Accommodation Validation of MALE type RPAS IFR operation in General Air Traffic (airspace class A-C)

Final Report

FINAL REPORT

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Document History

Issue	Date	Reason For Change
01	18/03/2022	Initial Delivery
02	06/04/2022	comments made by SCG members taken into account
03	13/04/2022	Updated version following the gate review and taking into account responses to questions raised during the dissemination seminar.

Abstract

This document is the third and final deliverable of the MALE RPAS Accommodation Validation Study. After recalling the context and the scope of the study, it includes the main elements of the validation plan, the description of the safety case analysis methodology and the scenario that were effectively carried out during the experimental flight of a French Air Force MQ9-REAPER.

It takes up the main observations made during this flight and continues the initial analysis by attempting to answer the main question concerning the accommodation phase:

"Is it possible to operate a MALE RPAS safely in GAT in non-segregated controlled airspace, alongside other manned air traffics, subject to the implementation of specific accommodation measures?"

It concludes by highlighting the main characteristics of these accommodation measures and the difficulties encountered in the implementation of this experimentation, suggesting an assessment of the level of maturity according to the E-OCVM- v3 methodology and identifying some points that would call for further study.

Disclaimer

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1. EXECUTIVE SUMMARY

1.1. Overview of the accommodation validation study

The launching of this study results from the willingness of the EDA Member States to consolidate the results of the various experiments aiming at authorising, under certain conditions, the flight of former MALE UAS under the rules of general air traffic in controlled non-segregated airspace of class A-C. It follows a first study conducted in 2017, based on simulation with human operators in the loop.

It included two strands, one generic, dealing with the validation by a cross-border flight of the accommodation principles developed and tested by the simulations of the first study, the other confidential, dealing with the human factor (MQ9 cockpit ergonomics, cockpit resource management, qualification ...). Some elements from the confidential strand are inserted in the D3 document, without reference to the classified work.

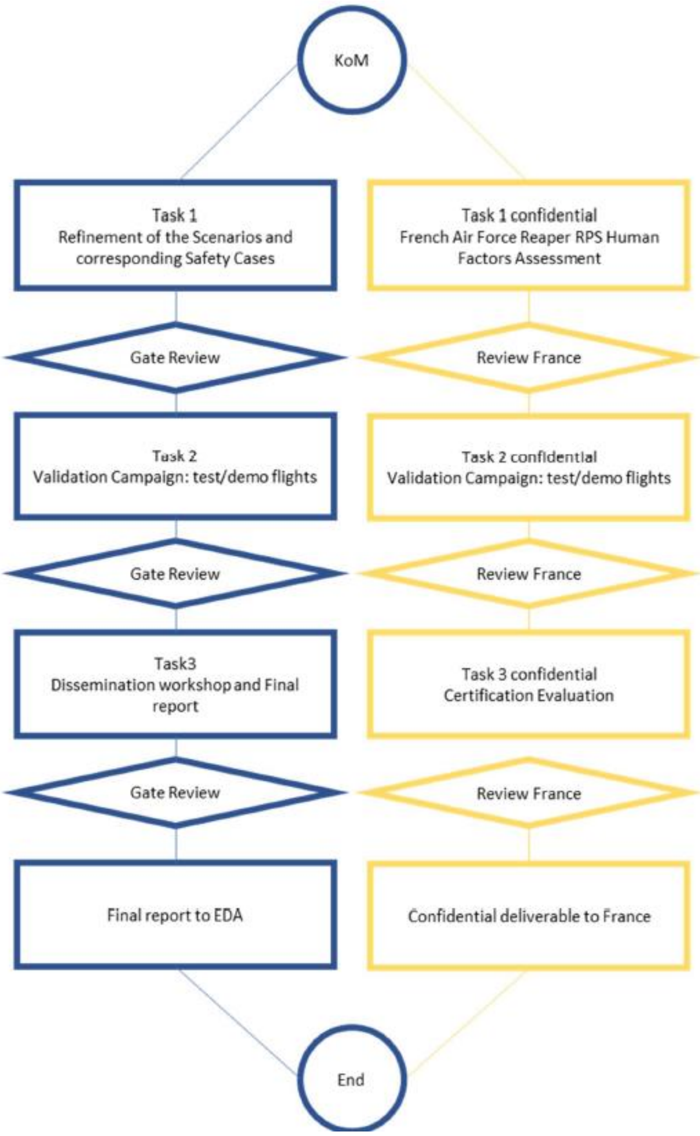


Fig 1: Study Organisation in two work strands

1.2. Reminders of the study's objectives and methodology

This follow-up study aims at performing flight test validation of RPAS accommodation scenarios for MALE-type operations in non-segregated airspace. The scenarios come from the initial accommodation study, the EDA/EASA guidelines and are identified in the framework of this study.

It intends to demonstrate that operating a MALE-Type RPAS in GAT, outside segregated areas in class A to C airspace (D for France) is safe, and to validate that the adverse impacts on ATS, in terms of safety or workload, due to the RPAS specificities are acceptable to ATCOs and appropriately compensated by the accommodation measures

The approach taken to refine the safety case scenario was to assess the impact of the introduction of this new type of operation (to which extend will it induce a change in ATS system). For this purpose, we compared the requirements for operating in IFR-GAT a manned, single-engine turboprop aircraft of less than 5700kg with the characteristics of the MALE UA system.

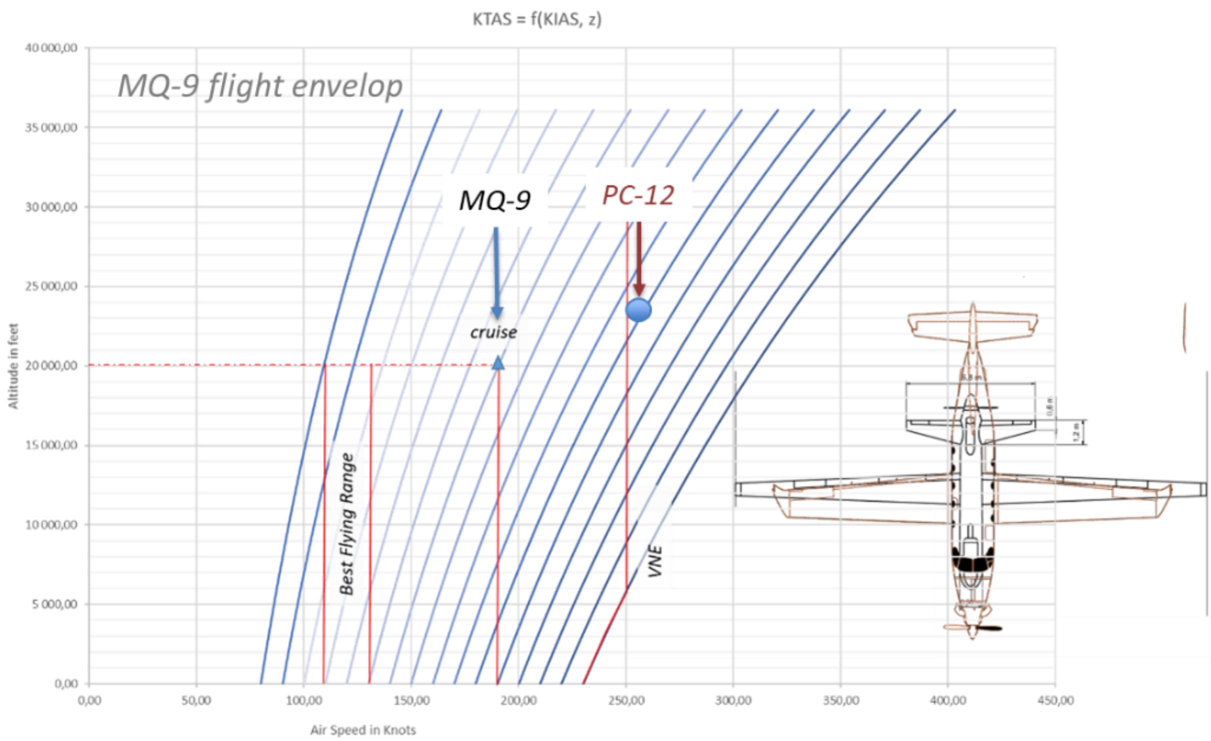


Fig 2: comparison of MQ9 cruise performances an dimension with a single turboprop aircraft

The focus is set both on the airspace risks and on the ground risks aspects (not considered during the initial accommodation study).

The issue of "ground risk to life" is covered by the certification of the MQ-9, as the French authorities have issued a type certificate for both versions of the MQ-9 REAPER currently in service with the French Air Force (Nota Bene: :The version used for the flight was a MQ-9 block I.). We have focused on the "Airborne risk to life" by considering the main themes generally covered by safety case assessment studies. Weather, CNS, ATS

1.3. Summary of finding and analysis results

The table below summarises the main findings of the specificities of a MALE RPAS resulting from this comparison

Event category	Identified gap between MQ9- RPAS and a IFR certified light manned A/C
Weather	Absence of de-icing device requires increased vigilance on weather conditions. **Compensated by preparation and a permanent access to an updated regional forecast / internet.**
Communications Navigation Surveillance	**C:** In BRLOS (long distance), ATC coms rely on the on-board VHF: - *Critical dependency on SATCOM link for VHF and C2 link* - *Single on-board VHF radio* **Both compensated by implementing direct telephone line between the Remote Pilot and the ATCO for the experiment (see §7.1)** **N:** 3 independent hybrid GPS/INS, but absence automatic landing capability prevent any diversion. **Compensated by the constant updating of an "Contingency Route" allowing a return to base and switch to LOS mode for recovery or direct the UA to a safe crash zone** **S:** the MQ9 is equipped with a transponder mode C (compliant to minimum requirement)
ATS	**Strategic Layer: Flight Plan (circular, mixed OAT/GAT) may generate processing difficulties** **Tactical Layer: The controller team in its CWP can easily manage the presence of UA alongside other traffic** **Collision Avoidance:** no TCAS – **same as for manned aircraft < 5700 kg –** and no DAA capability functionality – **mitigated in CONOPS/Safety Case by limiting to Class A-C** **→ Access limited to controlled Airspace (A to C; D for France)**
ATFCM	MQ9 performances comparable to any "slow mover" (TAS around 190 to 200 kts at FL 220)
AIS	The UA uses the published airways per the flight plan (adherence to flight plan) and is able to comply with ATC instruction in a timely manner. **An objective of the flight is to demonstrate this**
AIRSPACE & PROC	**An objective of the flight is to demonstrate that impact, if any, is acceptable**
Flight Operations	Critical dependency on SATCOM link that may induces some particularities (latency). **An objective of the demo flight is to observe and assess the impact of these particularities**
RPAS	**SATCOM link criticality:** In BRLOS a single SATCOM links encompass long distance ATC coms and C2 link and payload exploitation. **→ Specific contingency procedures developed in CONOPS**

1.4. Summary of findings, recommendations and Maturity assessment

The table below summarises the main observations made during the preparation and execution of the mission and the analysis of these observations.

Event category	Gaps Drone vs equivalent Manned A/C & potential impact on ATM
Weather	T/Off delayed by adverse weather conditions in LFBG managed by crew and ATC
CNS	Observed (~2") Latency in ATC communication considered acceptable

Event category	Gaps Drone vs equivalent Manned A/C & potential impact on ATM
ATS	**Strategic Layer:** Flight Plan (circular, mixed OAT/GAT) required manual intervention but was correctly processed. **Tactical Layer:** The ATCOs in their CWP can easily identify and manage the presence of the RPA alongside other traffic **Access limited to controlled Airspace**
ATFCM	MQ9 performances (observed TAS around 180 to 190 kts at FL 220) did not generate unacceptable additional workload to ATCOs
AIS	Perfect adherence to FPL
AIRSPACE & PROC	No Impact
Flight Operations	No Impact when low to moderate traffic density. Number of RPAS per control sectors remains limited (induced by dedicated tel. line by ACC as backup coms)
RPAS	**Contingency Procedures need to be further tested (Loss of C2 Link)**

The table below presents a summary of the criteria for assessing the level of maturity according to the E-OCVM method.

Criteria (V2 → V3)	Our finding/ assessment
Operational feasibility (user acceptance, safety)?	<u>**Yes, with some limitations**</u> induced by the accommodation provisions (low to moderate traffic density, backup telephone line…) **Some critical aspects require further actions.** - *Need for Basic training on RPAS for ATCO* - *Emergency (loss of C2 links, Radio failure) procedures tested in simulation in first EDA study but need to train ATCOs to implement these emergency procedures*
Technical feasibility (preliminary assessment based on research prototypes)?	<u>**Yes, with limitations**</u> proven by real cross border flight of a REAPER between France & Spain. **Generalization to other Legacy RPAS and other EU MSs, due to existing differences in the organization of ATM, requires further investigation.**
Transition feasibility (including institutional issues)?	<u>**Manageable:**</u> **Different approaches between EU MSs in implementing ATM rules regarding OAT and GAT results in several difficulties with national regulation and delayed the realization of this experimental flight for months.**
Potential benefits validated for concept options ?	**Improved flexibility and traffic flow capacity in a given sector of Airspace Management (no need to establish corridor)** *This induces improved safety for the RPA, thanks to possible route change for the RPA for avoiding degrading weather condition*

Criteria (V2 → V3)	Our finding/ assessment
Affordability for stakeholders?	**Limited investment** (eventually keypad programming of CWP, fixed telephone line management)
Alternative solutions compared ?	**N/A- the "accommodation phase" is a transitional phase** until the technical solutions for full integration have been fully tested and qualified.

Taking into account the observations made and the feedback from the main actors, pilots and controllers, we can consider that this concept of MALE UAS accommodation in general air traffic is at level V3.

However, we have observed a number of difficulties resulting from the lack of experience and harmonisation in the application of certain procedures. In order to increase confidence, it would therefore appear necessary to envisage other flights of this type with transfers to other civilian control centres and other European countries. The attainment of level V3 makes it possible to envisage the continuation of this type of experimentation on a larger scale.

2. INTRODUCTION

This study takes place in a suite of works initiated by EDA in response to Member States' willingness to make progresses toward the integration of MALE type RPAS in non-segregated Airspace.

An intermediate step, before reaching the full integration, which supposes the implementation of not yet developed systems (equipment, processes and environmental conditions) is to allow a safe integration of existing legacy MALE –type RPAS, pending proper adaptations which do not entail major changes in the ATM environment and do not downgrade the level of safety. The package of those adaptations is the "accommodation measures".

2.1. MALE type RPAS Accommodation Study

In 2018, EDA ordered a study entitled "accommodation of large RPAS scenarios and safety case"[1]. A report published in February 2019, defined standard scenarios and associated tailored risk assessment (safety case) of this kind of operation. Some real time simulations were used to validate the safety cases. The result was an enhanced "aviation safety case assessment" for RPAS, based on the Bow-Tie methodology. The aim was to cover, through various scenarios stemming from a generic one, relevant threats and aviation hazard analysis, which may occur when accommodating a MALE type RPAS into the European airspace, alongside manned aviation.

Following the presentation of those simulations result, during an EDA SES Military Aviation Board (ESMAB) policy meeting in January 2019, France offered the possibility to perform a real flight, including a cross border portion.

France's offer aimed at facilitating the validation of the methodology defined by the initial accommodation study, and testing use cases developed in the common EDA-EASA document "Guidelines for the Accommodation of Military IFR MALE-type RPAS under GAT Airspace classes A-C"

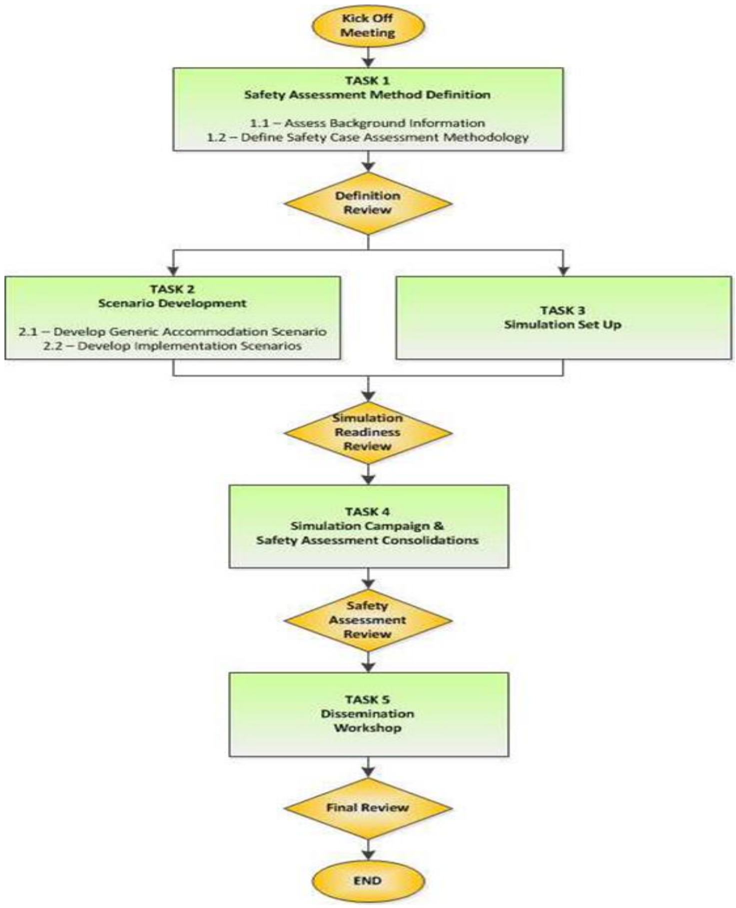


Fig 3: Study overview

2.2. MALE type RPAS Accommodation Validation Study

The present study (19.ISE.OP.19) launched in 2019 aims at refining the proposed safety case methodology and validate some of the proposed accommodation measures through an actual experimental/demo flight.

The approach adopted for this follow-up study consists, after taking into account the results of the previous study, in refining the scenarios, then completing the safety case analysis, taking into account in particular, with regard to the air-to-air risk, the impact of the introduction of male drones in nominal operation as well as the air-to-ground risk. The figure below shows the organization of the work into three main tasks.

[1] MALE-Type RPAS Accommodation Study (17.CSP.OP.17)

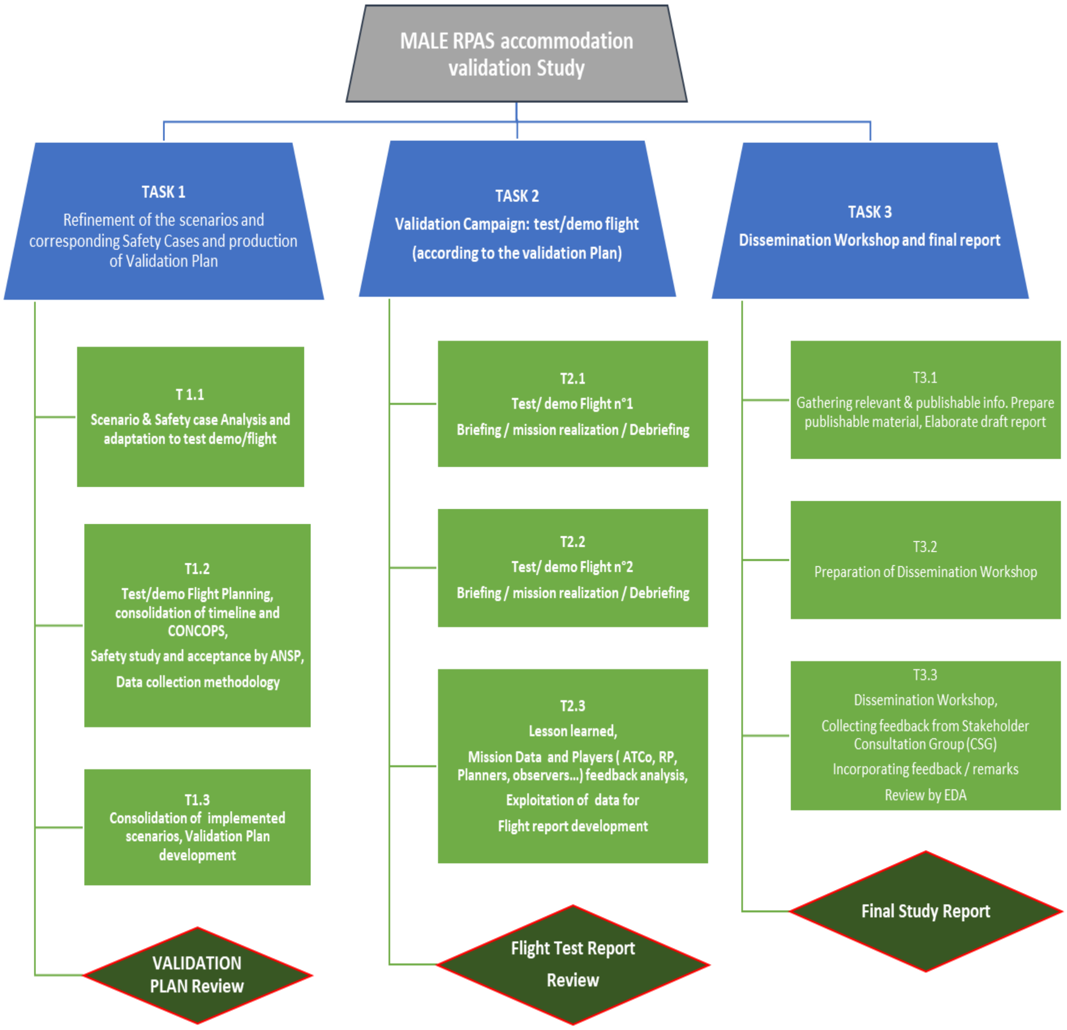


Fig 4: Study work breakdown structure

- The first task consisted in refining the scenarios and, where relevant, completing the safety case study in the light of recent work carried out by other European bodies, such as EASA and EUROCONTROL on the integration of MALE type RPAS in GAT[2].
- The second task dealt with the preparation and execution of an experimental cross border flight of a French Air Force MQ9- REAPER, as part of an experiment carried out by DSAE and DGAC, the French ANSP in the framework of SESAR.
- The third task of the study relates to the analysis of the observations during the preparation and execution of the cross-border flight and the results obtained; the assessment of the conditions and limits of the accommodation measures implementation and finally the dissemination of result to the stakeholders consultation group (SCG).

A few points concerning the timetable associated with the completion of this study are worth developing at this stage. As described in more detail in the first document "D1-Accommodation validation Plan", the conduct of the study has suffered from a lack of uniformity in the European aeronautical landscape.

[2] "in GAT" to be understood as "under GAT flight rules".

This is not to question the legitimate sovereignty of each Member State over its own airspace, but rather to highlight the difficulty of a multinational exercise in a non-homogeneous world in the way certain regulation are interpreted an implemented. The difficulties in implementing accommodation measures for a military MALE type RPAS are symptoms of this lack of homogeneity. The identification of solutions on a European scale should make it possible to find common answers so as not to accentuate the already existing divergences. On the contrary, it could be a concrete way to find solutions to bring EU member states structures and processes closer together regarding the accommodation principles. This can be considered as a major lesson identified and analysed, which should be retained for any further study of this type.

This is one of the reasons why, although it has been imposed on us, the use "Bow-Tie" methodology for safety case analysis is not our preference. This method has the great advantage of simplicity and is very effective, particularly for analysing a chain of causes, but it has limitations when it comes to quantifying a risk and evaluate the effectiveness of a mitigation measure (barrier).

We would privilege a more classical approach, although more complex, to safety case, based on the establishment of a fault tree, which is more compatible with the process recommended by EUROCONTROL and EASA. This methodology allows multiple causes combinations analysis and, subject to causes' statistics availability, enables a quantitative assessment of conditional probabilities related to the occurrence of the hazard Top Level Event.

3. SCOPE OF THE STUDY

It is essential to bear in mind that the scope of the study is limited to some part of the flight. The reason for this choice are twofold.

- The proposed accommodation measures are feasible now, with a minimum of impact, both technically and on organisational, on current existing RPAS and ATM system.
- The operational benefit for civil and military stakeholders is maximised for operating existing legacy MALE-type RPAS.

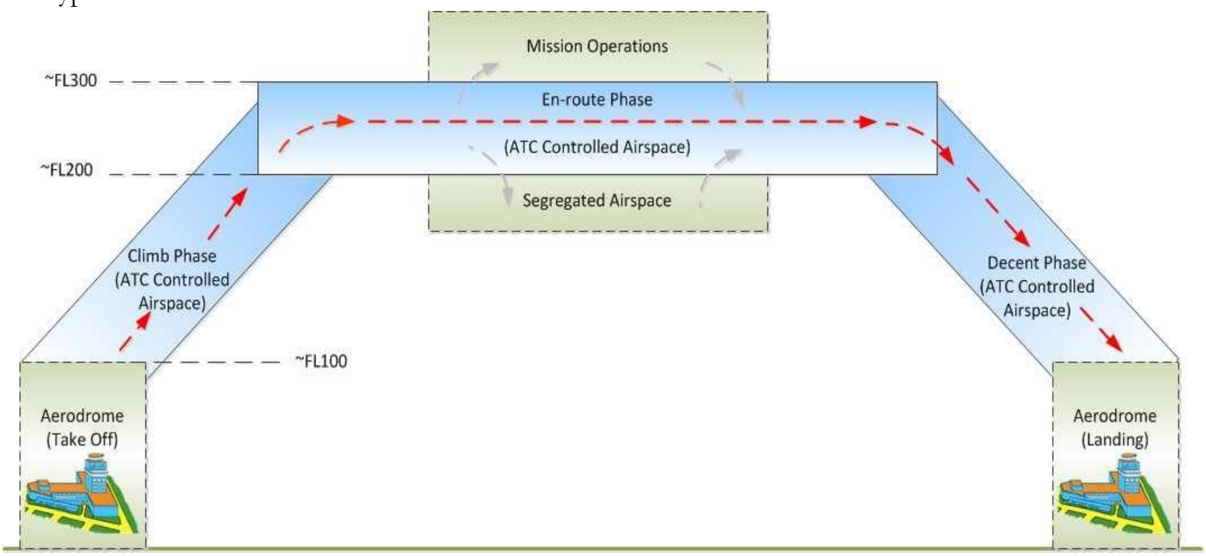


Fig 5: scope of the Study

4. OUTCOME OF D1 – ACCOMMODATION VALIDATION PLAN

This document D1-accommodation validation plan contains two key elements:

- The safety analysis of the different scenarios and the identification of those that can be validated by the experimental flight.

- the CONOPS concept of operations, which describes in detail how this scenario will be implemented and the risk mitigation measures planned in the event of deteriorating conditions or failure (critical breakdown)

It also specifies what was intended to observe and what data to be collected during the experimental flight and the validation methodology.

In the following paragraphs, we propose a more detailed description of the methodology used by the DGAC, the French ANSP, to carry out the safety study submitted to the supervisory authority (DSAC) which authorised the experimental flight in French Airspace.

5. OUTCOMES OF D2- FLIGHT REPORT AND MAIN RESULTS

Document D2-Flight Report constitutes the second deliverable of the accommodation validation study. This document contains the results of the flight validation campaign. The main section of interest are listed below:

- Section 3 provides a description of the flight preparation, the safety studies carried out by ANSP and the flight plan processing;
- Section 4 describes the execution of the flight;
- Section 5 provides a summary of the observations made during the flight as well as the feedback from the remote pilot and the control officers on duty in the various en-route control centres;
- Section 6 provides an initial analysis of these observations
- Section 7 summarize the global outcome of the experimental flight and propose some follow-on reflections

Obviously, the Contingency procedures in case of a critical failure (radio failure or loss of C2 link) were covered by CONOPS and addressed by the safety study submitted to the supervisory authority, but were not tested during the flight. However, these procedures had been tested by the real-time simulations of the previous 2017 EDA study and during the trial flights carried out with the Harfang RPAS.

The combination of the results of the two studies offer a complete view on relevant threats and aviation hazard analysis, as well as safety impact in normal situation when introducing a MALE RPAS within a non-segregated airspace (Class A to C, D for France) in a defined portion of the flight.

6. FINDING AND ANALYSIS

6.1. From the first study with hybrid simulations runs

The first 2017 study implemented cross border flight scenarios, supported by a hybrid simulation including the human operators, ATCOs and Remote Pilot, in the loop.

Findings from this first study were presented in the final report MALE-Type RPAS Accommodation Study Final Report– Issue 08 (1st March 2019) and are summarized below.

6.1.1. Participant Workload

Team SIRENS concluded that the ATCO participants were able to predict potential 'loss of separation' events between aircraft represented in the Simulation runs some time before they would occur and instigate avoidance procedures well in advance. This begs a numbers of questions:

- What happens as the level of proximate air traffic increases?
- At what point would 'normal' ATCOs start to miss spotting and dealing with potential conflicts?
- Is there a point where the level of traffic is so high that the ATCOs could get overwhelmed and this Barrier begins to fail?
- What then is the potential for the hazard to occur leading to consequential risk to life?
- What happens if there are more RPAS for the ATCOs to manage? At what point would the same set of issues outlined above start to occur?

- What happens if RPAS pilots begin to fly more than one Aircraft each? Does their ability to liaise with ATC diminish and at what point does this represent a failure of the Barrier leading to the occurrence of the TLE/Hazard?
- What happens if all of these situations occur?

In addition, it was thought that additional manpower (resources) may be required to help dealing with RPAS emergencies:

- In most ATC centres, an assistant who provides basic coordination support and can take a role in situations that require more attention supports the operational air traffic controllers. These assistants will be able to deal with MALE-type RPAS emergencies and ensure sufficient measures are implemented to avoid conflicts with other traffic.

Other workload issues that arose included:

- Dutch controllers were not familiar with the UK airspace, which influenced their capability to handle the traffic efficiently, but on the other hand, it caused them to be very busy thus making the RPAS integration more stressful. This was a consequence of the fact that the ATCO participants in the Simulations were Dutch.
- In the event of a Transponder failure, additional resources may be required to help handle the situation. This could be mitigated by the use of additional surveillance equipment such as ADS-B.

6.1.2. Back up Communications Procedures

In the Simulation runs a back-up communications set-up was used whereby the ATCOs could talk to the RPAS Pilots via a dedicated phone line in case of emergency (i.e. in case of radio relay failure on-board the RPA). This was considered a reasonable measure with the following caveats:

- A good communications procedure needs to be established for the use of back up phone line.
- This includes several important considerations such as how to routinely identify the pilot's phone number by ATC (and vice versa); maintenance of communications with other air traffic and workload implications
- The phone procedures take some familiarisation effort, after some time using the phone, it became easier to use.

6.1.3. Route Awareness

As RPAS are accommodated alongside manned aviation, the ATCOs need to gain confidence that the RPAS will behave as expected. To help gain this level of confidence the ATCOs will need "good briefing on planned RPAS routes". This is really to ensure that RPAS flights are planned in the same way and to the same level of detail as manned flights are today.

6.1.4. Dual- RPAS flying & Communications Failures

In future, it is conceivable that an RPAS Pilot may take control over more than one RPA. This situation was simulated during the Simulation campaign in order to present a new and difficult situation to all participants, in particular since they were challenged with simultaneous loss of communications to both RPAs. In the relevant simulation run both the ATCOs and RPAS Pilot coped well and made the following observation:

When two RPAS simultaneously have a loss of R/T voice communications with the same controller and are flown from a single GCS and by a single pilot and the pilot can separate these RPAs, then for the controller (ATCO) the situation would be equivalent to the loss of R/T voice communication of one RPA.

6.1.5. Navigation System Failures

Specific conclusions arising from the examination of the effect of a failure in the RPAS navigation system include:

- Should this be a pan-call? In the discussion, the tendency was no
- It may be decided to define standard phraseology for this (or use "unavailable RNAV", which is standard ICAO terminology)
- The RPAS pilot shall inform the controller about the consequences of a failure on the performance of the RPAS, not on the failure itself.

6.1.6. Overall Safety and Control

In general, the ATCOs were satisfied that they retained a level of control over the airspace under their responsibility and its proximate traffic with a MALE-type RPAS present, with the following specific observations:

- The level of control that the air traffic controllers indicated in the simulations was reasonably low in some of the runs. These were the runs where controllers used the phone connection the first time. Later on in the simulations the phone connection between the controller and the ground control pilot became a more standard a part of their working procedures.
- The concerns on safety of the situation correlate with the answers on the level of control the air traffic controllers experienced. The same applies for their ability to plan and organise the work as they wanted.
- The impact of the MALE RPAS that controllers indicated on situation assessment and on their workload was mostly concerned with the need to give the RPAS a different route and the effect of its slow (slower) speed.
- Therefore we conclude that the accommodation of MALE-type RPAS as demonstrated in the simulation runs conducted under this study does not compromise ATCOs ability to maintain safe skies.

6.1.7. The 'Impact' of RPAS Accommodation

The participants were questioned about the overall impact of accommodating a MALE-type RPAS in the scenarios and their conclusion was that the RPAS had no significant impact on ATCO workload or scenario complexity. The only thing that was noted to be different from "normal" traffic was the way the RPAS was routed.

There were times during the simulation runs (particularly when positional information was compromised) where the ATCOs were not aware of or familiar with the remaining RPAS capabilities and it took them a few iterations to become comfortable with the ability of the RPAS to navigate as expected.

In circumstances where controllers were not initially familiar with RPAS capabilities it is considered advisable to ensure capabilities are provided as part of the flight plan.

6.2. Observation, finding and analysis from the second study

The aim of the follow-up study was to validate the accommodation measures and principle in flight.

The objective of the experimental flights was to show that "flying a MALE RPAS in non-segregated airspace (Cat A to C within the limits of the scenario) is safe subject to appropriate accommodation measures".

The flight being carrying out in real conditions in non-segregated airspace with real ATCOs, a real RPAS and remote pilot, it was not possible to simulate critical failures for obvious safety reason. Therefore, the observations and feedback focused on the "Normal conditions" as illustrated below.

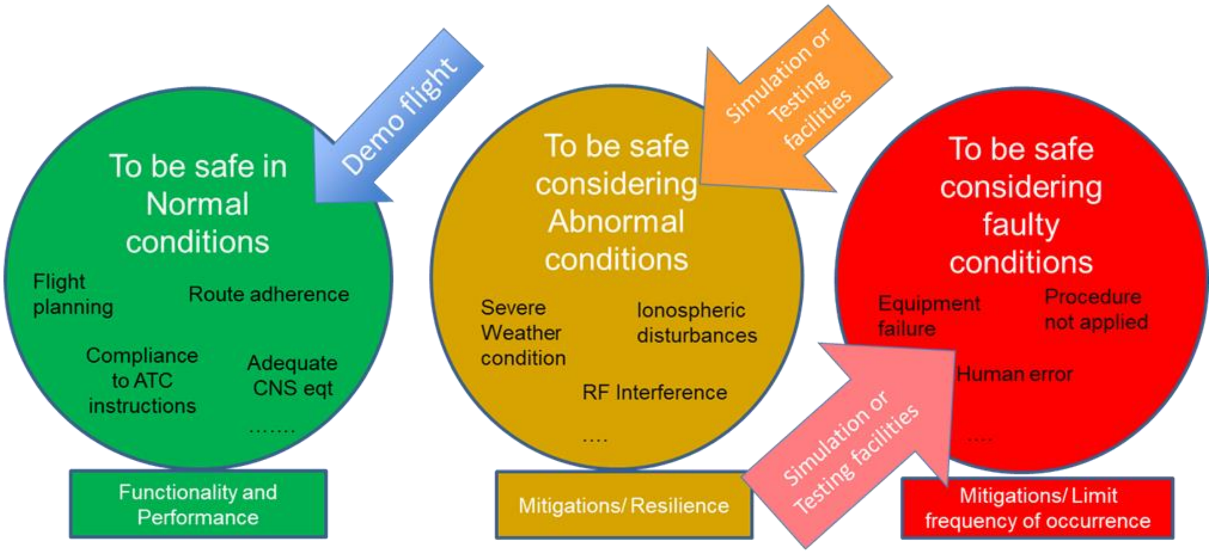


Fig 6: Operational Conditions

6.2.1. Preparation:

6.2.1.1.Strategic level

The preparation burden for an experimental flight is heavy especially for a cross-border flight.

The extended duration of this study demonstrates the importance of an initial preparation meeting to initiate work on a CONOPS jointly approved by the civilian and military authorities of the involved states, which then serves as a basis for the national safety studies that, according to ATM regulation must be carried out and endorsed by ATM surveillance authorities.

The CONOPS constitutes the key piece of work at the "strategic" level that ensures that all actors share a common vision of the result to be achieved. It is an opportunity to measure the differences in understanding of the desired goal and to find ways to progress specific to each participating Member State.

In the case of this French-Spanish cross border flight, it took a long time for the principle of civilian control of a military RPA in non-segregated airspace to be accepted. This acceptance was made possible by OAT coverage over Spain, but handled by civilian ATCOs and inserted alongside other air traffics. Once both parties agreed this adaptation, the adoption of a CONOPS was very quick.

The CONOPS that has been produced is a solid basis and its framework constitutes the core of what a generic CONOPS could be for similar scenario and mission profiles.

6.2.1.2.Safety case Study

Different methods are used to conduct safety studies. The previous study used the "Bow-Tie" method, which has the great merit of facilitating the analysis of the causal chains that could lead to the occurrence of a feared event (serious incident or accident such as AIR MISS or mid-air collision). It has the disadvantage of not allowing multiple causes to be analysed, each cause being considered as an independent event.

In order to refine the safety studies relating to the points likely to be validated by the experimental flight (preparation and execution), we took as a starting point the barrier safety model used by EUROCONTROL and the "ANSP". After a 90° rotation to the right, we reorganised the chain of causes by removing the links that these may have within them. This transformation is depicted by the figure below.

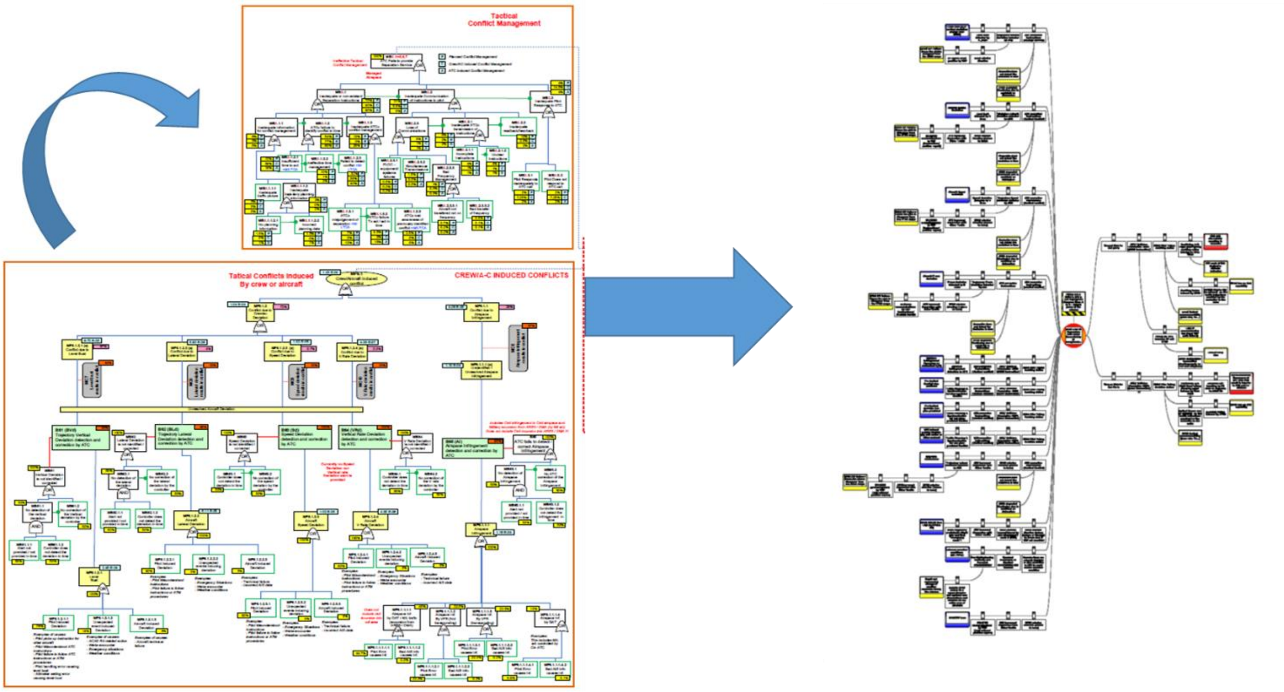


Fig 7: transformation from safety barrier model to Bow-Tie representation

This transformation results in the loss of some of the information contained in the cause failure tree.

The safety case study for the second flight took some time because it used the EUROCONTROL formalism that is more in line with European Commission Directive (EU) No373/2017. The differences between the first study (EPIS) and the second one are the consequences of the implementation of new recommendations resulting from the work of Eurocontrol and EASA following the adoption of Directive (EU) No 373/2017.

A copy of this study is an appendix to the second deliverable document "D2-flight report". The latest version of the safety study elaborated by DSNA, the French ANSP, for the second flight details the objectives of the experimentation and its possible impact on the safety level of the ATC system through its functionalities.

Of course, this safety case study takes into account the experience gained from the former experimentations already conducted nationally and not all Events or Hazards are detailed as if it was the first experimentation. An abstract of this safety case study is provided below, where salient elements are underlined. In the assumptions taken into account, we can note in particular that:

H1	The experimental flight takes place in accordance with the conditions defined in the document "CONOPS of the experiment of RPA flights out of segregated airspace".
H2	From the ATC environment point of view, the RPA flight is considered as an ordinary flight in the control sectors or groups of control sectors concerned by this experiment.
H3	The communication between the air traffic controller and the remote pilot is permanently ensured thanks to the presence of a dedicated telephone line used as a backup[3].

[3] Cf. §3.4.3.2 of the EDA & EASA Guidelines on accommodation of Military IFR MALE TYPE RPAS UNDER GAT AIRSPACE CLASSES A-C

Operating a RPAS in non-segregated airspace is considered as the “new operation”. The following impacts on the ATM systems of the introduction of this “new operation” are identified and analysed:

- Impact of the change on work procedures/methods
- Impact on equipment/software. No impact

In the series of barrier safety case models, two models are considered as impacted: Mid Air Collision “En Route” (MAC-ER) and Mid Air Collision in TMA. (MAC-TMA). The annex III provides these models

The main threats analysed, potential cause of the hazardous event, are the loss of C2 link as well as a failure to respect the trajectory "En route" or in TMA when operating the RPAS in Normal condition (fig 4).

Events that, thanks to experience already gained from live experiments, were not considered as Danger (Hazard) are also mentioned in the safety study:

- Latency in communications
- Loss of radio communication between the pilot and the air traffic controller
- The controller does not know the drone's performance and gives an inappropriate separation order
- Actual transponder failure

In the safety study, non-surprisingly, we find descriptions of the hazards, their potential causes or “threats”, the Risk Reduction Measures (MRRs), justification of their a priori effectiveness, and declination of the Risk Reduction Measures into requirements. Refer to the diagrams in Annex III presenting the barrier safety models to see which elements of the ATS system are impacted by a loss of the link between the Remote Pilot and the RPA.

Note the use of the barrier safety model

<table>
<tr><td colspan="2">Hazard 1 (TOP LEVEL EVENT): En-Route Non-control of the drone trajectory following a loss of communication between the RP and ATC (PLOC[4])

Communication between ATC and the drone pilot is by voice. In case of loss of communication between the RP and the ATC, the two tactical and recovery barriers are impacted. This danger may arise in a normal flight situation, due to the potentially higher probability of occurrence since the C2 link and the RP-ATC communication chain are supported by the satellite link in BLOS

MAC-ER MF4: “Crew/AC imminent infringement”
MB6.2.3.1 : Equipment/systems failures impacting barrier B6 : Crew/AC Induced Conflict Management
MB4.3.1.1 : Equipment/systems failures impacting barrier B3B4 : ATC collision prevention</td></tr>
<tr><td>Cause :</td><td>Communication between ATC and the drone pilot is by voice. In the event of a link loss, both tactical barriers recovery barrier of the ATS system are impacted.</td></tr>
<tr><td>Benefit:</td><td>The management of an RPA in GAT is similar to the management of a conventional flight, especially in case of a Radio failure (display of code 7600).</td></tr>
<tr><td>Applicable Assumptions</td><td>H2: From the ATC environment point of view, the drone flight is considered as an ordinary flight in the sectors or groups of sectors concerned by this experimentation.

H3: The communication between the air traffic controller and the pilot of the RPA is ensured in a permanent way thanks to the presence of a dedicated telephone line.</td></tr>
</table>

[4] PLOC stands for “Prolonged loss of communication” that mean loss of communication between RP and ATCO

MRR1/1:	Informing ATCOs and CDSs on what to do in the event of a radio failure with the drone, including using the dedicated backup telephone line.
Safety Criteria	**Danger 1 is deemed to be under control.**

<table>
<tr><td colspan="2">Hazard 2 (TOP LEVEL EVENT): En-Route Trajectory alteration due to a C2 link failure
Hazard 3 (TOP LEVEL EVENT): Trajectory alteration in TMA due to a C2 link failure
In the event of an internal drone failure involving a course alteration procedure, deviations of the drone are expected. However, no specialized cause that would cause a specific type of deviation is identified. The causes are therefore considered as high level in the MAC-ER and MAC-TMA models(provided in annex III)
MAC-ER: “MF6.1 Crew/Aircraft Induced Conflict” and “MAC-TMA MF6.1 Crew/Aircraft Induced Conflict”
The set of MF6.1.2.X Conflict due to XX deviation (level burst, lateral deviation, speed deviation, V rate deviation) impacting barrier B6: Crew/AC Induced Conflict Management in the Model provided in Annex III</td></tr>
<tr><td>Applicable Assumptions</td><td>H1: The experimental flight proceeds according to the conditions defined in the document "CONOPS of the experiment of RPA flights out of segregated airspace".</td></tr>
<tr><td>MRR1/2:</td><td>In the event of a more severe ground-to-aircraft link failure, a good knowledge of CONOPS is required to predict trajectories (pre-programmed emergency routes).
To inform the controllers about the failure cases and their related emergency procedure. Presence of a person, frome the “real tim” entity, with a good knowledge of CONOPS and emergency procedure who can assist the ATCO.</td></tr>
<tr><td>Safety Criteria</td><td>Hazard 2 and 3 are deemed to be under control</td></tr>
</table>

6.2.1.3.Flight Plan

The flight plan was carefully prepared and required a thorough study. Its acceptance and its implementation were possible thanks to the involvement of specialized military and civil offices, which intervened manually to compensate for the inadequacies of a civil management system, which can have difficulties in ingesting and processing the specificities of a military flight plan.

The major difficulty does not come from the RPAS itself, but from the specificity of the military mission, (long trip, circular flight with same departure and arrival airfield, mixed civil-military flight plan…). Similar difficulties can be encountered with manned aircraft.

In the end, a circular flight plan such as the one drafted works adequately and needs to take preliminary measures such as those described in the analysis.

Note that elements of the flight plan were those of the former nomenclature[5] of the French OAT flight plan, not adapted to the new context. This document had to be processed by the BIV-C, a military organization that

[5] The military authorities (DSAE/DIRCAM) have updated their directive on how to file a flight plan in the in the first quarter of 2022. This updated directive aims at harmonizing the nomenclature : https://www.dircam.dsae.defense.gouv.fr/fr/documentation-4/cmia

handles flight plans and provides the link with the civilian services. Presently, in France, the procedure is being reviewed and the today applicable text (MIAM_OACI_ENR 1.10) is taking into account the new environment, both technical and procedural.

6.2.1.4.Tactical Level

The crew briefings before the flights contained all the necessary elements to safely implement the flight, insisting on emergency measures and quality of communications.

In ACCs, the preparation for the ATCOs was done through a specific memo in the binder of instructions, which the team of ATCO must read before taking their shift. Some progress can still be made on the document made available to the controllers in the control room. DSNA, the French ANSP and DSAE, its French military counterpart, are currently working on a synthetic note, which, for the experimentation, already contained the main points needed to ensure a good understanding of the specificities of the RPAS.

In the first instance, the presence of someone who knows the CONOPS "in case of" is reassuring and may prove necessary in case of a problem. This observation is completely in line with the conclusions of the first study and the simulation experiments. As mentioned above, the presence of a person with a good knowledge of the CONOPS and emergency procedures is one of the risk reduction measures that was retained in the safety study carried out for this experiment.

As an accommodation measure, the information provision before the flight is considered efficient for normal operations; for the crew through a briefing and for the ATCOs through information notices to be carefully read by ATCOs before taking their shift (duty).

It should be noted, however that comments and questions raised during the flight confirmed some ATCOs' lack of knowledge of the RPAS and its behaviour in abnormal or faulty operating condition.

The reason for this is due to the fact that the ATCO community is generally not aware of the performance of military RPAS. This means that all the salient points must be highlighted in the briefing note. Nothing should be taken for granted. The specific performance of the RPA (speed), the radio performance, the use of the dedicated telephone line (specific to the REAPER), etc…

These flights trigger a necessary reflection on the best way to relay the necessary information in a synthetic, efficient and systematic way.

These tactical measures can only be alleviated when controllers are used to the specificities of RPAS and their behaviour in case of deteriorating flight conditions or critical breakdown.

As a strategic measure, and taking into account that the number of RPAS flying in general air traffic could rapidly increase, it might be advisable to introduce this specific knowledge into the training programme of air traffic controllers. In the meantime, military RPAS crews should gradually become more familiar with GAT procedures and phraseology.

For aeronautical information, such as the coordinates of published waypoints, provision should be made to make it available in the RPAS ground station. Efforts shall be made to automate the input of such data in order to minimise human intervention and the risk of input errors when inserting them into the RPAS navigation system.

6.2.1.5.Flight management

Due to bad weather conditions, on the second flight, the take-off was delayed by approximately 1:30. A slot requirement in the military working area at Bardenas, led the crew, to expedite departure as soon as allowed by weather improvement. In order to save time, the RPAS crew decided to depart in IFR GAT via the Aquitaine TMA (Bordeaux approach) to climb directly toward the planned route and asked the local control of Cognac to activate the IFR flight plan at engine start. Cognac Approach did not realised that this decision was not in accordance with the CONOPS and therefore requested a clearance for Engine start-up to Aquitaine, the Bordeaux approach. The Bordeaux Approach (TMA Aquitaine) had not been informed of this flight plan since, in the CONOPS, the transfer was to be made directly between the Cognac approach and the CRNA SO, after an initial climb under the control of the approach and in the Cognac military restricted area.

Bordeaux approach, although surprised, adapted to the situation. Added to this was a poor transition from LOS in BLOS mode (human factor). The RPA was therefore put on hold several minutes, at FL 70 staying close to the limits of the Cognac restricted Area, while the satellite link was stabilized. The flight then resumed without incident. This unplanned deviation and incident demonstrated the ability of civil ATC to quickly adapt to an unforeseen situation that could just as easily have occurred with a manned aircraft. The fact that the Bordeaux approach was not informed of the flight, as pointed out in a reply to the questionnaire, proved to be problematic. It is advisable to operate the LOS to BLOS transfer in a segregated area, ahead of the transfer to the civilian control entity.

En-route transfers did not present any particular difficulty, nor did compliance with ATC instructions and clearances given. The RPA and the Remote crew reacted to the ATC instructions with time and accuracy compatible with insertion in GAT and comparable to any manned aircraft. In the favourable conditions of the flight, the low speed of the RPA and the risks of overtaking were considered as part of the normal work of a controller.

6.2.1.6.Communications

Communications between ATC and the RP in the day's flying conditions were efficient and the exchanges consistent with what one would expect from an aircraft operating in GAT in non-segregated airspace class A to C. The one to two seconds latency observed, due to the satellite link delay, in the exchanges is almost transparent.

On the first flight, at the time of a first contact with Marseille control (CRNA-SE), probably due to the limit of the radio range, the quality of the communication was very poor. As this was a clearance prior to entering a new control sector, the crew took the initiative to rapidly contact the ATCO via the dedicated telephone line and to ensure that the clearance was received. Subsequent contacts were resumed on VHF, the quality of radio transmission having improved considerably. While this should remain a backup, the use of the phone line was nevertheless considered premature and, for the second flight, it was reminded that using the telephone line must remain a backup for dealing with emergency situation.

This minor deviation proved that the dedicated telephone line is effective. This confirms that it can be considered as a good accommodation measure to mitigate the risk of loss of communication.

6.2.1.7.Confidence

The confidence of ATCOs in inserting a RPA into general air traffic can be considered good under the normal operating conditions of the experiment.

There is a concern about how to handle a degradation of these operating conditions or if traffic is dense, especially in airspace close to TMAs with many arrivals and departures from large airports. The handling of critical failures, such as loss of communication or C2 link, and how the RPA would behave raises a number of questions for controllers

The presence of a controller with knowledge of the RPAS and the behaviour of the RPA is a reassuring factor that helps to bridge this knowledge gap. It is also worth bearing in mind that some emergency procedures may be different depending on the type of RPAS.

The ATCos' confidence in the insertion of a RPA in GAT can be considered as good under the favourable conditions of the experiment.

6.2.1.8.Validation success criteria (reminder)

Positive feedback from air traffic controllers and remote pilots on the flight and associated accommodation measures was a success criteria.

With the conditions of the day, and taking into account the accommodation measures, it is fair to say that the feedback is positive and that « flying a MALE RPAS in non-segregated airspace (Cat A to C, D for France, within the limits of the scenario) is safe subject to implementing appropriate accommodation measures.

The D2-flight report document thoroughly describes this positive feedback.

7. MAIN OUTCOMES FROM THIS EXPERIMENTAL FLIGHT PHASE

7.1. Strategic measures/Preparation

For establishing a real cross border flight, a long preparation may be necessary to take into account the national specificities of the Civil-military coordination. Some innovative national solutions may be developed to satisfy first an experimental phase and then move to a routine exploitation of the potential given by flying MALE-Type RPAs in GAT and non-segregated airspaces class A to C (D for France).

To pave the way of the common work to be implemented, the CONOPS, which was developed for this study, contains the main elements of a GENERIC CONOPS, which can be adapted to the local specificities.

Another point of attention is the flight plan, which may also reserve some surprises. Some test runs should be carried out before an actual experimental flight to ensure that the Eurocontrol and national flight plan automated processing systems are compatible and properly take into account the specificities of a mixed OAT/GAT, circular flight plan.

All actors identified the dedicated phone line as an important complementary mean, for the trial, in case of loss of VHF communication(PLOC) whatever the cause (loss of satellite links or failure of the on-board VHF radio). The use of this telephone line requires the prior development of an implementation process and leaves no room for improvisation.

> The back up telephone line is a recommendation, which is valid for an experimentation. This recommendation will be questioned in the future with the multiplication of RPAS operating at the same time in the same sector and all controlled airspaces.
>
> The establishment of a dedicated back up telephone line to compensate for a Prolonged Loss Of Contact (PLOC) remains a recommended and appropriate measure et the experimental stage (One RPAS and limited number of cross borders). Its generalization as a mandatory accommodation measure on a larger scale, with an increasing number of ACCs and nations involved is likely to generate major difficulties of a technical and operational nature (out of scope for our study).

Both during simulations and during the actual flights, the lack of knowledge of the RPA capacities and the RPAS behaviour was obvious. The successive rounds in the simulation tests showed that the ATCOs rapidly gained confidence in the fact that the RPA could be considered, to a large extend like a manned aircraft.

This underlines the necessity to rapidly reach a good level of knowledge for the ATCO on the specificities of RPAS.

This can be achieved through education and training in the long term, provision of CONOPS, and daily service note to ATCO in the short term, to be read, just before the ATCO takes his duty position.

This note has to be carefully written to underline the main point that ATCO have to address when handling an RPAS flight:

- behaviour of the RPA;
- emergency procedures;
- use of the dedicated telephone line;

In the meantime, beyond theoretical knowledge, military RPASs' crews should seize any opportunity to train for GAT flights. The RPAS piloting system should allow a fully updated GAT route information for the Crew as well as a rapid adaptation to any change of routing ATC clearance.

7.2. Flight management

7.2.1.1.General

In a low or moderate operating traffic context, there is no or few impact of the introduction of a RPA in the ATM. The working positions and the organisation of the control actions (planner and executive controller) do not need any specific adaptation. From the ATCO's perspective, the RPA can be considered as a manned slow aircraft.

The en-route transfers did not represent any particular difficulty, nor did the compliance to ATC instructions and clearances given. The RPA and the RPAS crew reacted to the instructions of the ATC on timely manner and accuracy compatible with an insertion in GAT and comparable to any manned aircraft. In the favourable conditions of the flight, the low speed and the risks of overtaking were considered as part of the normal work of a controller

7.2.1.2.Specifics

The transition of the RPAS from LOS to B-LOS mode, which is a sensitive point, must be performed in the segregated Airspace portion of the flight prior transfer to the civilian ACC.
Communication latency is not a challenge and apart from an extremely overloaded traffic, should not pose any problem. This is particularly true for the portions of the flights, subject of the proposed accommodation.

7.2.1.3.Traffic Density

The studies show that in a low to moderate traffic situation, one RPA flying at 180KTs true air speed or higher in one control sector is manageable.

A legitimate question in the case of high-density traffic must be answered through other tests, eventually using simulation. This same question arises in the appreciation of the presence of an RPA in case of abnormal or faulty conditions. Here again, the density of the traffic will have an influence on the perception.
Some questions remain on the number of RPA which could be managed, at the same time, in one sector. Instead of RPA the first study shows that the question should be RPAS as it is envisaged in the future to have one remote pilot piloting several RPAs and as depicted in the studies, the limitation factor is the number of fixed lines that ATCOs, in one sector, can cope with. Further studies based on simulations with human operators in the loop would allow to quantify the number of RPAs not to be exceeded in a given sector for a given traffic density

7.3. Emergency and contingency situations (abnormal or faulty condition)

It is obvious that, for any kind aircraft, an abnormal or faulty occurrence would entail serious impact on the control environment.
We can consider that from ATCO's perspective, an RPA is a slow mover with some characteristics attached to the UAS specificities. Mainly, no human live on board and a satellite link dependence.

7.3.1.1.Engine failure

An engine failure, in the case of an RPA, without automatic landing capability, is less of a problem than it would be for a manned aircraft because the aim in that case in to crash in good conditions to preserve life and property. The batteries autonomy allows the remote crew to pilot the RPA until the crash zone and there is no attempt to find any kind of landing zone. The instruction is simple: crash safely. For that purpose, RPAS crew is also able to use its on-board cameras to evaluate visually the most appropriate and safe crash zone. The on-board batteries have sufficient autonomy to maintain control of the RPA during this manoeuvre.

7.3.1.2.Loss of C2

For a RPAS, the major problem, apart from an engine breakdown is the loss of C2 link. This would mean that the RPA is no longer piloted by the Remote Pilot and will fly along a pre-determined route flight plan. It also entails a loss of VHF communication that can be overcome through the use of the direct line phone.

The first study and the numerous simulations showed that the direct phone line was an efficient means to remediate a loss of communications. The second study confirmed, by chance, as it was not planned, that the tool is working. It has to clearly be considered as a contingency tool and used with a standard aeronautical phraseology.

To estimate this impact on the ATS system, we can compare this situation to a loss of communications for a manned aircraft of the same category (less than 5.7 tonnes):

In the case of conflictual situation between slow and fast movers, the first instinct of an ATCO is to give instructions to fast mobiles as he can see immediately the effects. In the C2 link failure situation, for the Reaper, we should be systematically in that case with the RPA flying along a predicted contingency route, as mentioned in the CONOPS and reminded to the ATCO through the direct phone line when available (see § 9.2.1.3).

The Reaper type RPAS used for the experimentation has no autonomous landing capacity. This explains it cannot divert to an airfield where there is no LOS reception ground station. As stated in the simulation campaign, the knowledge of the RPAS actual capacity and the RPAS behaviour helps the ATCO's understanding of contingency procedures and makes it easier to manage it.

The table below presents a comparison between a light manned aircraft (<5700 Kg) and a RPAS.

	Actual Flight plan	Speed impact	Communications	Lenght of the abnormal situation	Impact on ATCO's workload
RPAS	Predictable, in accordance with CONOPS. Prediction given through Direct phone line	Low speed, some manageable impact if dense traffic.	7600 is switched on Direct line with a low risk of failure	Potentially long track and long-time along a scheduled track. Until the UA is in LOS space and can be piloted manually again.	The impact should be light, in accordance with the expectations before the failure. Manoeuvres around the scheduled track

	Actual Flight plan	Speed impact	Communications	Lenght of the abnormal situation	Impact on ATCO's workload
LIGHT AIRCRAFT	Not predictable. Diversion to the nearest suitable airport?	Medium speed in general, few impact	A failure of the two mandatory radio sets is very unlikely to happen, but if it is the case, there is no other spare solution. 7600 is switched on	The flight should be short, in principle, with a diversion to the nearest suitable airport.	The impact could be high in a short time frame to divert the surrounding traffic while guessing the intentions of the pilot

In any case, the contingency procedure has to be very simple so that it can be simply applied and explained through the direct phone line. We should limit changes of flight levels or routings, taking into account the long range of the RPA.

7.4. Confidence

The ATCOs' confidence in the insertion of a RPA can be considered as good under the normal conditions of the live experiment.

The first study showed that confidence augmented with the increase of knowledge of RPS and RPA behaviour.

There is a concern about the treatment of a failure if the traffic is dense. The cases of failure and the reactions of the RPA raise questions. The presence of a controller knowing the RPS and the behaviour of the RPA is a reassuring factor, which makes it possible to fill a knowledge deficit. At least during the first flights, the presence, in the ACC OPS room, of a person who has a sound knowledge of the CONOPS is advisable.

8. FREQUENTLY ASKED QUESTIONS THAT CAN BE ANSWERED AT THIS STAGE

Based on these observations and analyses, it is possible to provide some answers to a number of frequently asked questions.

Frequently asked question	Answer
What are the lessons learned on “Accommodation” in the FR-ES environment?	Feedback from cross-border flights in French and Spanish airspace is the subject of document D2 (flight report) and this document D3 depicts the lessons. At this stage, it can be said that the accommodation of unmanned aerial vehicles has not posed any major difficulty, once the problems linked to the difference in interpretation of the regulations at national level have been resolved. The compromise found with a mixed GAT/OAT flight plan allowed the flight to be carried out according to the planned profile (cruising in upper airspace, controlled by civil agencies, using published routes and not segregated from other traffic.
Are those lessons learned on “Accommodation” applicable for «Accommodation” inside the rest of Europe?	Most of the Lessons for REAPER MALE RPAS are applicable for the rest of Europe. The experimentation approach model is applicable to other certified MALE – type RPAS and should take into account, when identified, national specificities.
Are those lessons learned on “Accommodation” expendable or not to “Integration”?”	The process followed for this experiment with simulation and then actual flights can be extended, but the detailed lessons are generally not applicable for integration across all flight segments (from start-up and taxiing, to landing and full stop). No integration is possible without the DAA function. Two factors that will be probably pregnant for integration will be Speed and Density of the traffic. Saying this sounds like pushing open doors, but more importantly it shows that one should not only focus on abnormal or contingency and emergency procedures, but also cover the aspects of a normal flight

9. RECOMMENDATIONS

9.1. Using this case and the experience gathered to extend it to other cases

The team suggests that the whole dossier and its annexes that have allowed the accommodation of an RPA in GAT non segregated airspace is considered as a solid basis for accommodating "MQ9-REAPER" RPAS in the portions of others European member state airspace concerned

It can also help to accommodate other type of MALE RPAS within the portion of the Airspace concerned.

From this basis, adjustments can be made to respect national particularities or different RPAS performances and characteristics.

The filling of the flight plans needs special attention when the mission involves a circular mixed GAT/OAT profile, e.g. to perform an operational mission after cruise to the the working area in GAT/IFR. Our experimental flights that were using the old national nomenclature for the flight plan did'nt bring a solution that could be replicated for future flights.

9.2. For the MALE RPAS comparable to Reaper

These flights did not identify any obstacles to carrying out this type of RPAS flight in GAT and non-segregated Airspace, as conducted, with the prescribed accommodation measures. We therefore recommend repeating this type of experimentation by continuing these kind flights. This will have a beneficial effect in increasing the confidence of ATCOs in their ability to handle this type of RPAS traffic with their specificities and will allow the implementation of these accommodation measures to be extended to other member states.

It would also allow remote crews to become more familiar with the specifics and rules of IFR practice in general air traffic. In addition, it would provide training opportunities for both remote crews and ATCOs.

Some improvements can already be made quickly, based on the lessons learnt. Through post-flight discussions with ATCOs and crews after the flights, and taking into account lessons analysis from the first and second study, some rapid improvements were evoked and some deserve further investigations.

9.2.1.1. In the ATM system

To be considered as avenues for developing confidence and knowledge

- Work on the note to controllers to make all points become obvious
- Flight plans that could contain more information, use of case 18. Suggestions are to beconsidered for further improving the acceptability of the flight plan and better informing ACC about the nature and specificities of the RPA when arriving in a control sector.
- A specific call sign to warn ATCOs of the nature of the RPA

9.2.1.2. In the RPAS system

The Reaper system has been optimized for operational missions, a simple process must be used to integrate the access and presentation of up-to-date GAT aeronautical information, in order to benefit from all the flexibility offered.

As soon as possible, replace the Mode C IFF with a Mode S to facilitate recognition of the RPA by other users.

9.2.1.3.Accommodation

The team proposes to agree that, for a MALE RPAS comparable to Reaper RPAS, following accommodation measures allow a safe flight.

- The RPAS is certified (this is a national responsibility and it can be understood that for some obvious operational reasons, not all the details of the certification can be disseminated).
- The RPAS has the equipment and performances for an airplane of its category (< 5700 kg) in the considered class of airspace.
- A direct telephone line is operative between the Pilot and the ATCO, for contingency procedures. This recommendation will be challenged in the future with the increase of RPAS operations in GAT
- The remote pilot and ATCO are qualified.[6]
- The portions of the airspace concerned are limited to class A to C (D for France), as depicted in the study. The switch from LOS to BLOS is performed in a segregated area.
- A CONOPS describes normal, abnormal and emergency situation and the crew and the concerned ATCOs know keys points.
- The meteorological and electromagnetic conditions forecasts are compatible with the RPAS integrity.
- For the first experimental flights, and as long as the acculturation of controllers to drone is insufficient, the presence in the control room of a person with a detailed knowledge of CONCOPS and emergency and contingency procedures remains necessary.

9.3. For all MALE-type RPAS

For the Reaper model, the performances are equivalent to those of a light aircraft MTOW below than 5700 Kg, flying in GAT.

For other MALE-type RPAS, it would be advisable to set some minimum performance requirements to ensure that a given type of RPA can smoothly be inserted into GAT.

For example, they should specify a minimum rate of climb, which will allow ATCOs to position the RPA with ATC instruction to ensure smooth compliance with separation directives. Similarly a minimum rate of descent, transit speed, loiter direction & radius (in the event of Loss of C2 link) and manoeuvrability characteristics should also be considered to ensure safe separation is maintained even in adverse environmental conditions.

Of course, to be inserted in class A to C, it is advisable that the RPA can respect a precision of +/- 200ft in the vertical plan and an +/- 1 NM precision of navigation.

It is difficult to specify a minimum speed but it should be compatible with the traffic density. At present, a combination of the conclusions of the two studies show that flying an UA at a speed of 180kts or higher in one sector is possible and safe.

If the RPA had inferior performance, a safety analysis and specific tests should be carried out before authorising this change in the ATS system.

9.3.1.1.Experimentation process for different types of RPAS

We propose that the processes described in our study are followed and serve as a basis for accommodating RPAS in class A to C, (final climb, en route, initial descent) GAT airspace, including cross border flights.

[6] Crew qualification :2nd degree military pilot qualification and a military instrument flight qualification. No systematic CPL or formal IR ; these military qualifications are recognized by civil aviation authorities. For the test, ATCOs were actual ATCOs qualified and operational on their positions, with no specific formation or training apart from standard information process.

We suggest that, as soon as an intention for a cross border flight is identified, a first initial planning conference is launched, including all military and civil participants to work on the basis of an agreed CONOPS with the necessary adjustments in accordance with national specificities.

The CONOPS presented in the study contains all the generic elements to be filled.

Samples of notes to controllers, briefings for the crews, etc… can usefully help the ANSPs and air-forces of other member states.

Once the CONOPS is agreed, national safety studies, in the national preferred format (which would probably differ from the bow-tie method and preferably take its inspiration from EASA/EUROCONTROL works and models) should cover all the elements of the safety study presented in the present experimentation.

9.3.1.2.Live flying and future simulation

Simplicity is key for emergency and contingency procedures, especially in the case of the introduction of a new user in the ATM environment. Typically, in the event of a loss of C2, a simple procedure, respecting the standard routes, must be prepared. It must limit level changes, which are sources of trajectory inaccuracy, and must lead to a military (or civil if applicable) airfield capable of recovering the RPA in a segregated airspace. It is not feasible to do otherwise until significant progress is made on RPAS DAA systems.

9.3.1.3.RPAS equipment priority

From the observation of the flight and simulation, it is our opinion that the first step in the upgrade of a legacy UA, beyond the necessary compliance with existing GAT rules, should include the introduction of a mode « S » IFF (if not already present).

Another point of attention is to insert in a smooth way all the necessary updated GAT navigation documentation in the navigation interface to the pilot, so that the access to the GAT routing is easily managed by a single pilot. A simple tablet on the knee is not sufficient and the system should avoid, as far as possible, the manual transcription that is always a source of mistake.

9.3.1.4.RPAS Safety Case Methodology

The recommendation of Team SIRENS In the first study remains valid. There is still interest to « fully test the Safety Case Methodology and ensure study completeness. This wide-ranging safety case analysis may also include additional hazards and inputs from the EDA and wider community of experts supporting the study. This treatment will need to cover elements excluded from this study such as: take-off and landing, ground operations, en-route exercises and flight over densely populated areas »

Simulated tests should also allow answering the questions of diversions to military or civil en route airfields, which could not be explored with the Reaper model used, without automatic land and take off systems. Predictability versus duration of the flight should be evaluated for example in the case of a loss of communication situation.

It would also pave the way for exploring next steps of MALE RPAS insertion in the non-segregated airspace.

9.3.1.5.Building confidence

As the door is now opening for more RPAS in GAT, non-segregated airspace, reflexions should rapidly begin to educate ATCOs on the presence of accommodated RPAs and remote Crews on the specificities of the GAT. It today makes sense to introduce this specific knowledge in the air traffic controller, as well as in the crews training curriculum.

The number of live flights is not today significant, but already, education and training could be done in simulated environments as part of the routine work.

As the safety case methodology has been successfully applied to a low-risk and non-complex operation it is now possible to make a transition to address more-demanding conditions within Controlled Airspace – this may include more complex airspace structures; congested airspace and even more demanding environmental conditions, and of course realization of abnormal or emergency procedures.

This would be occasions to build up confidence in the RPAS accommodation measures first .

Those tests should help to define minimum requirements in terms of RPA performances and also better evaluate compatibility with traffic density.

How many RPAs, RPASs can be handle at the same time?

For the time being, the trials showed that one RPAS per sector is possible.

Two main limits are put forward for the insertion of this type of RPAS in GAT, in protected, non-segregated air space.

- Traffic density
- The number of RPAs that can operate simultaneously in a single control sector. The first study has already provided a partial answer since the simultaneous flight of two RPAs has been simulated in a dense traffic environment.

This deserves to be further developed through improvements linked to the fixed line which is today a serious limitation, and simulations tests on the number of manageable assets per one ATC sector (to characterize the challenge, catastrophic situation of one unforeseen electromagnetic blast and all C2 satellite links are down).

9.3.1.6.Possible practical improvements

During our exchanges, some quick wins practical improvements where mentioned and it seems that this document is a good place to relay those proposals.

Flight plans; the phone numbers of the RPAS ground station could be introduced in the flight plans in the case 18 RPAS/+33… and the ATM could system could then automatically process those numbers.

To inform the ATCO of the presence of an incoming RPA the keyword « unmanned » could be put before the call sign.

In the event of a C2 loss of link

- A specific code 7400 could be employed (see if it is already in ICAO recommendations)
- In case of contingency, would it make sense to fly at a VFR FL, eg 205 instead of 200 as it would ensure a separation of at least 500 ft with other IFR traffic?

Voice communication systems should in the future integrate telephone and VHF to allow "party line". The operation of a telephone line the ATCOs should be as automated as possible. Furthermore, the ATM system should report a VHF loss to the ATCO, request the Voice communication system to initiate the phone call(s) and integrate the call with the rest of the radio traffic on the frequency used for the involved control sector. This would allow "party line" for the neighbouring air traffic. This is probably too cumbersome for the accommodation phase, but as the final objective is integration, such arrangement would need to be considered to cover cases where the communication link between the Remote Pilot and the ATC is lost (on-board radio failure or loss of satellite link).

9.3.1.7.Airspace design (out of scope for the study)

SIDs and STARs specific for slow movers like RPA's could be designed in case of an increase of this type of air traffic (another kind of segregation, limited to dense areas).

10. MATURITY ASSESSMENT (E-OCVM3)

10.1. Summary of the study outcomes

These two flights test pave the way for cross-border flights and confirms the risk analysis carried out under the aegis of the EDA, while providing initial feedback on the accommodation of MALE RPAS in non-segregated controlled airspace. It demonstrates the possibility of operating a MALE UAS without specific see-and-avoid equipment in GAT, subject to adequate flight preparation and coordination with the involved air navigation services providers.

This study has demonstrated the adequacy of the scenario for operating current generation MALE UASs in general air traffic, alongside other air traffic in the same control areas, without this change in the ATS system having a negative impact on safety.

The aim was to demonstrate that, with the implementation of accommodation measures, it is possible to operate a MALE RPA without having to create segregated areas with light to moderate traffic density.

The approach followed to prepare and carry out this flight constitutes in our opinion a good model for replicating this type of activity, and moving from experimentation to regular implementation.

Further studies will be necessary to, for example, further calibrate the density of traffic allowed per control position or the number of RPAS that can operate simultaneously in a control sector. In simulation or in real flights, these further investigations will be opportunities to identify ways of improving certain procedures, or even to orientate the evolution of the equipment.

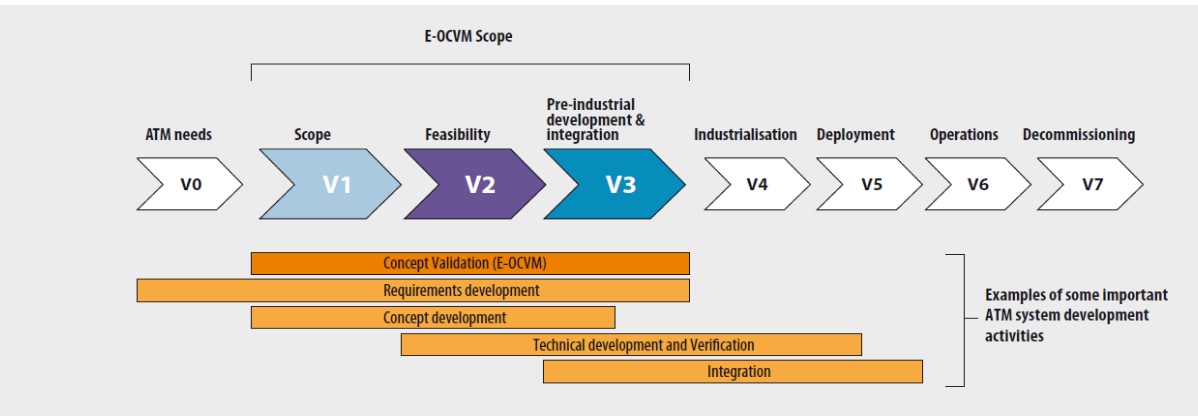
This study constitutes a sort of photo, but the film that should lead from the current situation requiring the setting up of corridors (segregated areas) to the integration of RPAS in the entire course of its flight is not yet fully scenarised.

Some of the accommodation measures may evolve over time as civil controllers become accustomed to the specificities of RPAS, and as Remote crews become accustomed to civil IFR procedures in GAT.

Each state remains sovereign in its airspace, but a reasonable convergence on the experimental model as proposed in the study would benefit all member states.

10.2. E-OCVM (European Operational Concept Validation Methodology)

The figure below, from the European document "EUROPEAN OPERATIONAL CONCEPT VALIDATION METHODOLOGY", presents a synthetic view of the life cycle of a new concept or change in the ATM system.



The accommodation phase of RPAS is considered as the introduction of a change in ATM system. It is therefore necessary to determine in which phase of operational concept the lifecycle we stand and to assess the level of maturity of this operational concept.

10.3. V2-V3 Transition Criteria

The assessment establish whether the following key questions are adequately answered. The table below presents a summary of the criteria for assessing the level of maturity according to the E-OCVM method.

Criteria	**Our finding/ assessment**
Operational feasibility (user acceptance, safety)?	Yes but there are some limits. Requires more investigations. - *Basic training on RPAS for ATCO* - *Contingency procedures to be tested (loss of C3 links, Radio failure)*
Technical feasibility (preliminary assessment based on research prototypes)?	Yes- proven by real cross border flight
Transition feasibility (including institutional issues)?	No major difficulties to setup the XP flight but different approaches between EU Ms results in several difficulties in implementing ATM rules regarding OAT and GAT.
Potential benefits validated for concept options?	- Improved flexibility of Airspace Management (no need to establishes corridor) - This induces improved safety for the RPA, thanks to possible route change for the RPA for avoiding degrading weather condition
Affordability for stakeholders?	Limited investment (key pad of WPC, fixed telephone line management)
Alternative solutions compared?	N/A- the "accommodation phase" is a transitional phase until the technical solutions for full integration have been fully tested and qualified.

Taking into account the observations made and the feedback from the main actors, pilots and controllers, we can consider that this concept of MALE UAS accommodation in general air traffic is at level V3.

However, we have observed a number of difficulties resulting from the lack of experience and harmonisation in the application of certain procedures. In order to increase confidence, it would therefore appear necessary to envisage other flights of this type with transfers to other civilian control centres and other European countries. The attainment of level V3 makes it possible to envisage the continuation of this type of experimentation on a larger scale.

This study has demonstrated the adequacy of the scenario for operating current generation MALE UASs in general air traffic, alongside other air traffic in the same areas, without this change in the ATC system having a negative impact on safety.

The approach followed to prepare and carry out this flight constitutes in our opinion a good model for replicating this type of activity, and moving from experimentation to regular implementation.

Further studies will be necessary to, for example, further calibrate the density of traffic allowed per control position or the number of RPAS that can operate simultaneously in a control sector. In simulation or in real flights, these will be opportunities to identify ways of improving certain procedures, or even to orientate the evolution of the equipment.

This study constitutes a sort of photo, but the film that should lead from the current situation requiring the setting up of corridors (segregated areas) to the integration of RPAS in the entire course of its flight is not yet fully scenarised.

Some of the accommodation measures may evolve over time as civil controllers become accustomed to the specificities of RPAS, and as Remote crews become accustomed to civil IFR procedures in GAT. Each state remains sovereign in its airspace, but a reasonable convergence on the experimental model as proposed in the study would benefit all member states.

11. LIST OF REFERENCES

#	Source organism	Title	Ref
1	EASA	European Plan for Aviation Safety (EPAS)	EASA RMP-EPAS 2017-2021
2	EASA	Introduction of a regulatory framework for the operation of drones	EASA NPA 2017-05
3	EDA	Service Contract for the provision of a study : "accommodation Validation" for MALE-Type RPAS operations	19.ISE.0P.159
4	EDA	MALE RPAS Accommodation Study- Task 1 Report- General Approach and Safety Assessment Method Definition	17.CPS.OP.017
5	EDA	MALE RPAS Accommodation Study- Task 2 - Simulation Readiness Report	17.CPS.OP.017
6	EDA	MALE RPAS Accommodation Study- D3-Simulation Campaign & Safety Case Assessment	17.CPS.OP.017
7	EDA	MALE RPAS Accommodation Study- Final Report	17.CPS.OP.017
8	EDA/EASA	Guidelines for the accommodation of military IFR MALE type RPAS under GAT Airspace classes A-C	Nov. 2019
9	EU Commission/ EUROCONTROL	E-OCVM Version 3.0	
10	EUROCONTROL	Specification for the use of Military Remotely Piloted Aircraft as Operational Air traffic outside segregated airspace	EUROCONTROL-SPEC-0102
11	ICAO	Remotely Piloted Aircraft System (RPAS) Concept of Operation (CONOPS) For International IFR Operations	March 2017
12	ICAO	Manual on Remotely Piloted Aircraft Systems (RPAS)	Doc 10019 AN/507
13	ICAO	Safety Management Manual (SMM)	Doc 9859 AN/474
14	ICAO	Global Air Traffic Management Operational Concept	Doc 9854 AN/458
15	ICAO	Procedure for Air Navigation Services- Air Traffic Management	Doc 4444
16	ICAO	Manual on RPAS	Doc 10019
17	ICAO	Procedures for Air Navigation Services – Aircraft Operations	Doc 8173
18	JARUS	JARUS guidelines on Specific Operation Risk	JAR-DEL-WG6-D.04
19	NATO	Stanag 4671	
20	SESAR JU	Project CLAIRE Demonstration Report	Project RPAS.07
21	SESAR JU	SESAR Safety Reference Material (SRM)	D27/ edition 00.04.00
22	SESAR JU	European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace	

ANNEXES

Annex I- Terminology and definitions

Acceptable risk	Acceptable risk defines the target risk for an ANSP as defined in their Risk Classification Scheme (RCS).Acceptable risk is more demanding than tolerable risk.
AIP	Aeronautical Information Publication. An AIP is defined by the International Civil Aviation Organization as a publication issued by or with the authority of a state and containing aeronautical information of a lasting character essential to air navigation.
AIS	Aeronautical Information Service
ANS Air Navigation Service(s)	Air traffic services; communication, navigation and surveillance services; meteorological services for air navigation and aeronautical information services.
ANSP	An "Air navigation service provider" (ANSP) shall be understood to include an organisation having applied for a certificate to provide such services.
Assumption	Statement, principle and/or premises offered without proof.
ALARP	As Low As Reasonably possible
AMC	Acceptable Mean of Compliance
ATC	Air Traffic Control / Controller
ATCO	Air Traffic Controller
ATI	Air Traffic Integration
ATFCM	Air Traffic Flow and Capacity Management
ATM	The aggregation of ground based (comprising variously ATS, ASM, and ATFM) and airborne functions required ensure the safe and efficient movement of aircraft during all appropriate phases of operations.
ATM functional system	ATM functional system' shall mean a combination of systems, procedures and human resources organised to perform a function within the context of ATM;
ATM System	ATM System is a part of ANS System composed of a Ground Based ATM component and an airborne ATM Component.
BLOS/BRBLO/BVLOS	Beyond Line of Sight / Beyond Radio Line of sight/ Beyond Visual Line of Sight
C2	Command and Control
CAE	Claim Argument Evidence
CLAIRE	Civil Airspace Integration of RPAS in EUROPE
CNS	Communication Navigation and Surveillance
DAA	Detect And Avoid

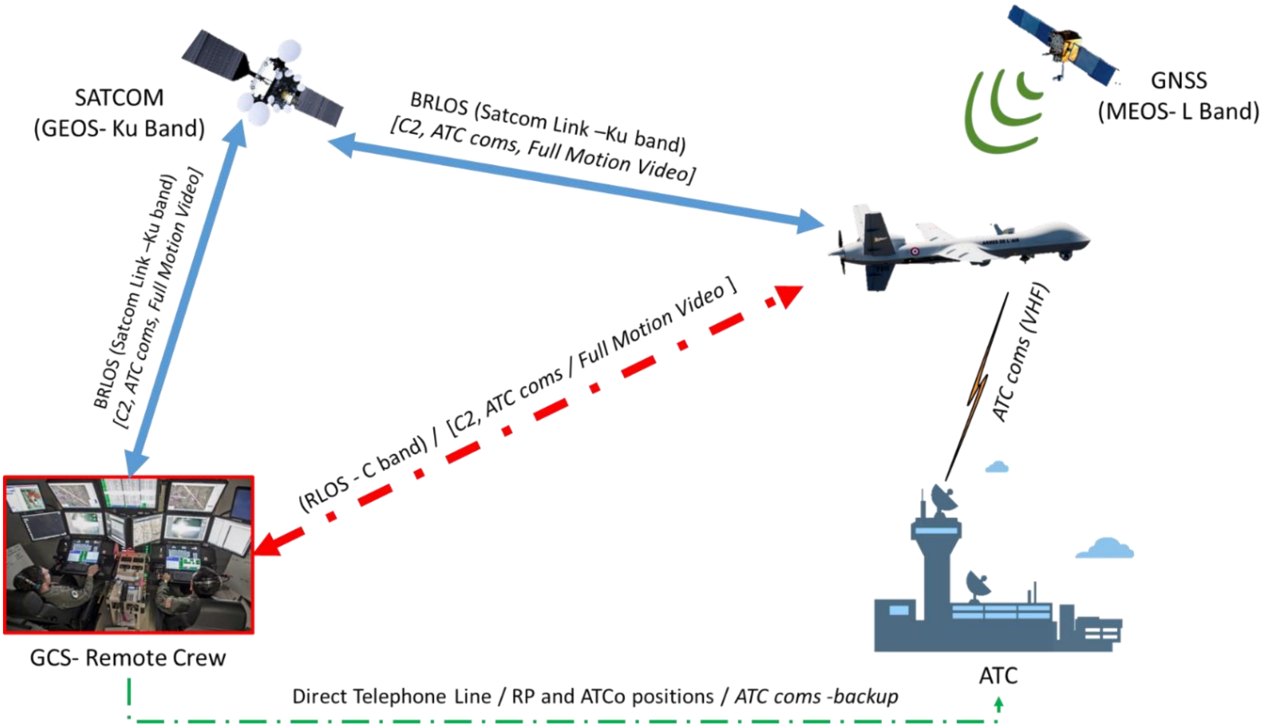
DGA	Direction Générale de l'Armement: General Directorate of Armament, The French Defense Procurement Agency which is responsible for acquisition of any military equipment
DGAC	Direction Générale de l'Aviation Civile: The French Civil Aviation Authority , attached to the Ministry of Transport
DIRCAM	Direction de la Circulation Aérienne Militaire: The French Military air Navigation service provider, attached to DSAé
DSAE	Direction de la Sécurité Aéronautiques de l'Etat : The State Aviation Safety Directorate, attached to the French Minister of the Armed Forces
DSNA	Direction des Services de la Navigation Aérienne : the French ANSP.
EASA	European Aviation Safety Agency
EATMP	EUROCONTROL's European Air Traffic Management Programme.
EC	European Commission
EDA	European Defense Agency
Environment of operations	The environment of operations consists of the physical and institutional characteristics of the airspace within which operations occur. The environment includes ATM services being provided, technologies used, airspace organisation, ambient conditions and people.
ESARR	EUROCONTROL Safety Regulatory Requirement
EU	European Union
EUROCAE	The European Organisation for Civil Aviation
FL	Flight Level: In aviation and aviation meteorology, flight level (FL) is an aircraft's altitude at standard air pressure, expressed in hundreds of feet. The air pressure is computed assuming an International Standard Atmosphere pressure of 1013.25 hPa (29.92 inHg) at sea level, and therefore is not necessarily the same as the aircraft's actual altitude, either above sea level or above ground level.
GCS	Ground Control Station The remote Cockpit./ Crew deck
Hazard	Any condition, event, or circumstance, which could induce an accident.
ICAO	International Civil Aviation
IFR	Instrument Flight Rules: Instrument flight rules (IFR) is one of two sets of regulations governing all aspects of civil aviation aircraft operations; the other is visual flight rules (VFR).
Incident	An occurrence, other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations.

ISR	Intelligence, Surveillance and Reconnaissance
JARUS	Joint Authorities for Rulemaking on Unmanned Systems.
LOPA	Layer Of Protection Analysis
LOS/RLOS	Line of Sight / Radio Line of Sight
MALE	Medium Altitude Long Endurance
Mitigation (or risk mitigation)	Steps taken to control or prevent a hazard from causing harm and reduce risk to a tolerable or acceptable level.
National Supervisory Authority (NSA)	The body or bodies nominated or established by EU Member States as their national authority pursuant to Article 4 of Regulation (EC) No. 549/2004.
Risk	The combination of the overall probability, or frequency of occurrence of a harmful effect induced by a hazard and the severity of that effect.
Risk Assessment	Assessment to establish that the achieved or perceived risk is acceptable or tolerable.
RP	Remote Pilot
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft Systems
RtL	Risk to Life
Safety	Freedom from unacceptable risk.
Safety Assurance	All planned and systematic actions necessary to provide adequate confidence that a product, a service, an organisation or a system achieves acceptable or tolerable safety.
Safety Objective	Quantitative or qualitative statement that defines the maximum frequency or probability at which a hazard can be accepted to occur.
Safety Requirement	A risk mitigation means, defined from the risk mitigation strategy that achieves a particular safety objective. Safety requirements may take various forms, including organisational, operational, procedural, functional, performance, and interoperability requirements or environment characteristics.
SCG	Stakeholder Consultation Group
SERA	Standardized European Rules of Air
SESAR	Single European Sky ATM Research
Severity	Level of effect/consequences of hazards on the safety of operations, including the aircraft operations.
Severity Class	Gradation, ranging from 1 (most severe) to 5 (least severe), as an expression of the magnitude of the effects of hazards on operations, including the aircraft operations.
SQEP	Suitably Qualified & Experienced Personnel

SRM	SESAR Safety Reference Material
Target Level of Safety	A level of how far safety is to be pursued in a given context, assessed with reference to an acceptable or tolerable risk.
Tolerable risk	Tolerable risk defines the target risk for a National Regulator as defined in their Risk Classification Scheme (RCS).
UAS	Unmanned Aircraft System
UA	Unmanned Aerial Vehicle (A/C part of an UAS or RPAS)
Validation	Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. (ISO 8402)

Annex II - Male RPAS capabilities
Performances characteristics and Equipment

MQ-9 Reaper- System Overview:



The RLOS link is used only for Launch and Recovery of the RPA. During the Launch Phase, once the UA is airborne and check-list after take-off is completed, the Crew Switch on BRLOS and check that SATCOM link has the expected quality of service while it is still within optical range and it is possible to return on RLOS mode.

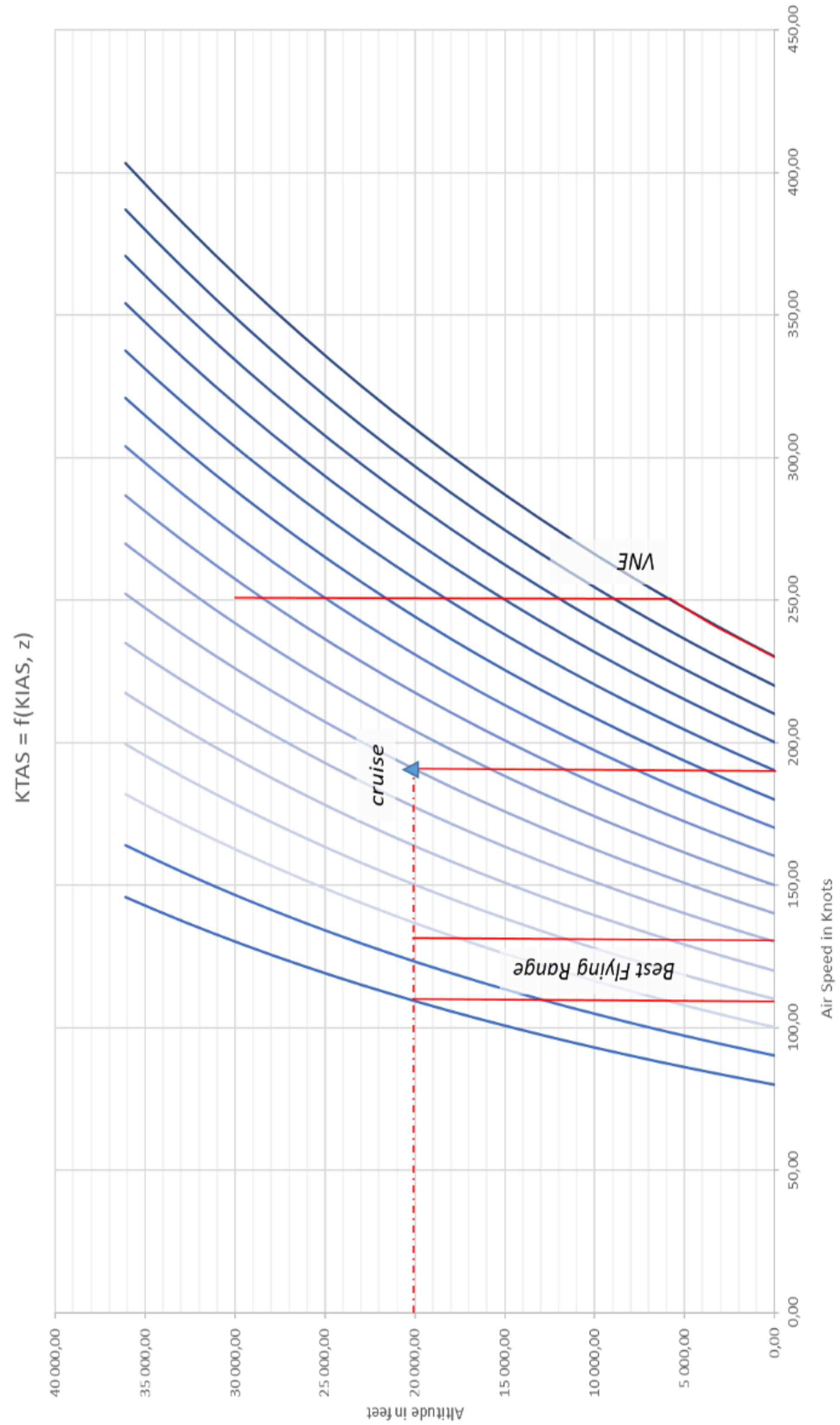
Link Loss:

Should a link Loss occur while the UA is airborne, It would first, continues according to the flight plan, then after a pre-determined period of time (determined in mission preparation), if attempts to re-establish the link fail, it adopts a pre-programmed and therefore predictable contingency route, both for the Remote crew and for the ATC. The IFF of the UA would initially switch automatically to A-7600 (coms failure). If the UA cannot reach the area where it is possible to regain control in RLOS for a safe landing, it then moves to a predetermined emergency landing/crash zone. In this case, the IFF would squawk the emergency code A-7700.

Its actual position reported to ATC through the Secondary Surveillance Radar (SSR).

Main characteristics:

Item	*Specifications*
Dimensions & Weight	– Wing Span: 20 m – Lengh: 11 m – hight: 3.56 m – Wing Surface 11.5 m2 – MZFW 2 220 kg – MTOW 4 540 kg
Crew	***Flight Deck (2):*** Left Position: Remote Pilote Right Seat: Sensor Operator The two positions have the same instrumentation and controls. The visualizations can be adjusted on demand. The positions are independent and interchangeable. ***Mission crew:*** Located in a separate cabin, but in connection with the crew screws the onboard telephone. The tactical coordinator has access to environmental information and can provide support when the situation requires it
Endurance	24 hours
Communication	1 On board VUHF radio set. The ATC coms are relayed by the Satcom link between the Remote Cockpit and the UA and, then, radiated by the UA between the UA and the ACC. 1 VUHF radio set in the Cockpit that is used to communicate with the Airport, Tower and Approach, during the Launch and RecoveryPhases. Telephone line (backup)
Navigation Equipment and Performances	– Three independent Hybrid GPS -Inertial Navigation System. A single GPS receiver – The performances are compliant to RNAV requirement and allow performing GNSS approach.
Surveillance	– IFF mode 1,2,3,4,C
Instrumentation	– Three independent air data systems (Pito probes with anti-icing). – Two independent Altimeters – Vertical Velocity, digital display on th HUD – HIS indication elaborated by the Air-data system – OAT probe and indication
Speed / velocity	– KIAS Climb: 100 to 120 kts – KIAS Descent: 100 to 160 kts (adjustable) – Vv climb(rate of climb) : 1200ft / mn (max) – Vv Decent (rate of descent): 500 to 2500 ft/ mn (adjustable)
Turn Rate (manouverablitiy)	– 14° max roll angle in automatic mode – 25° max roll angle in BLOS mode – 40° mas Roll angle in LOS mode

Item	*Specifications*
Speed / Velocities	

Annex III- Some frequently asked questions

The table below lists a number of frequently asked questions about the accommodation phase and the attempted answers that can be offered at this stage. It also entails questions raised during the "chat" in the margins of the dissemination Work shop held April, 1st ,2022

Question	Tentative answer
Have all major Safety-related issues found during the assessments been adequately addressed, by modifying the concept/scenario and/or supporting technical enablers and validating the results?	Yes for the Reaper and similar type of MALE RPAS, some minor improvements are foreseen and will be addressed by DSAE and DGAC (eg, elaboration of and standardized Service Note to ATCOs, ….)
Is the study transposable for other MALE types (e.g. Patroller)?	Yes, it is, to a large extend. Differences should be analyzed and eventually accommodation measures adapted. Equipment, performances, are factors. The process and the structures of the documents are, to a large extend, generic.
Is the study covering or transposable for several MALEs operations in the same airspace?	Today, vis à vis GAT, the most limiting factor is the fixed line. The study shows that one (flight test) or two (simulated) MALE UAs, piloted from one ground station, operating a transit in the same non segregated airspace sector is possible.
Is the study only valid for an experimental flight or could the ConOps be re-sued for regular operations? Only in France or also in other MSs? Also the safety analysis?	The intend is to give the frame of generic documents to be reused in any case with the necessary adaptations. Type of MALE UAS, national regulations. For the safety analysis, the French safety analysis is an example, at disposal of MSs
Flight plan: transfer conditions/points OAT/GAT Exchange of info with ATC prior the flight (iOAT)	Mixed flight plan topic is a point of vigilance. The civilian processing tool and standard routings are not taking military specificities into account. The flight plan is a tool which can be used to warn the ATCO. The Note to be read before duty is also important. Some improvements are still possible in the accommodation phase
Proposal to have a "summary of C2 LL behaviour" passed at each initial contact with an ATCo	It seems to be too heavy for the traffic density. We prefer a warning on the nature of the UA « unmanned » and the summary of C2 LL behavior as fragged on the note for the ATCO. « summary of C2 LL behavior » should be a first message through the fixed line in case of real C2 LL.
RPA airframe sensitivity (?)	Each UA is a particular case. All would suffer from CBs and electromagnetic flares or solar eruptions. This underlines the importance of the MTO folder. Those conditions are part of the accommodation and also a reason for using GAT non segregated airspace flexibility.
Is the potential deployment context (local/regional/pan European use) well defined and adequate to permit the identification of the safety issues?	Yes if the process is followed, and warnings respected, deployment can be envisaged and should be rapid (pending actors and decision makers willingness)

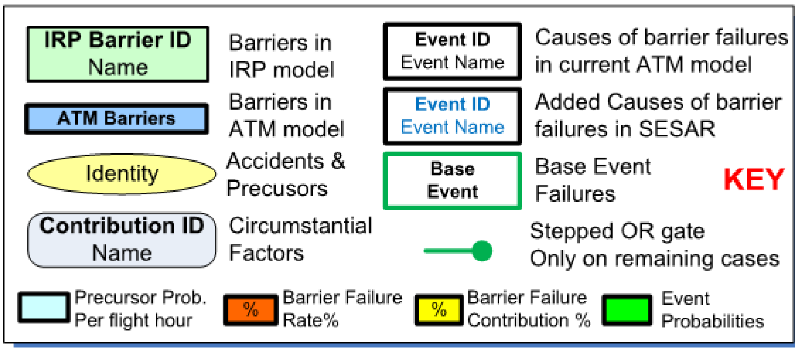
Question	Tentative answer
Have the potential effects on Safety been identified for all relevant stakeholder groups?	Yes, we believe that we have taken into account the main elements and recommendations contained in documents produced by European bodies and other studies. Should this not be the case, the remarks formulated at the dissemination seminar and their consideration in the final version of this report will allow us to make the necessary corrections.
Level of maturity "V3" (e-OCVM): is V3 maturity level of the scenarios and Safety Case reached in view of implementation/deployment of the validated operations	Yes. There are three main objectives to this phase. - Firstly, to further develop and refine operational concepts and supporting enablers, in order to achieve their transition from research to a live environment. - Secondly, to validate that all simultaneously developed concepts and supporting enablers (procedures, systems and human performance aspects) work together coherently and are capable of delivering the required benefits. - Thirdly, it also validates that they can be integrated into the target ATM system.
Loss C2 link without SAA: safety case/mitigations?	The answer depends on the capabilities of the UAS. In the event of a loss of the satellite link, resulting in the loss of both the C2 link and long range radio communication with the ATCO, the RPA will continues on a contingency route programmed by the crew according to the mission segment in which it is located. Main mitigation measure is the use of fixed line to explain to the ATCO what will be the contingency procedure adapted to the MALE UA. Then, contingency procedure predictable and as simple as possible. This point is covered in document D1 (comparison table between a UAS and a manned aircraft and CONOPS).
Choice of emergency fields: also civilian airfields?	The version of the REAPER currently in service has no automatic landing capability and must be recovered in "LOS" mode to land.

Question	Tentative answer
Was the timing between the link loss declaration (and the 7600 setting) and the start of the loss link procedure was "tuned" for the test flight or standard for the FAF Reapers ?	No, this experiment was carried out with a standard MQ-9 on the occasion of a routine training mission of the air force's UAV squadron. The change (flying under IFR GAT outside of a segregated area) only concerned the transit phase between the air base and the work area located in Spain. The procedure as described in the CONOPS for the second flight test is the usual one when the operation zone is around the middle of the mission (this is the general feature). In the segregated operational zone 10' allow possible recovery and preparation of the return path. In the GAT (OAT controlled by civil ATCOs in the specific case of the flight), no delay is planned between the 7600 setting and the application of the contingency procedure, as it is described in the note for the ATCO and the CONOPS.
Bow ties: some MS are reluctant to using bow ties. On MS understood that the study (D1) was "promoting" bow ties usage in safety analysis.-	Last November, it has been told to the MS that contractor was not at all convinced by the the bow ties. The bow ties were inherited from the initial study (2017) as an "easy representation", not as a "computing tool". For safety analysis, we recommend that the MS use a method more in line with EASA and Eurocontol tools. The French model proposed in the D2 doc can feed the inspiration.
Who is reluctant for the introduction of MALE UAs in GAT? Why?	No major reluctance was found to the introduction of MALE RPAS in GAT. - Military actors are favorable for operational purposes. - Civil actors are favorable for a better flexibility of airspace. - We should better speak of national priorities including operational pressure, which entails a different pace for each MS. The main difficulty is the national ability to adapt regulatory environment to a constantly evolving landscape (within EU, priority is given to « small » RPASs for commercial reasons). This paves the way for a second difficulty, which is the multiplicity of national frames.
Materials exchanged (e.g. ATCO briefing in view of the flight – civilian/military; is there a special briefing for the remote pilot for the test flight? What does it includes when GAT A-C?)	All material to brief the crews and ATCOs used for the second flight test can be found in the annexes of D2. This can serve as a valuable set of examples for future flights.

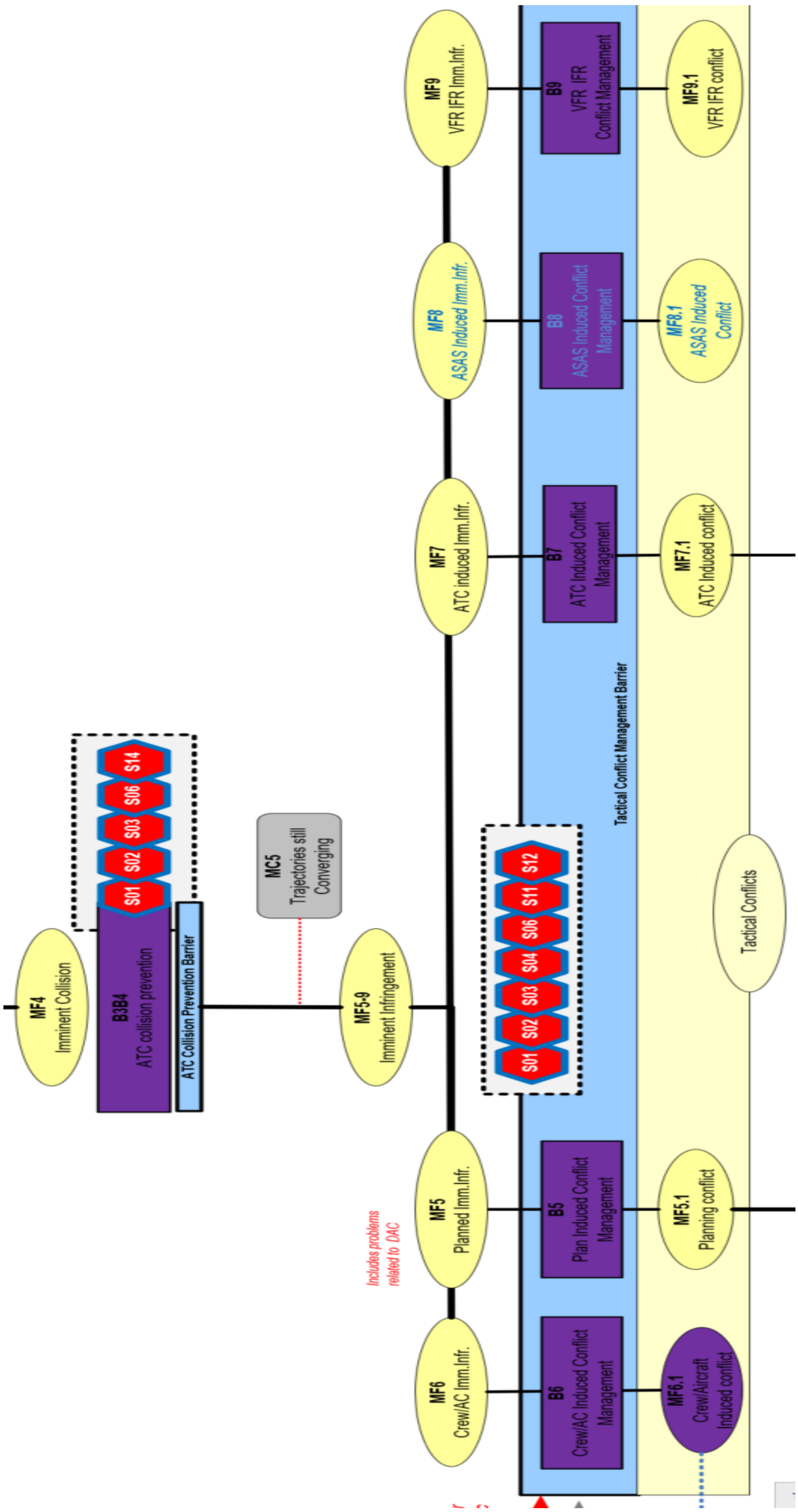
Question	Tentative answer
What are the differences in civ/mil organisations on both side of the borders which challenged the ATI aspects? How can it be extrapolated for the rest of Europe?	Without entering into details, the main difference that we noticed was the level of experience and knowledge in the introduction of a MALE UAS in a non segregated airspace. This could be considered as normal because of the recent introduction of the Reaper in the Spanish Airforce. This kind of aircraft was unknown by the national civil safety agency and it takes time to develop the interest and involvement. First lesson is that a MS should not wait for the introduction of such capacities to develop interest and prepare the associated documents and processes.
What was modified along the version history of the ConOps (V11) to get buy-in? How to take lessons from the experience gained with ConOps?	Appart from the « normal » routing adjustments, minor precisions and re-phasing, some exchanges were conducted on the emergency spellings to precisely describe the associated descriptions. The explanation of the specific OAT coverage of the flight over Spain was also necessary to make sure that the goal of the test flight could still be managed. The structure of the document has been immediately adopted and forms a valuable example for a Generic CONOPS.
More info on the population density (ground risks) and density of traffic (air risks). What is the values/limits considered? How are those parameters on board for the Safety Case? So basically if the routing was different, like above or in the vicinity of a city, what would have changed?	The ground risk is covered by the « certification » of the RPAS and also the fact that, in case of engine failure, the aim is to find a crash zone, in coherence with the glide ratio of the UA, instead of trying to find a « crash landing » zone. It seems fair to say that in that sense, it is even safer than a manned single-engine aircraft. Nevertheless, some certification constrains may exist and for operational reasons are not communicated
Regulation 373 implementation is mentioned as a delaying factor, so how to help EDA MS with ATI mitigation after implementation of 373?	A modernisation of the safety analysis process is one practical element of the impact of regulation 373. It may not be the case for all countries at the same level. The examples given by French DSNA are at disposal in the annexes of D2 document. An advice would be to associate as far as possible civil and military authorities to the changes, to build up an understandable for all process. Also, we favor an architecture which is based on EUROCTL and EASA processes.
How far are we from daily Accommodation operations? How mature is Accommodation?	We are at the beginning of daily accommodation. The team considers that today, it is safe and acceptable to fly a MALE RPAS of the type of the one used for the real flight experimentation, pending some accommodation measures. Of course, some improvements can be done to make this flight even safer and smoother. Some limits still exist and could be pushed away, pending some other supplementary trials, especially in simulation. This work has to be done and shared extensively to build up confidence and reach a full maturation of accommodation.

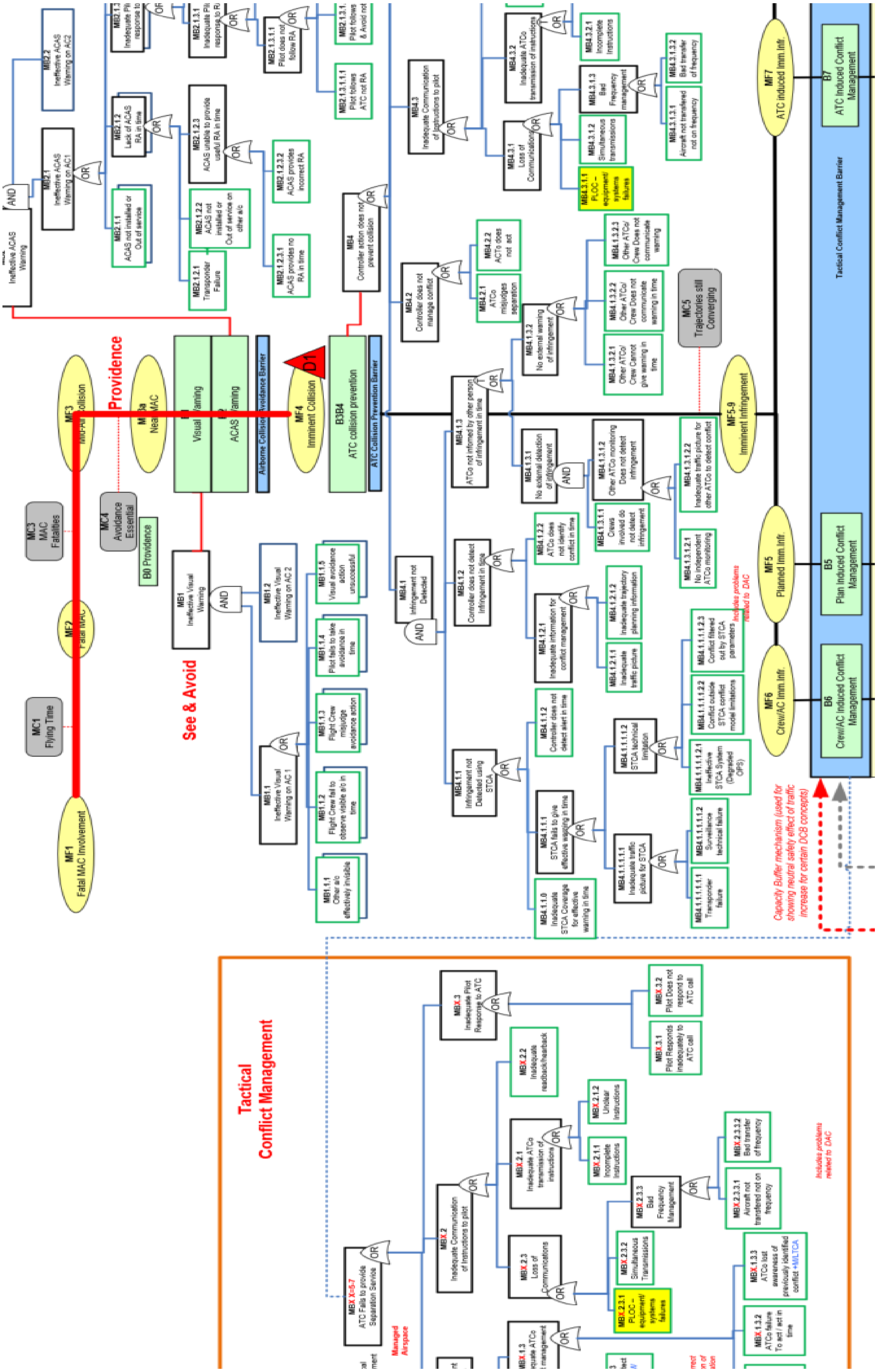
CHAT question Bandwidth for the satellite and was it a civilian provider?	6.4 Mbps and it was a civilian satellite E10
CHAT question Source of documentation for certification?	Documentation provided by USAF (non releasable because of US foreign military sales regulation)
CHAT question What about using 7400 for th C2 Link Loss?	At the time of the flights and today, this is not formaly agreed at ICAO LEVEL; this code is used in several coutries for other purposes (air policing,…) . the discussions are ongoing and possibly, the concerned annexes 6 and 10 could be modified in the coming months (one spoke of may 2022) . Then, if it is confirmed, the depoyement and implementation period could take several years, during a transition period.
CHAT question Should we consider C2 lost link as an emergency or a contengency?	The question is opened in this emerging domain. The team prefers contingency because the aircraft will operate along pre-planned known trajectory.
CHAT question Were specific measures taken on the ATC FPLN?	Yes, they are described in details in the D2 related paragraph of the D2 document. Manual actions from the flight plan operators were necessary, mostly related to the profile and nature of the flight, not the RPAS itself.
CHAT question Flight profile starting/landing as segregated, specific procedure?	No specific flight profile, The aircraft should stay in the segregated zone untill it has reached a proper FL for being tranfered to the proper ACC and the BLOS mode is settled.. No specific procedure.
CHAT question Note / information to ACCs on wider different routes?	The note that we are describing is the one to be read by ATCOs before they take their duty. It mostly relates to the description of the RPAS and associated specificities (contengency and emergency cases) It has to be complete and short. For the routes, nothing specific is prescribed other than the FPLN.
CHAT Remark As a note to take into account, the military certification covers the risk of ground collision only in part, in the case of accomodation/integration of a new actor, the uncertainty added by the risk of collision in the air might pose a new threat that is the falling of debris into populated areas.	This topic of debris was taken into account in the study for our experimental flight. In the class of airspaces at stake, there is no noticeable specific difference with a manned aircraft, similarly equipped and with the same performances.

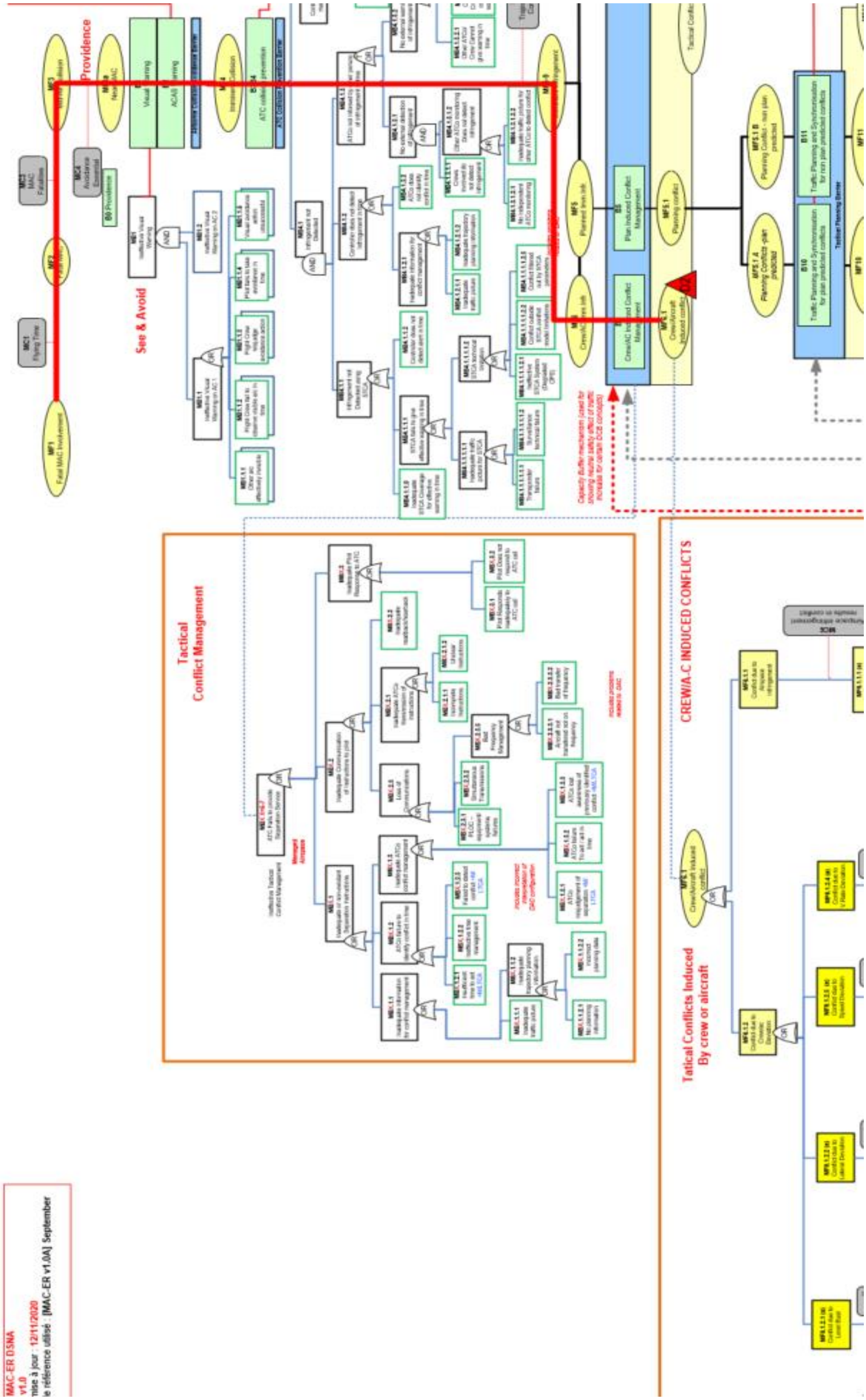
Annex IV- Safety case barrier-based models



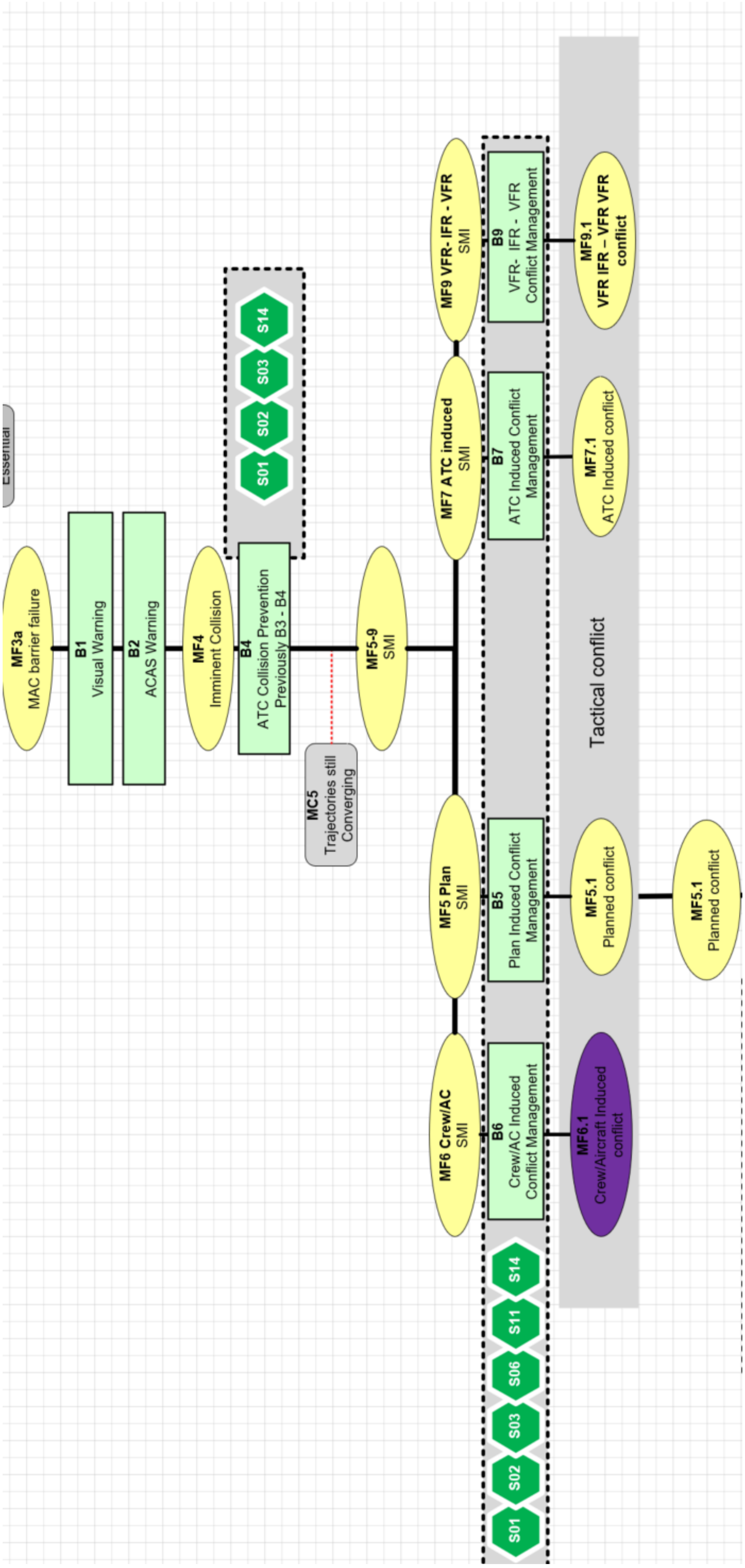
MAC-ER- Mid-air Collision En-Route

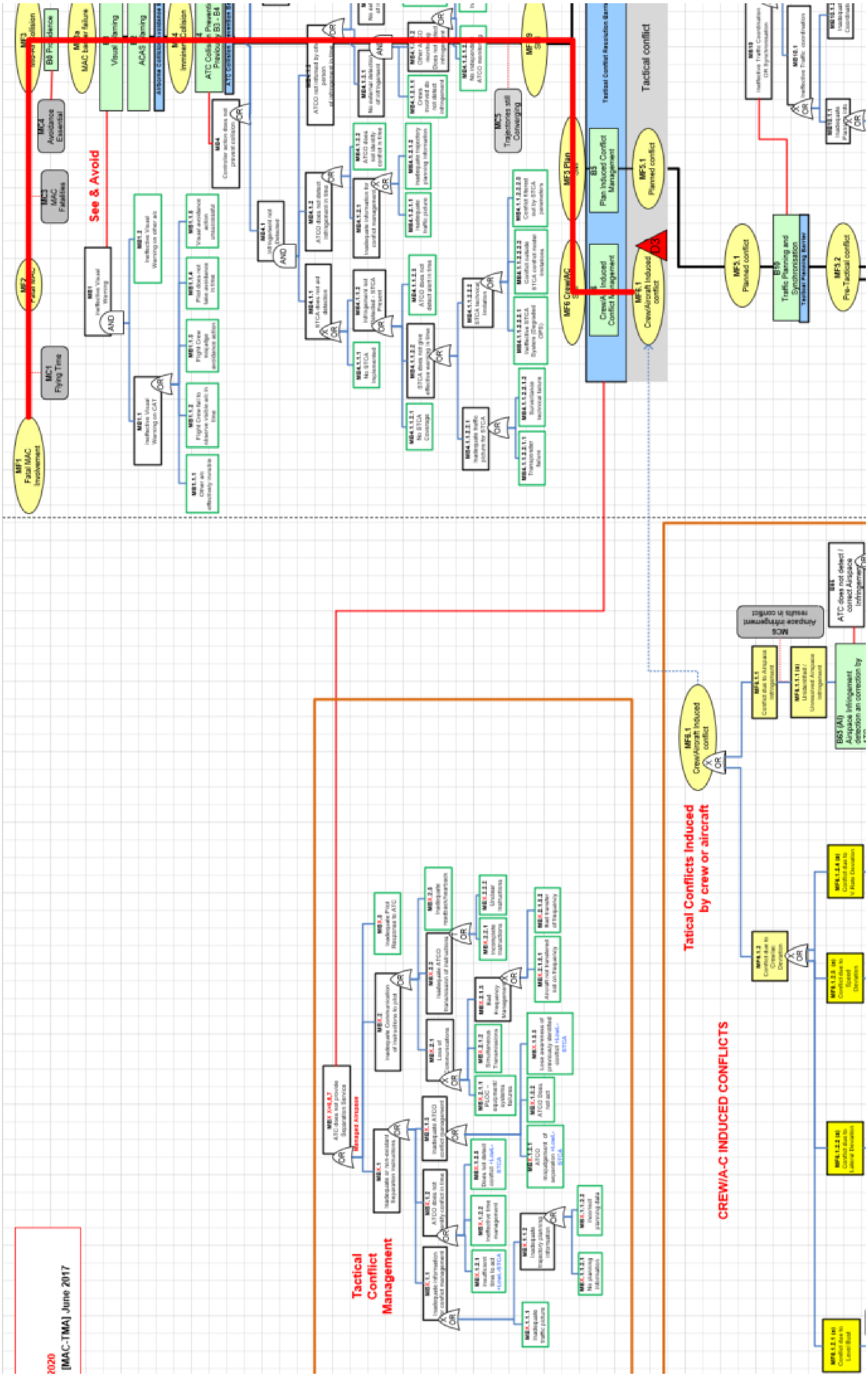



Providence
See & Avoid
Airborne Collision Avoidance Barrier
ATC Collision Prevention Barrier
MF1 Fatal MAC Involvement
MC1 Flying Time
MF4 Imminent Collision
B3B4 ATC collision prevention
MC5 Trajectories still Converging
MF5-9 Imminent Infringement
MF5 Planned Imm Infr.
MF6 Crew/AC Imm Infr.
MF7 ATC induced Imm Infr.
B5 Plan Induced Conflict Management
B6 Crew/AC Induced Conflict Management
B7 ATC Induced Conflict Management
Tactical Conflict Management Barrier
Tactical Conflict Management


See & Avoid
Providence
Tactical
Conflict Management
CREW/A-C INDUCED CONFLICTS
Tatical Conflicts Induced
By crew or aircraft
MAC-ER DSNA
v1.0

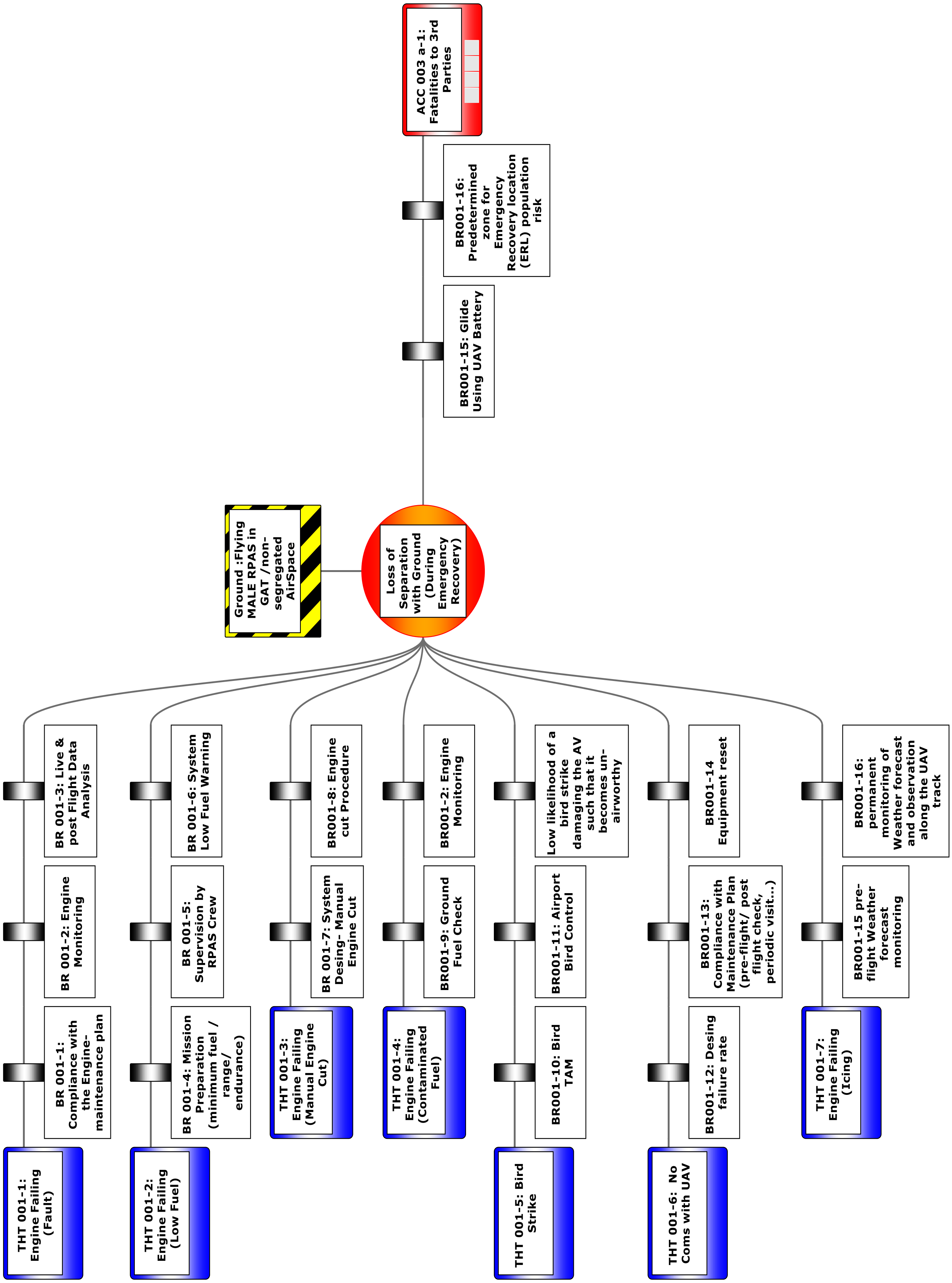
MAC-TMA- Mid-Air Collision in a TMA



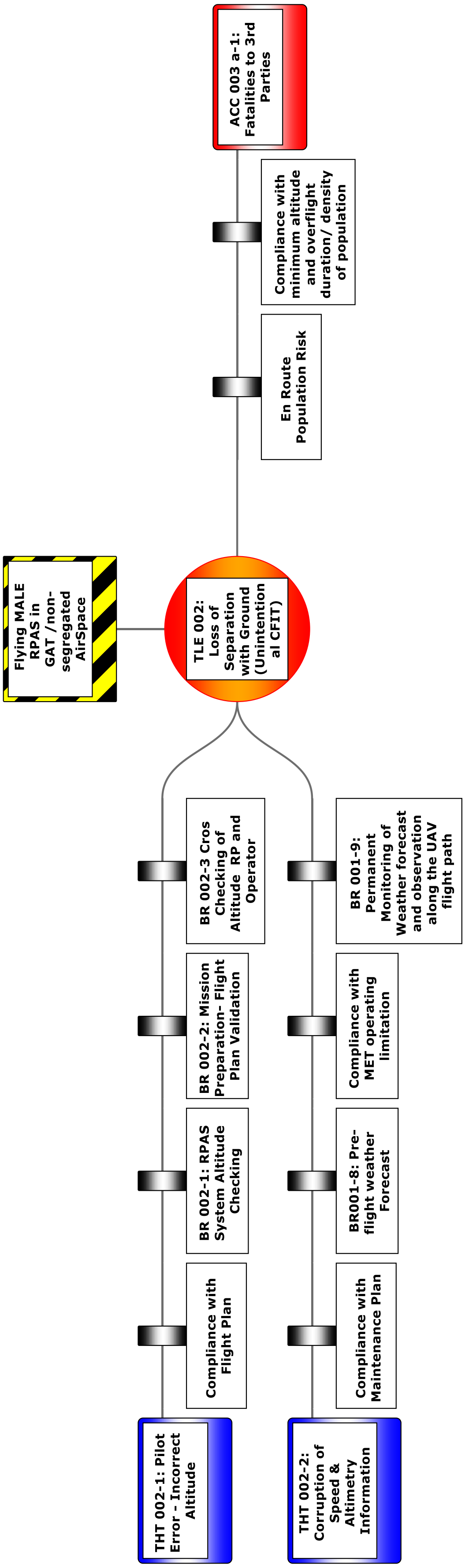

See & Avoid
Tactical conflict
Tatical Conflicts Induced by crew or aircraft
CREW/A-C INDUCED CONFLICTS
Tactical Conflict Management
[MAC-TMA] June 2017

Annex V - Refined Bow Tie Charts

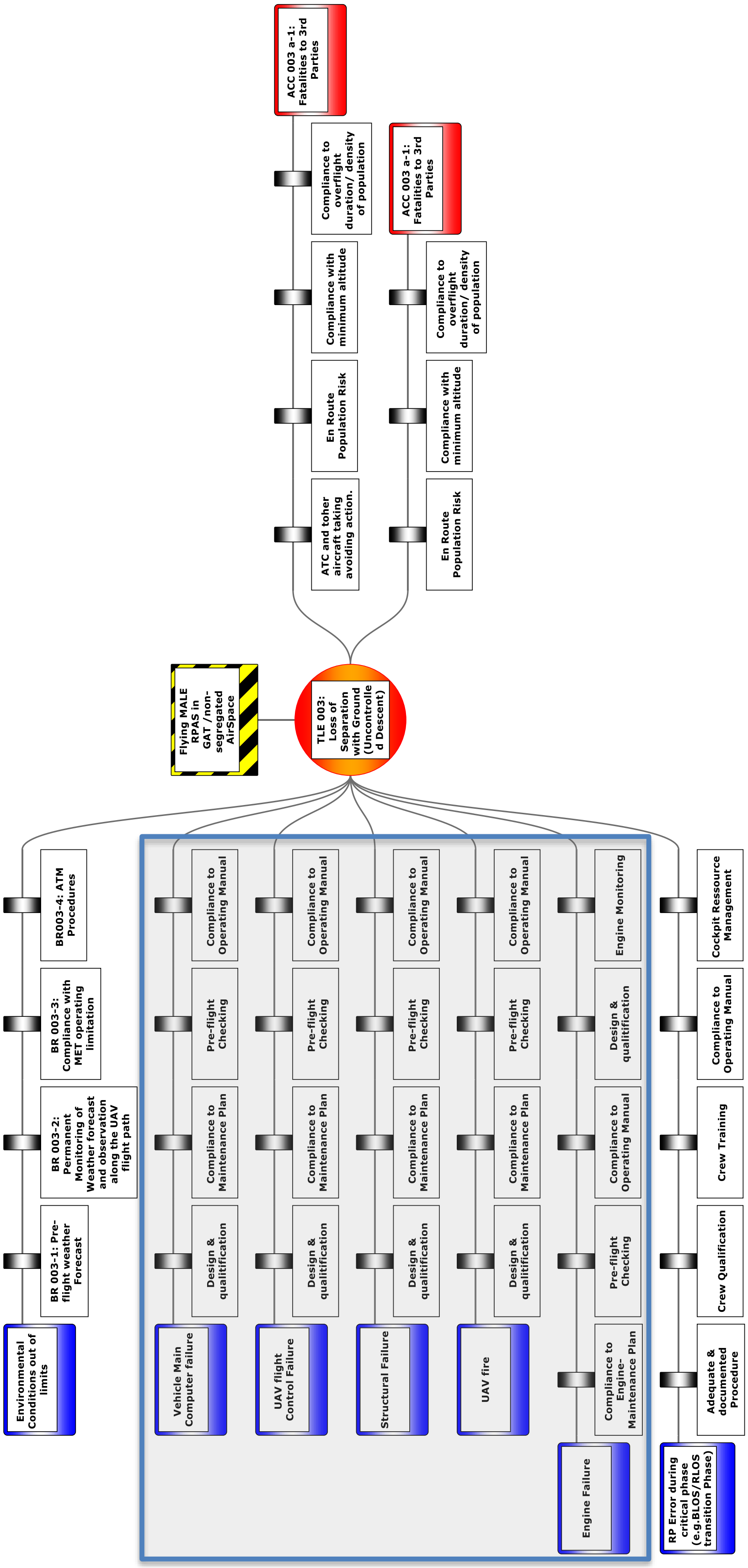
TLE 001: Loss of Separation with ground (during Emergency Recovery):



TLE 002: Loss of Separation with ground (Unintentional CFIT):



TLE 003: Loss of Separation with ground (Uncontrolled Descent):



TLE 005: Loss of Separation with other Users (MAC)