognisance of the ICAO Global Air Navigation Plan (GANP) and EASA airworthiness CONOPS. The document assumes enabling technologies, standards and procedures are available within the 2018 to 2023 timeframe – performance considerations (speed; latency, manoeuvrability) are highlighted along with challenges associated with airport and TMA operations. The overarching integration principle is that RPAS have to fit into the extant ATM system and not that the ATM system should be adapted to accommodate RPAS – operations have to be treated in a similar manner to manned operations. Interestingly, a two-step 'accommodation to integration' (post 2023) is described with flexible use of airspace (FUA) used to support initial operations through dedicated corridors or RPAS separation bubbles. The CONOPS is predicated on a proposal to organise RPAS traffic into classes, VLL Operations (sub 500ft); IFR/VFR Operations (500ft to FL600) and VHL Operations. The VLL management system also applies a discrete set of flying rules, processes and procedures to classes of RPAS from Class 1 (but and fly) to highly capable platforms performing commercial and special operations under specific or certified rule sets. The VLL CONOPS describes a number of conceptual operations building from the present identification of non (limited) permissive flight zones (NDZ/LDZ) to more advanced 'free flight' and 'route structure' options able to accommodate a larger volume of RPAS flights.

			VFR/IFR operations (500ft to FL600) are similarly decomposed into traffic classes ranging from (V) suitably equipped RPAS operations outside the ATM network in uncontrolled airports or dedicated L&R sites to (VI) operations in all flight phases with RPAS able to fly SIDS and STARS comply with network requirements. The final section details VHL operations above FL600, highlighting transit challenges to access/depart from higher-level airspace which is in itself unlikely to directly impact the lower airspace. Utilisation of VHL airspace is expected to increase significantly, with a variety of RPAS types, this will necessitate some degree of traffic management in the future.
5	Roadmap for the Integration of civil RPAS into the European Aviation systems	EUROCONTROL	"Mainly concentrates on the Regulatory Initiatives (RIs) but includes an important roadmap for 2013-2018 which mentions: - VLOS, E-VLOS, harmonised civil/military airworthiness, VLL/B-VLOS, breakthrough to RPAS flying under GAT (Classes A-C), Cooperative DAA, SWIM, CS-UAS & BR-LOS Also discusses consultations with EASA. EDA, EUROCAE, EUROCONTROL, ECAC, JARUS etc.
6	European Operational Concept Validation Model (E-OCVM) Volume 1, Version 3.0	EUROCONTROL	It has been 'Mandatory' since 2005 to apply e-OCVM in collaborative ATM R&D projects of the European Commission & EUROCONTROL. The primary focus is on Concept Validation (hence applicability to this study) and the development of the Operational Concept. E-OCVM is a framework for carrying out R&D rather than a strict set of rules - essentially another way of 'managing' the Systems Engineering required to develop a system from expression of need, through development, to delivery, deployment and disposal (and draws heavily on INCOSE) and is focused on the validation process using maturity levels and transition criteria. Another key factor is the Business Case which presents a balanced synthesis of the critical issues from the other cases (Safety, Human Factors etc.). Part 1 covers the position & role of validation and E-OCVM in the wider context of ATM Systems development Key points include: • Concept Lifecycle Phases (V0 - V7) & relationship to TRLs

			• Structured Planning Framework (SPF) • Case Based Approach (CBApp) The study should perform an initial maturity assessment of the Generic Accommodation Scenario using CLM and ought to develop validation plans for V2 & V3. During tasks 3 & 4 the team will need to understand the Common Performance Framework as the setting for integration conduct a comparison of results across a number of related studies. Study set-up matches SPF and results will need to be referenced against this model. Case Based Approach (CBApp) defines 'expectations' for Consultation Strategy & Dissemination which will feed into Task 5.
7	e-OCVM (Volume II Annexes)	EUROCONTROL	Part 2 covers the following subjects: 1. Requirements Development 2. A comparison between NATO TRLs and E-OVCM CRLs 3. A detailed description of the Structured Planning Framework (from Step 0 to Step 6 at the Programme, Project and Exercise levels). 4. Maturity Criteria (for the R&D Phases, V0-V3 of the Concept Lifecycle Model) 5. A guide on how to incorporate 'Cases' (specifically the Safety Case, Human Factors Case, Business Case and Environment Case) in ATM R&D Projects 6. Guidance material on the validation support to standardisation and regulation (explains how the European Operational Concept Validation Methodology (E-OCVM) may support standardisation and regulatory (S&R) processes)
8	EASA Policy Statement (E.Y013	EASA	Covers general principles for Type-Certification of UAS, generally to do with Airworthiness. The main objective of this policy is to facilitate acceptance of UAS civil airworthiness applications, while upholding the EASA's principle objective of establishing and maintaining a high uniform level of civil aviation safety in Europe together with the additional objectives stated in Article 2 of the Basic Regulation. Provided guidance on the impact of the following 'special' conditions on certification:

			• Emergency recovery capability • Integrity of the C^2 link • Levels of Autonomy • Human Machine Interface • Control station design • 'Due to type operations' such as CS-VLA or the use of DAA equipment • Systems Safety Assessments Also provides a guidance methodology for selecting (and another for tailoring) applicable airworthiness codes giving worked examples for Global Hawk, Predator, Hunter & StratSat.
9	EASA RMP EPAS (2017-2021)	EASA	Rule Making and Safety Promotion Programme including the European Plan for Aviation Safety (EPAS) and presents concise strategic priorities for the safety programmes based on the Commissions' Aviation strategy and the EASA strategic plan. The safety priorities were based on the newly developed European Safety Risk Portfolios in the Annual Safety Review 2016. The key drivers for this programme are: **Safety** — the need to increase the current level of safety in the aviation sector. **Environment** —the need to improve the current environmental protection in the aviation sector **Efficiency/proportionality** —the need to ensure that rules are cost-effective in achieving their objective as well as proportionate to the risks identified. **Level playing field** - the need to ensure that all players in a certain segment of the aviation market can benefit from the same set of rules, thereby promoting fair competition and free movement of persons and services. RMT.0230 covers the introduction of a regulatory framework for the operation for drones and identifies the three categories of UAS operation: Open, Specific & Certified.
10	EASA NPA (2017-05)	EASA	EASA Notice of Proposed Amendment for a new regulatory framework for drone

			operations. This NPA is evolution of A-NPA 2015-10 (consulted between 31.7.2015 and 25.9.2015), and the feedback received during its consultation. The proposed Basic Regulation, currently under discussion between the Council, the European Commission and the European Parliament, contains requirements regulating all UAS, except those used for 'state' operations and defines the key requirements to ensure the safety of UAS. The EASA concept of UAS operations is based on the definition of Open, Specific and Certified categories – a number of subcategories are also defined by a series of parameters. For example the open category accommodates three main subcategories A0 to A2 using parameters such as MTOM, distance from persons; pilot competence and e-ID. The objectives of the NPA are to ensure an operation-centric, proportionate, risk and performance-based regulatory framework; to ensure a high and uniform level of safety for UAS; to expedite the UAS market; and support privacy, data protection, and security. The NPA provides high-level requirements for operations focusing on the open and specific category (e.g. requirements for registration, geofencing and electronic identification, competent authorities, the concept of UA zones, and model aircraft). *Note* 'open category' covers UAS operations that, considering the risks involved, neither requires a prior authorisation by the competent authority, nor a declaration by the UAS operator before the operation takes place. Note 'specific category' requires authorisation by the competent authority before the operation takes place, taking into account the mitigation measures identified in an operational risk assessment, except for certain standard scenarios for which a declaration by the UAS operator is sufficient. The NPA does not assume availability of either cooperative or non-cooperative DAA.
11	JARUS Guidelines on Specific Operations Risk Assessment (SORA)	JARUS	The JARUS SORA guideline provides detail of a process for assessing the specific risk for UAS. It follows a generic process which caters for a wide variety of UAS Characteristic dimensions. For MALE RPAS (Alt 10000 - 30000 ft. & 24-48hrs Endurance) the Ground Risk Classification is required to be below '7' which essentially precludes operation over populated areas and over gathered people. Whilst it appears suitable for identifying a broad band of risk level the MALE RPAS classification will require a more robust approach.
12	SORA Toolset (Java)	JARUS	Not reviewed as this is a software toolset for implementing SORA and Team SIRENS does

			not recommend using SORA for this study.
13	SESAR European ATM Master Plan (End. 2015)	SESAR	This document builds on the 2012 edition and is presented in a useful 'tiered' format. The ATM MP provides a comprehensive vision for a future (to 2050) pan-European ATM system building on SESAR deployment initiatives and scenarios. The 2015 edition makes some reference to RPAS as well as military aircraft operations within the future ATM. The 'building blocks' of a future and more efficient, safe, secure, environmentally friendly and higher capacity ATM are described including concepts such as trajectory based operations, increased levels of automation and secure digital connectivity. It is worth noting that the ATM Master Plan will be augmented by a new draft "Drone Master Plan addendum" which was completed and ratified by the SJU Board in late 2017. This addendum will be subsumed in the updated of the European ATM Master Plan planned for Q1 2018. The update was written by three working groups from a number of key European aviation institutions (inc. European Commission, EASA, EDA and Eurocontrol) as well as industry experts.
14	ICAO 9854 - Global ATM Operational Concepts	ICAO	2005 ICAO ATM vision for services required to operate the global air traffic system up to and beyond 2025 highlighting the need to increase user flexibility and maximise operating efficiencies to increase capacity and improve safety levels. The publication seeks to articulate benefits to all members of the ATM community including airspace users; service providers and regulators. The main body of the Global ATM Operational Concepts describes a number (7) of ATM system components (airspace organisation and management; demand/capacity balancing; aerodrome operations; traffic synchronisation; conflict management; airspace user operations and ATM service delivery management) which are described separately but are highly integrated as a 'holistic entity'. The document is complimented by a series of annexes including a comprehensive glossary and a high level system safety approach.
15 & 16	ICAO 4444 - Procedures for Air Navigation Services (PANS-ATM) and ICAO 8173 - Procedures for Air Navigation Services (Aircraft Ops)	ICAO	Comprehensive 2016 (Iss.16) publication originating in 1946. The Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM) specify the practices and procedures to be applied by air traffic services units in providing actual air traffic services to air traffic. While the PANS contain material which may eventually become Standards or Recommended Practices (SARPs), they also include material to provide additional detail to assist users in the application of SARPs. No specific section is provided on PANS-

			ATM for unmanned aircraft operations (other than unmanned free balloons).
17	ICAO 9859 - Safety Management Manual	ICAO	"ICAO guidelines on Safety Management Principles. Includes fundamental approach to implementation and oversight of safety Management Systems. Includes Human Factors, Error Management, Safety Culture, Occurrence reporting, Standards & Recommended Practices (SARPS).
18	RPAS Concept of Operations (Edn. 4, March 2017)	ICAO	An important document as it contains discussion on the framework topics to be expanded within this project. Considering the extent of RPAS i.e. what is included? The responsibility of flying safely, Performance characteristics both systems and RPA along with sense & avoid and 'remain well clear' systems, Common & recognised emergency & contingency protocols are also discussed.
19	10019 Manual on RPAS	ICAO	As stated within this document the aim was to produce an international legal regulatory framework through Standards & Recommended Practises (SARPS). There were many SQEP personnel who contributed to the document development of Safe SARPS for the operation of RPAS in segregated, non-segregated and aerodrome operation. The document will provide essential guidelines for the underpinning considerations for risk analysis and safety case development. It is recognised that this document demonstrates a good grasp of the requirements for RPAS operation.
20	SESAR Project CLAIRE (RPAS.07) Report	SESAR	Supporting information on safety case development, licencing and operating procedures from 2015 trials activity. The report describes the overall approach adopted by Project CLAIRE (Civil Airspace Integration for RPAS in Europe) as part of the Single European Skies ATM Research (SESAR) demonstration programme. The project was undertaken by Thales, NLR and NATS to investigate how RPAS may be safely inserted into non-segregated, controlled airspace using an initial safety case underpinned by a series of simulations and flight trials using the UK Watchkeeper military RPAS. Air traffic controllers successfully interacted with suitably qualified RPAS pilots in a remote ground control station using normal voice communications with standard VHF radio relayed via the air vehicle. Demonstration flights were authorised subject to provision of a full ATC service at all times and ATC separation service for IFR operation - no flights were permitted in non-segregated uncontrolled airspace, even in the event of catastrophic failure. The outcomes were encouraging with evidence gathered to prove that that it will be possible to safely integrate and control RPAS in non-segregated airspace alongside

			manned aircraft subject to establishment of regulatory frameworks, operating procedures and standards.
21	STANAG 4671	NATO	NATO STANAG 4671 comprises two parts. 1. General rules of UAV and the UAS airworthiness certification process. 2. Measures of compliance to the minimum requirements of Part 1 Covers UAVs from minimum MTOW of 150kg upwards and therefore covers certification of the medium to large UAVs (Tactical, MALE and HALE).
22	EDA Study on RPAS Detect & Avoid	EDA	EDA commissioned study into key enabling technology by Deep Blue and CIRA (Italy) completed in April 2016. The key objective of the study was to determine the current maturity of Detect and Avoid technologies and capabilities at global level and provide an assessment of activities necessary to develop a certified DAA for larger and more capable RPAS likely to operate in the EASA Certified category only. Extant DAA solutions were examined and assessed to support RPAS IFR operations in controlled airspace. The study draws heavily on the EDA MIDCAS technology demonstrator and also proposes taxonomy to classify DAA systems on the basis of functionality / performance requirements. The study also discusses the ATM implications of a DAA equipped RPAS operating in non-segregated airspace (in a similar manner to the SESAR RPAS demonstration activities) and in particular specific platform requirements, on its ability to detect and interact with other airspace users and the resultant impact on the ATM Concept of Operations.
23	Specifications for the use of Military RPAS as OAT	EUROCONTROL	These are high-level, generic specifications drafted by the UAV-OAT Task Force to revert to autonomous flight in the event of loss of data-link. A similar hierarchy is followed with regard to traffic avoidance and collision avoidance. Thus, where ATC is not available to separate an RPA from other airspace users, the pilot-in-command will assume this responsibility using available surveillance information and technical assistance in the form of a DAA system. The latter will also initiate last-ditch autonomous collision avoidance should circumstances warrant. At aerodromes, RPA operations will interface with the aerodrome control service akin to manned aircraft. Whilst taxiing, RPAs should be monitored by ground-based observers.

			RPA emergency procedures are discussed in general terms but should mirror those for manned aircraft wherever possible. Likewise, weather minima for RPAs should be determined by factors similar to those that govern flight by manned aircraft. Moreover, for cross-border operations, state RPAs should be bound by the same international conventions as manned state aircraft. On the other hand, where RPA operations are not compatible with other air traffic, they should be accommodated within temporary reserved airspace. Finally, RPAs should carry similar CNS functionality to that required for manned aircraft, though the exemption policy for manned state aircraft should also apply to state RPAs. OR 2012 publication comprising a set of high-level specifications drafted by the UAV-Operational Air Traffic (OAT) Task Force comprising national military experts with experience of ATM for RPAS operations outside segregated airspace. The work draws on existing international and national civil/military regulations, procedures and guidelines and planned future development initiatives. A set of (31) proposed EUROCONTROL specifications are discussed in the main body of the document, these are in turn sub-divided into a number of topic areas covering issues such as RPAS ATM categorisation; airspace management, aerodrome operations; sense and avoid and flight across international borders A useful glossary and summary of national UAV/RPA ATM regulations is provided together with outcomes of an independent safety assurance process using a an inclusive Functional Hazard Analysis (FHA) and /Preliminary System Safety Analysis (PSSA) for unmanned military aircraft flying OAT outside segregated airspace. The work is predicated on key assumptions such as that RPAS operations should not increase the risk to other airspace users; that ATM procedures should be as per those for

			manned aircraft and that the provision of air traffic services to RPAS should be transparent to ATC controllers. The output report comprises a harmonised set of proposed EUROCONTROL Specifications which can be used by the Member States for implementation of UAVs as OAT in non-segregated airspace including cross-border operations.
24	MALE RPAS Accommodation Scenario Project Proposal	EDA	Not reviewed here.
25	SESAR Safety Reference Material (SRM) – 16.06.01/D27	SESAR	The SESAR Safety Reference Material (SRM) has been developed to provide a clear, complete, coherent and integrated approach to safety assessment that meets the need of the SESAR work programme aligned to the European Operational Concept Validation Methodology (E-OCVM) V1-V4 maturity model [Ref. 6]. The key novelty of the approach is the simultaneous use of both success-based and failure-based approaches to aviation safety. The success-based safety approach is used to show that a concept is intrinsically safe in the absence of failure, whereas EC regulations (CR 1035/2011) currently only requires a failure-based approach to identify hazards and risks and propose mitigations or barriers to them. SRM aims to improve the historical approach, whereby safety assessments have tended to assess how reliable the ATM system need to be (as a combination of equipment, procedures and human resources organised to perform a function within the context of ATM) to ensure that the system is adequately protected against internal failures. This restricted view of safety has been sufficient since ATM systems have gradually evolved and it has been adequate to rely on the assumption that ATM system is intrinsically safe when no failure occurs. Given the nature of SESAR concepts, the development of new technologies and the increasing use of automation this assumption is no longer valid. The accommodation of MALE RPAS into controlled airspace is a clear example of such a novel concept and, given the alignment to E-OCVM, SRM is clearly a significant source of guidance to the Safety Case Assessment Methodology under development in this study.

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