EUROPEAN DEFENCE AGENCY

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MALE RPAS MQ9 REAPER- Experimental flight

RPAS Accommodation Validation Study Contract 19.ISE.OP.159

Dissemination Seminar

https://eda.europa.eu/rpas-accommodation-validation

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Dissemination Seminar-Agenda

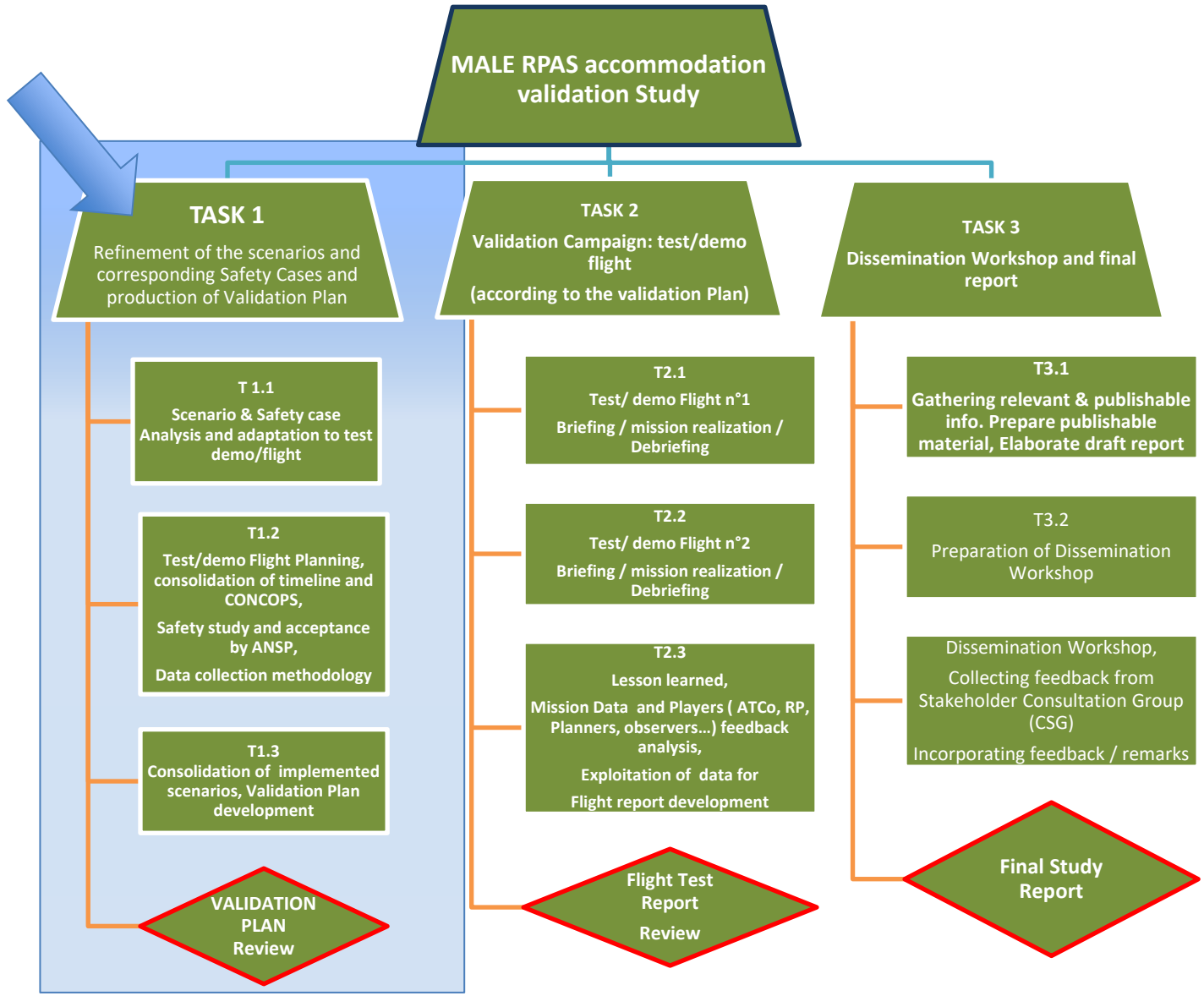
Item	Duration (minutes)	Time
Welcome	5	10.00 – 10.05
Introduction – Study scope and objectives	5	10.05 – 10.10
D1 – Validation Plan	20	10.10 – 10.30
D2 – Flight Report	10	10.30 – 10.40
D3 – Final report	35	10.45 – 11.20
Maturity assessment	10	11.20 – 11.30
Q & A	20	11.30 – 11.50
Next steps and closing remarks	10	11.50 – 12.00

Dissemination Seminar- Part 1

I. Scope of the Study
- *Background information*
- *Scope & Objectives*

II. D1 – Validation Plan
- *Approach to accommodation*
- *Safety case analysis*
- *Accommodation measures*

Scope of the Study



Scope of the Study

Background information

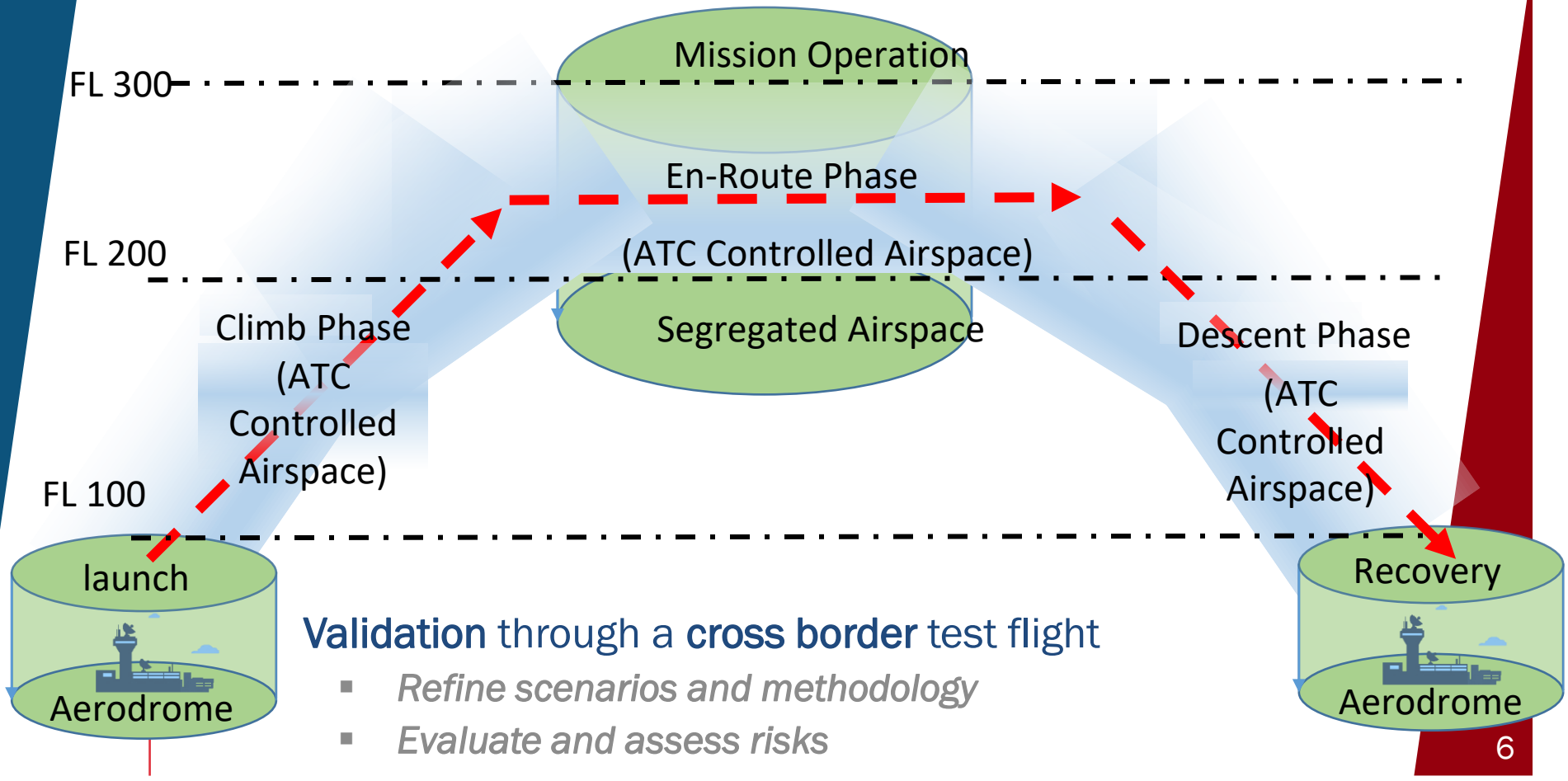
- Willingness of the EDA member states to consolidate the results of the various experiments aimed at authorising, under certain conditions, the flight of the legacy MALE UAS according GAT rules in non-segregated controlled airspace A-C.
- Development of the Guidelines for MALE-type Accommodation, jointly launched by EASA Executive Director and EDA Chief Executive.

- *Follow-up of EDA-MALE RPAS Accommodation Study, which covered in 2017:*
  - *Safety Assessment Method Definition*
  - *Simulation Campaign & Safety Case Assessment*

Scope of the Study

Objectives

SEGREGATION → **ACCOMMODATION** → INTEGRATION



Validation through a **cross border** test flight

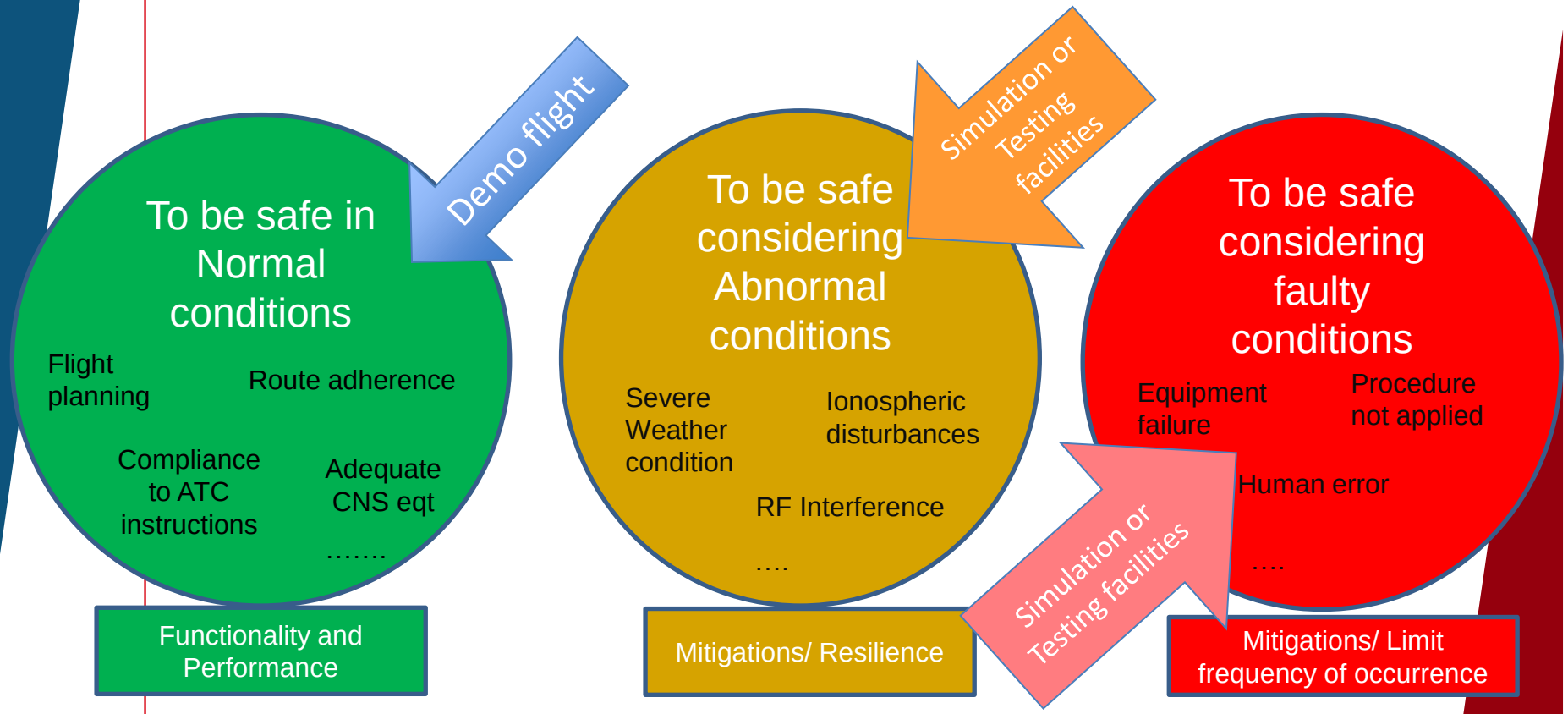
- *Refine scenarios and methodology*
- *Evaluate and assess risks*

Approach to the Study

1) Review of the works related to MALE RPAS integration in GAT.
   - *From ICAO, NATO, EU bodies*
   - *Guidelines for MALE-type Accommodation*
   - *Results of the previous EDA 2017 Study*
2) Impact analysis on the ATS system
   - *Identifying the differences between a manned aircraft of less than 5700 kg and a MALE RPA*
3) Review of safety case and selection of scenario validated in flight, assuming that:
   - *The test/demo flight is to be conducted in non segregated airspaces, alongside other traffics, handled by standard Military Remote Pilots and civilian ATCOs*
   - *Emergency situations (degradation or critical failures) are considered, but cannot be validated under these ATM condition*

Approach to accommodation

What are the ATM safety drivers for new concept/ operations?

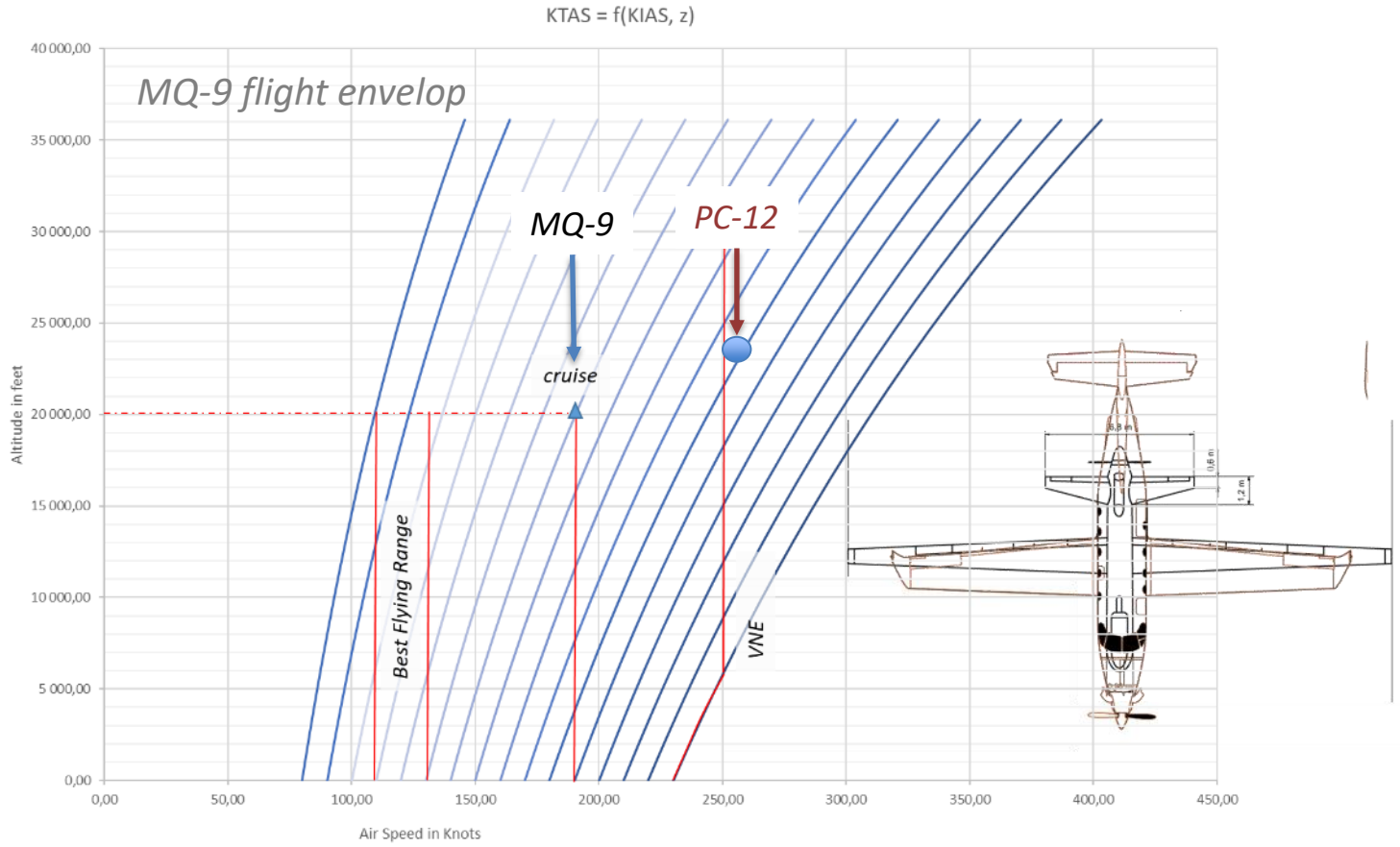


Objective:

Evaluate impact on ATS and other Users when introducing a «new operation »

Approach to accommodation

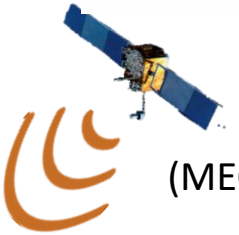
Impact analysis performed by comparing the capabilities of the MQ9-RPAS with those required for a single-engine IFR certified manned aircraft of less than 5700 Kg.



Approach to accommodation

SATCOM
(GEOS- Ku Band)

BRLOS (Satcom Link –Ku band)
[C2, ATC coms, Full Motion Video]

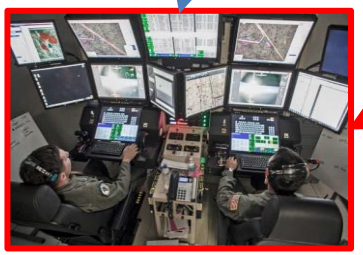


GNSS
(MEOS- L Band)

BRLOS (Satcom Link –Ku band)
[C2, ATC coms, Full Motion Video]

(RLOS - C band) / *[C2, ATC coms / Full Motion Video]*

ATC coms (VHF)



GCS- Remote Crew

ATC

Direct Telephone Line / RP and ATCO positions / *ATC coms -backup*

2017 Safety case selection and Refinement

Airborne Risk to Life:
Loss of separation with other airspace users leading to mid-air collision (MAC), this includes cleared airspace boundary proximity violation

Ground Risk to Life:
Mid-Air Collision (as above)
Equipment failure leading to uncontrolled descent into terrain
Equipment failure leading to falling debris

First Study- Top Level Event	
TLE 001: Loss of Separation with Ground (During Emergency Recovery)	RPA induced
TLE 002: Loss of Separation with Ground (Unintentional CFIT)	RP or ATC induced
TLE 003: Loss of Separation With Ground (Uncontrolled Descent)	RP or RPA induced
TLE 004: Debris falling from UAV in Flight	
TLE 005: Loss of Separation with Other User	Simulated
TLE 006: No-communication due to irrecoverable loss of data (Link/sat comms)	Simulated

Considered but not Simulated

2017 Safety case selection and Refinement

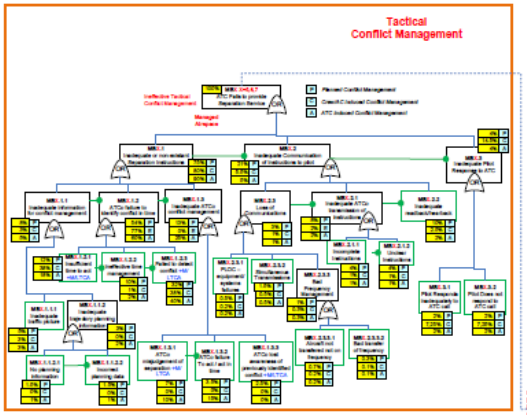
Airborne Risk to Life:
Loss of separation with other airspace users leading to mid-air collision (MAC), this includes cleared airspace boundary proximity violation

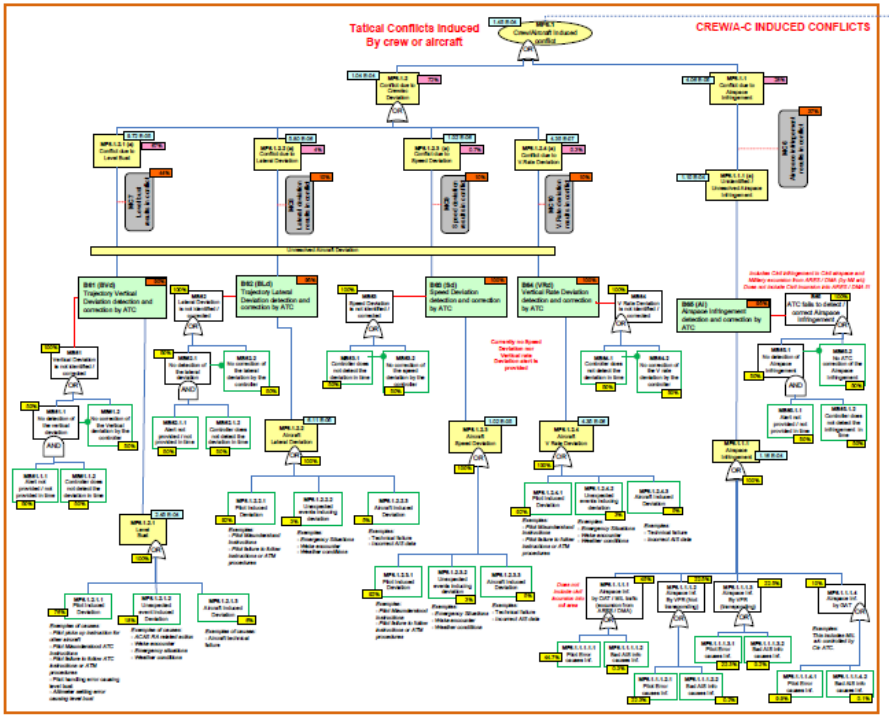
Ground Risk to Life:
Mid-Air Collision (as above)
Equipment failure leading to uncontrolled descent into terrain
Equipment failure leading to falling debris

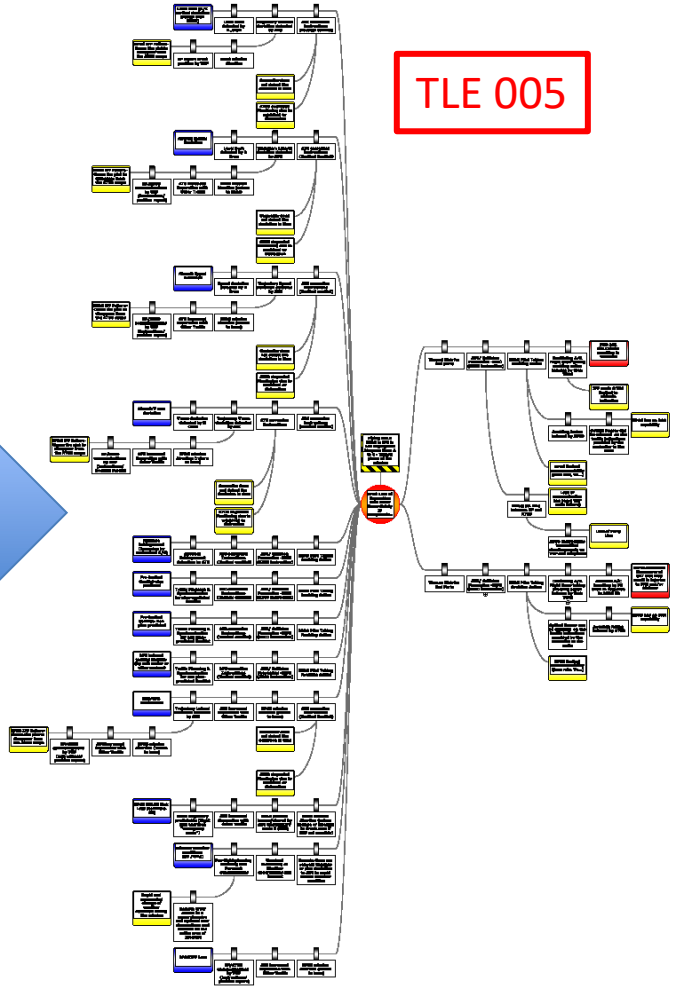
Top Level Event	
TLE 001: Loss of Separation with Ground (During Emergency Recovery)	Considered but not played Emergency procedure in CONOPS
TLE 002: Loss of Separation with Ground (Unintentional CFIT)	In flight validation
TLE 003: Loss of Separation With Ground (Uncontrolled Descent)	Certified RPAS
TLE 004: Debris falling from UAV in Flight	Certified RPAS
TLE 005: Loss of Separation with Other User	In flight validation
TLE006: Specific to the type of RPAS (different behavior depending on the system design)	Considered but not played Emergency procedure in CONOPS

Safety Case Assessment

MAC
Barrier Model







TLE 005

Flying MALE-type RPAS in GAT alongside Manned Aviation

Impact of the “new operation” in normal conditions

To be safe in Normal conditions

We compared the MQ-9 to a single-turbine aircraft of less than 5700 kg (PC12, TBM 700)

Smaller MALE-type RPAS, such as the Watchkeeper or the Patroller, powered by a turbo-compressed piston engine, should rather be compared to a smaller and lighter manned general aviation aircraft (type Cessna 172 or Piper Malibu).

Impact of Abnormal and faulty conditions

To be safe considering Abnormal Condition

To be safe considering Faulty Conditions

TLE 001- Loss of Separation with Ground (during Emergency Recovery)
We added a threat (Engine failure/ icing) and barrier (Weather Forecast), benefiting from a detailed and updated meteorological situation

TLE 006- C2 Link Loss (A 7600)
The RPA will automatically squawk A7600 and proceed according to the latest ATC clearance on FPL. After a predetermined time, the RPA will switch to the programmed Emergency Route ➔ predictable behavior that can be handled and coordinated.

IFF failure is critical when flying in controlled airspace (class A to C, D) considered as faulty condition

Approach to accommodation

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 permanent access to an updated regional forecast / internet.**
Communications **Navigation** **Surveillance**	**C:** In BRLOS (long distance), ATC coms rely on the onboard VHF: - *Critical dependency on SATCOM link for VHF and C2 link* - *Single onboard VHF radio* **Both compensated during the test/demo flights by implementing dedicated telephone line between the Remote Pilot and the working position of ATCO** **N:** 3 independent hybrid GPS/INS, but absence automatic landing capability prevent any diversion. **Compensated by the constant updating of an "Emergency Route" allowing a return to base and switch to LOS mode for recovery or direct the RPA 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 RPA 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**
ATFCM	MQ9 performances comparable to any "slow mover" (TAS around 190 to 200 kts at FL 220)
AIS	The RPA 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 asses the impact of these particularities**
RPAS	**SATCOM link criticality:** In BRLOS single SATCOM links encompass long distance ATC coms and C2 link and payload exploitation. → **Specific Emergency procedures developed in CONOPS**

One essential document: CONOPS

- In depth description of the scenario
  - *Operational procedures (**normal Conditions**)*
  - *Degraded mode description (**Abnormal** & **Faulty Conditions**)*
    - *Radio failure*
    - *Management of an unexpected trajectory of the RPA*
    - *Loss of the RPA command link (Loss of C2 Link: LoL)*
    - *RPA engine failure*
    - *RPA GPS failure*
    - *RPA Electric failure*
    - *RPA IFF failure*
    - *…*
  - *Description of the UAS*
  - *…*

- Base for a common agreement
  - *Civ-Mil, cross border flight*
- Base for safety studies
- Base for information of ATCOs and Crews

CONOPS: Annex III of first deliverable D1-Accomodation Validation Plan

Expected Outcomes

- For each event category (Aircraft, CNS, ATS… Environment), to assess Impact of RPAS specifities on ATM.
- To Assess the ability of the RPAS to meet essential flying safety criteria while flying under GAT in Airspace class A to C (D for France)
  - ✓ *flight plan adherence*
  - ✓ *Ability to comply/ follow ATC instructions*
  - ✓ *Ability of ATCos to handle, alongside manned aviation, MALE-type RPAS specificities*
- Validation objectives & Methodology
  - ✓ *Developed in D1-validation plan / annex V*
  - ✓ *Covered in more detail in D2 flight Report presentation*
- Success criteria
  - ✓ *Positive feedback from ATCOs and RP*

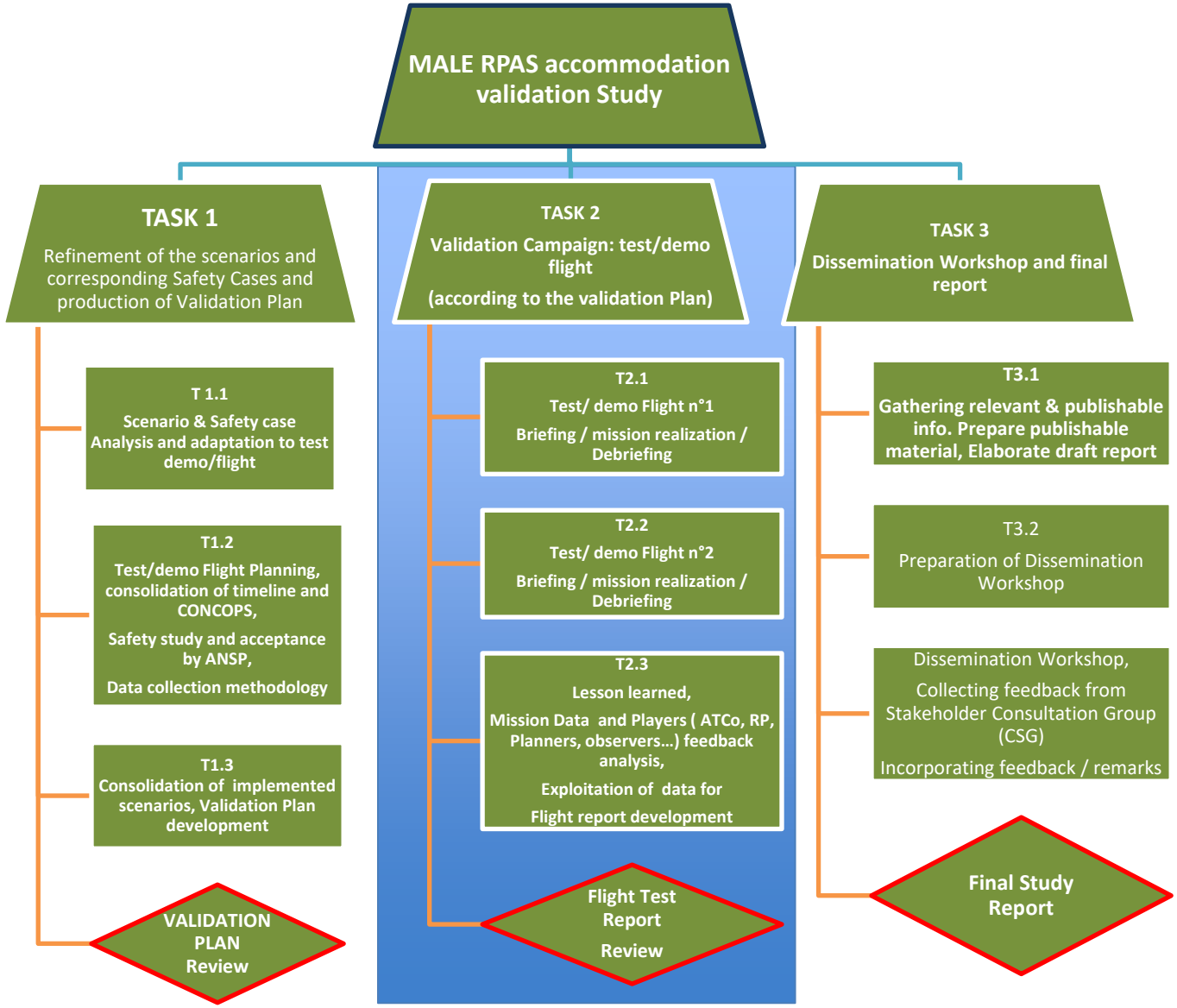
Dissemination Seminar Part 2

I. D2-Flight Report
   - *Overview*
   - *Validation Objectives*
   - *Methodology & success criteria*

II. Preparation
   - *Strategic*
   - *Tactical*
   - *Accommodation measures*

III. Mission Execution
   - *Observations & Main Results*
   - *Human factor*

Scope of the Study



D2- Flight Report Overview

- Goal of the Demo/test Flights
  - ✓ *To demonstrate that "**flying a MALE RPAS under GAT in non-segregated airspace (Class A to C airspaces within the limits of the scenario) is safe, subject to appropriate "accommodation measures**"*
- Objectives
  - ✓ *Evaluate, on a real flight, the impact on the air traffic management system of the introduction of a MALE type RPAS alongside manned aviation*
  - ✓ *To demonstrate the acceptability of this new type of operation in normal conditions.*

  *NB: Emergency procedures (abnormal situations or **critical failures**), considered, planned and briefed, but not played.*
  - ✓ *To Assess the ability of the RPAS to meet essential flying safety criteria while flying under GAT in Airspace class A to C (D for France)*
    - ✓ *flight plan adherence*
    - ✓ *Ability to comply/ follow ATC instructions*
    - ✓ *Ability of ATCos to handle, alongside manned aviation, MALE-type RPAS specificities*
- Validation objectives & Methodology
  - ✓ *Reminded in D2; section 2*
- Observations and findings
- Success criteria
  - ✓ *Positive feedback from ATCOs and RP*

Validation objectives

- To carryout multiple transfers of control between different Air Control Centre, within French and Spanish airspaces.
- To test flight plan processing (long duration, circular, mixed OAT/GAT…)
- To assess the ability of the RPAS to meet essential flying safety criteria while flying under GAT in Airspace class A to C (D for France)
  - ✓ *flight plan adherence*
  - ✓ *Ability to comply/ follow ATC instructions*
  - ✓ *Ability of ATCos to handle, alongside manned aviation, MALE-type RPAS specificities*
- To consolidate the emergency/contingency measures for managing degraded modes of MALE RPAS

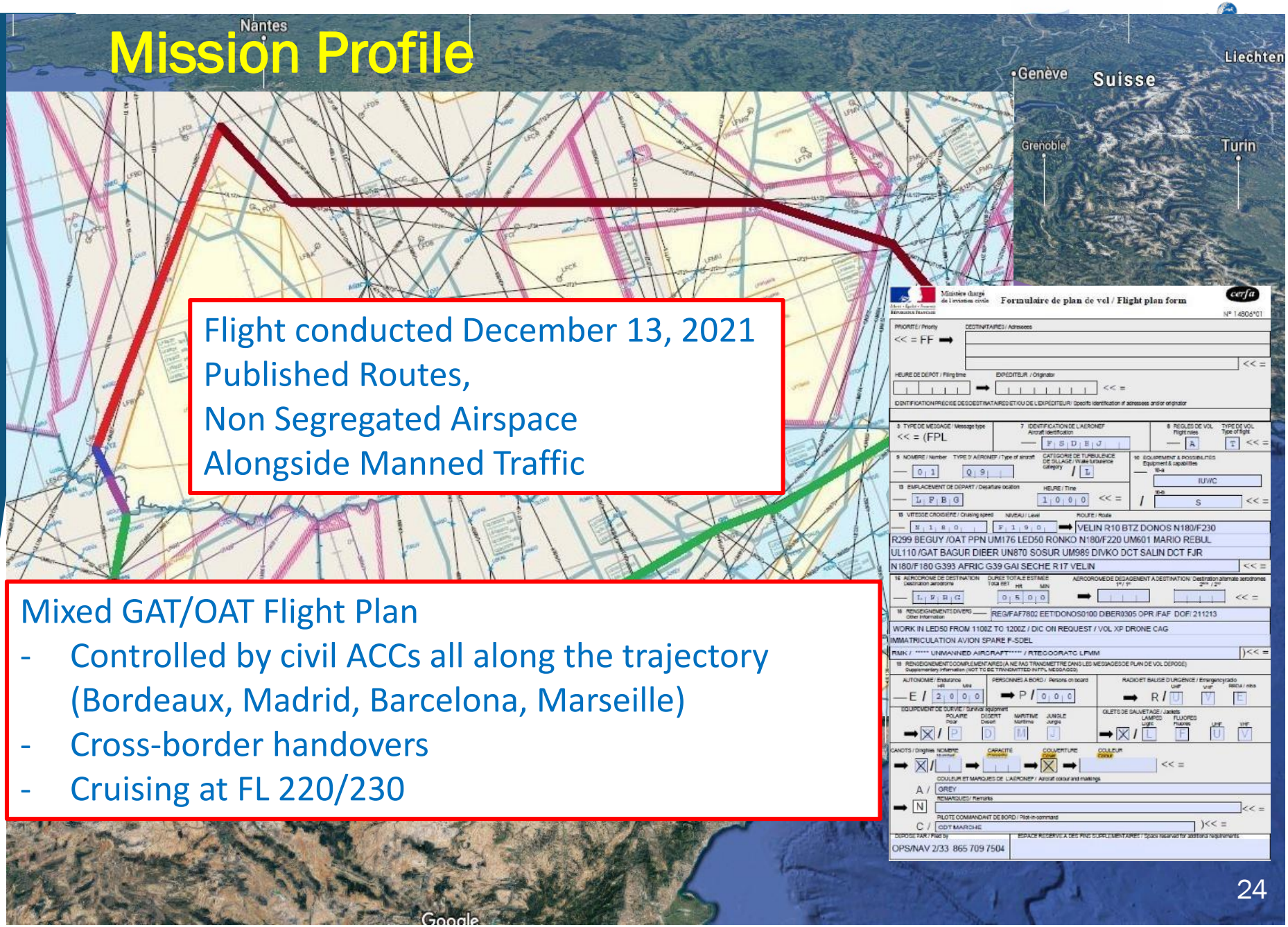
Methodology

- **Assessment**
  - ✓ *Fulfilment of technical and regulatory prerequisites*
  - ✓ *Implementation of accommodation measures and their acceptability by ATCOs*
  - ✓ *Flight plan adherence*
  - ✓ *Ability to comply/ follow ATC instructions*
  - ✓ *Ability of ATCos to handle, alongside manned aviation, the specificities of a MALE-type RPAS*
- **Observations**
  - ✓ *How the involved ATCOs were informed ?*
  - ✓ *By what means was this information given to them?*
  - ✓ *Did they ingest this information well before taking over their duties?*
  - ✓ *Impact of the introduction of an RPAS flight in normal condition?*

Preparation phase

- **Strategic**
  - ✓ *Initial, main, final conferences*
  - ✓ *CONOPS adoption: a trigger*
  - ✓ *FABEC Overarching Safety Argument document*
  - ✓ *Sharing the method: questionnaire + notice, observation positions. Debriefings (verbal and written)*
- **Tactical**
  - ✓ *Test flight plan and dedicated telephone line (backup)*
  - ✓ *Briefings remote crew and note to ATCOs*
- **Prerequisites**
  - ✓ *The RPAS is certified, Qualifications of the remote pilot*
  - ✓ *Accommodation measures for the experimentation are in place and operational (Weather, Telephone line, etc…)*

Mission Profile



Flight conducted December 13, 2021
Published Routes,
Non Segregated Airspace
Alongside Manned Traffic

Mixed GAT/OAT Flight Plan

- Controlled by civil ACCs all along the trajectory (Bordeaux, Madrid, Barcelona, Marseille)
- Cross-border handovers
- Cruising at FL 220/230

Mission execution

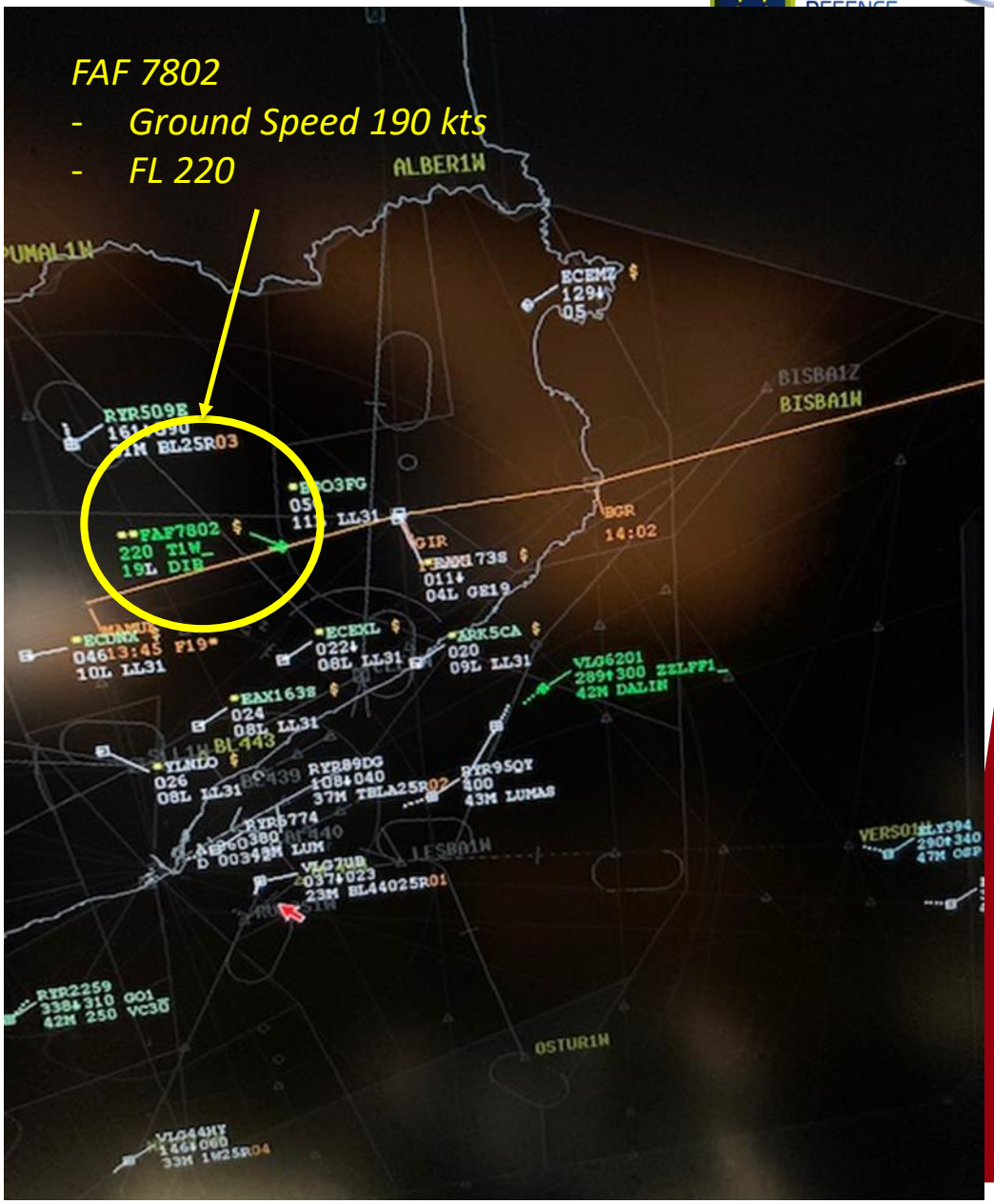
- **Observations**
  - ✓ *Low to moderate traffic*
  - ✓ *Debriefings (verbal and written) quotation and opened questions.*
- **Main results**
  - ✓ *Positive feedback on actual flights*
  - ✓ *Importance of some documents (note to ATCOs)*
  - ✓ *No equipment gap*
- **Human factor**
  - ✓ *Importance of the “what if” question*
  - ✓ *Low level of knowledge*
  - ✓ *Need to build confidence*

Flight plan adherence

- Cognac Military Approach <-> Bordeaux ACC
- Bordeaux ACC <-> Madrid ACC
- Madrid ACC <-> Military ATS unit (Zaragoza TACC)
- Military ATS unit (Zaragoza TACC) <-> Military tactical air control unit (GRUNOMAC / GRUCEMAC)
- GRUNOMAC / GRUCEMAC <-> Military ATS unit (Zaragoza TACC)
- Military ATS unit (Zaragoza TACC) <-> Madrid ACC
- Madrid ACC <->Barcelona ACC
- Barcelona ACC <-> Marseille ACC
- Marseille ACC <-> Bordeaux ACC
- Bordeaux ACC <-> Cognac Military Approach

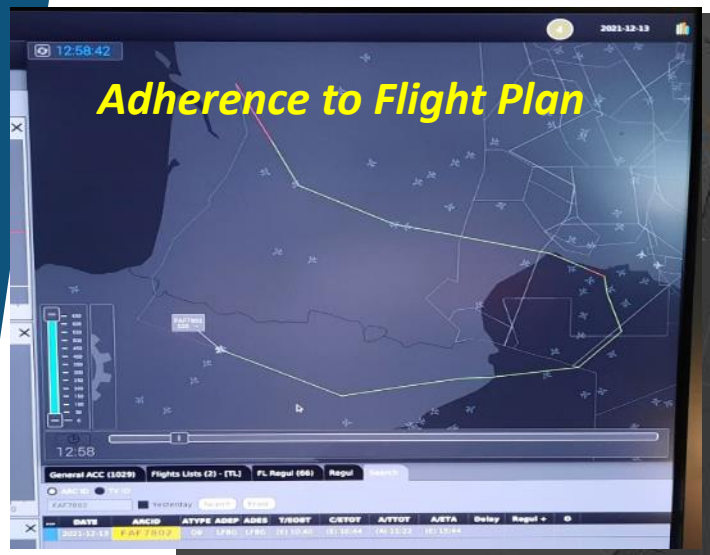
Observations

- ✓ UA was controlled as any other IFR traffic.
- ✓ Very limited additional workload to ATC
  - ✓ No impact to Bordeaux & Marseille Control
  - ✓ More coordination in Spain as it was the 1st time ATCOs had to handle an RPA IFR flight



Observations

Observations



Adherence to Flight Plan

Timely Compliance to ATC instructions

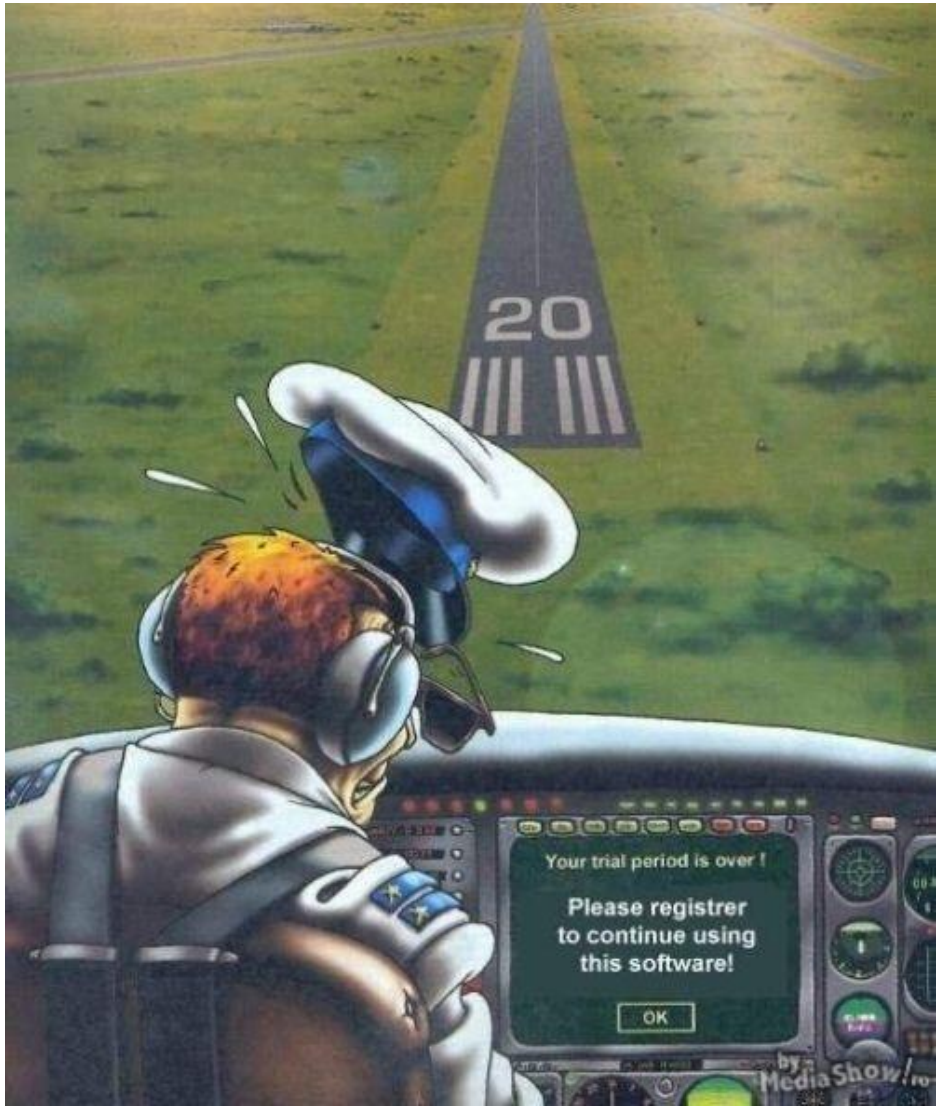
FAF 7802

- *Ground Speed 180 kts*
- *FL 220*
- *Squawking Ident*

Main observations

Event category	Gaps Drone vs equivalent Manned A/C & potential impact on ATM
Weather	T/Off delayed by adverse weather conditions in LFBG; crew and ATC adaptation
CNS	Observed (~2") Latency in ATC communication considered acceptable
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 fixed tel. line today used by ACC as backup coms for experimental flights)
RPAS	**Emergency Procedure need to be tested (Loss of C2 Link)**

5 minutes for a coffee break



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Dissemination Seminar- Part 3

I. Purpose of document D3
II. Findings and preliminary outcomes
III. Recommendations
IV. Maturity level assessment
V. Discussion

Purpose of document D3

- ✓ Recall on the context and scope of the Study,
- ✓ 3rd deliverable "D3 final Report" includes
  - ❑ Main elements of the D1-Validation plan, safety case analysis methodology.
  - ❑ Main Observations supporting the validation statement:

    "It is 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"
  - ❑ Highlights main characteristics of accommodation measures and the challenges that remain.
- ✓ D3 is a synthesis of the elements contained in the validation plan (D1) and the flight report (D2).
- ✓ We have already received comments and are working on them with the EDA. Comments are welcomed over chat
- ✓ This presentation focuses on the recommendations & outcomes

Findings and preliminary outcomes

- ✓ The experimental flights carried out in French airspace and, in December 2021, between France and Spain have demonstrated the acceptability of integrating a RPA in GAT alongside manned air traffic, without having to create segregated corridors.
- ✓ **No major inconvenience of accommodation measures in normal conditions for handling a single RPA alongside manned air traffic (low to moderate density).**
- ✓ **Induced limitations require further actions to build-up confidence regarding contengency measures adequacy by:**
  1) Testing /qualifying emergency procedures (SATCOM link Loss) through simulation for other legacy RPAS
  2) Determining the number of RPAS that can be handled by a single ACC (RPAS performances vs traffic density)
  3) Implementing specific training for ATCOs to allow them becoming more familiar with RPAS specificities so as to:
     - Provide Basic Information related to RPAS specificities
     - Test and practice Emergency Procedures (C2 Link Loss, automatic pre- programmed route..)

Recommendations (1/6)

- The study is a **solid basis** for accommodating "MQ9-REAPER" RPAS in other European member states airspace.

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

Recommendations (2/6)

Recommended accommodation measures:

- *The RPAS is certified*
- *The RPAS has the equipment and performances for an airplane of its category (< 5700 kg) in the considered class of airspace.*
- *The remote pilot is qualified and ATCO are qualified.*
- *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.*
- *As a back up during experimentations, a direct telephone line is operative between the Pilot and the ATCO, for emergency procedures.*
- *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 CONOPS and emergency procedures remains necessary*.

Recommendations (3/6)

- **MALE RPAS comparable to Reaper**
  - ✓ *We recommend repeating this type of experimentation by continuing these kind of flights to:*
    - ❑ *Increase the confidence of ATCOs in their ability to handle this type of RPAS traffic*
    - ❑ *Extend to other member states.*
    - ❑ *Enhance Remote Pilot knowledge of the rules specificities of IFR practice in GAT*
- **Some improvements deserve further investigations in the ATM system.**
  - ❑ ***Work on the note to ATCOs and ATCO training***
  - ❑ *Work on Flight plans that could contain more information, use of case 18.*
  - ❑ *Consider using a specific call sign to warn ATCOs of the nature of the RPAS*

Recommendations (4/6)

- **RPAS equipment priority**
  - ✓ When possible, replace the Mode C IFF with a Mode S to facilitate recognition of the RPA by other users.
  - ✓ Present all the necessary updated GAT navigation documentation in the navigation interface to the pilot.
- **RPAS Safety Case Methodology**
  - ✓ Simulated tests on diversion to civil and military airfields

Recommendations (5/6)

Building confidence

- ✓ There is a need to address more-demanding conditions
  - more complex airspace structures
  - congested airspace
  - more demanding environmental conditions
  - realization of abnormal or emergency procedures.
- ✓ Those tests should help to define minimum requirements in terms of RPA performances and also better evaluate compatibility with traffic density.
  - The trials showed that one RPAS per sector is possible. Maximum number was not investigated.

Recommendations (6/6)

- Some quick wins practical improvements mentioned by actors (out of scope but interesting points to investigate)
  - Flight plans improvements, in Case 18 Crew phone number ?
  - The keyword « unmanned » could be put before the call sign ?
  - In case of emergency, fly at a VFR FL, eg. 205 instead of 200 ?
  - Replacement of the dedicated telephone line
  - Voice communication systems should in the future integrate telephone and VHF to allow “party line”.
  - Airspace design 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).
  - Artificial intelligence to safely terminate a flight.

Maturity Level assessment

Criteria (V2 → V3)	Our finding/ assessment
Operational feasibility (user acceptance, safety)?	**Yes, with some limitations** 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)?	**Yes, with limitations** as 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)?	**Manageable: 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*
Affordability for stakeholders?	**Limited investment** (eventually keypad programming of CWP, fixed telephone line management)
Alternative solutions compared?	**The "accommodation phase" is a transitional phase** until the technical solutions for full integration have been fully tested and qualified. **To our opinion this is the best "win-win" approach for Civilian and Military**

THANKS

Special thanks to Spanish and French civil and military teams for their commitment as well as EDA supporting actors

It was an honour and a pleasure to share this study with the Stakeholders Consultation Group and we are keen to answer questions and take remarks on-board

The floor is open for Q& A

Question & Answer

Next steps & Closing remarks

- Final Report publication (> end of April)
- Floor to France ?

- Closing Remarks
- Crawl, Walk, Run….
  - Those wo are already walking are keen to help those who are still crawling ;-)
  - EDA is keen to support this effort