URClearED

A Unified Integrated Remain Well Clear Concept in Airspace Classes D-G

Federico Corraro - CIRA
Project Manager

Stakeholders Workshop - 11 October 2021

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Outline

- Project Scope
- Project Aim and Objectives
- Elements of the Operational Scenario
- URClearED RWC Functions
- Operating Methods
- Project Workflow and Status
- Next Steps

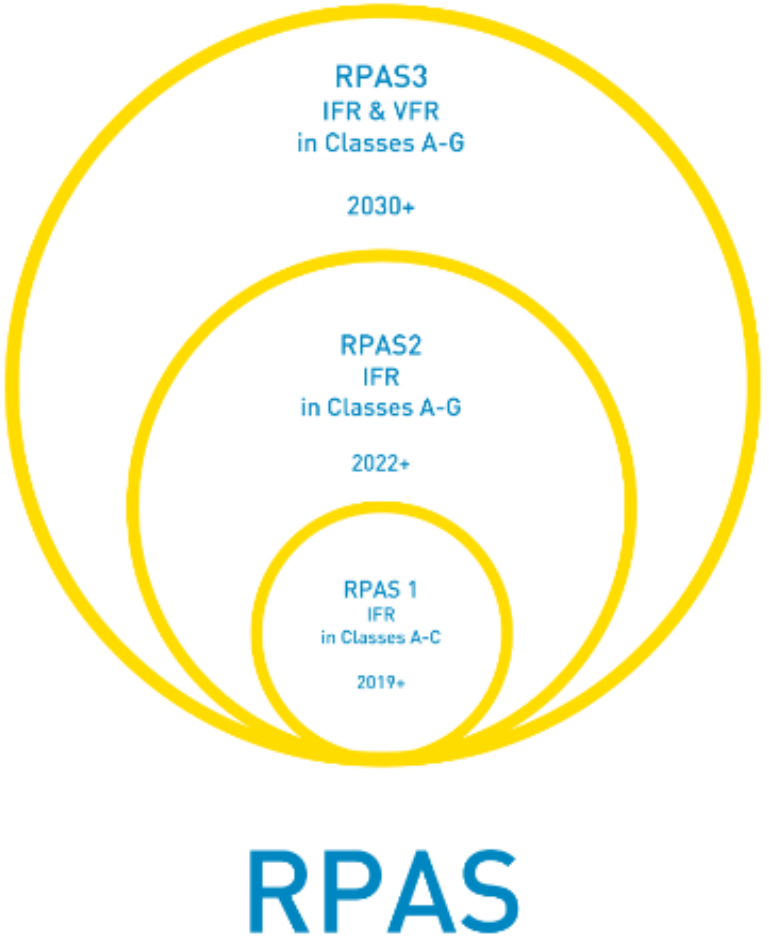
Workshop organisation

- You can use the chat to post questions during the presentation without interrupting the speaker
- We will try to answer in the chat if feasible and we can discuss your question at the end of the presentation
- Use the “raise hand” to ask to speak during the q&a sessions, we will unmute you
- At the end of the presentation we will run an interactive session to enforce discussion, you will need
    - To open a new tab of the browser to answer some questions
    - Or you can use your mobile phone and access the page through the QR Code

Project Scope

UAS INTEGRATION IN ATM

- The seamless integration of a certified Remotely Piloted Aircraft Systems (RPAS) in non-segregated airspace is one of the major objectives for the worldwide civil aviation system.
- Several technological and regulatory issues persist to comply with the need of keeping high safety levels of air transport
- The development of a Detect And Avoid (DAA) system is widely recognized as a primary need for the RPAS integration in the unsegregated airspace. The DAA system shall answer the challenge of matching the ability to Sense and Avoid airborne and ground hazards such as potential collisions with other airspace users.
- Many activities are ongoing all around the world that can support the development of effective and reliable DAA systems.

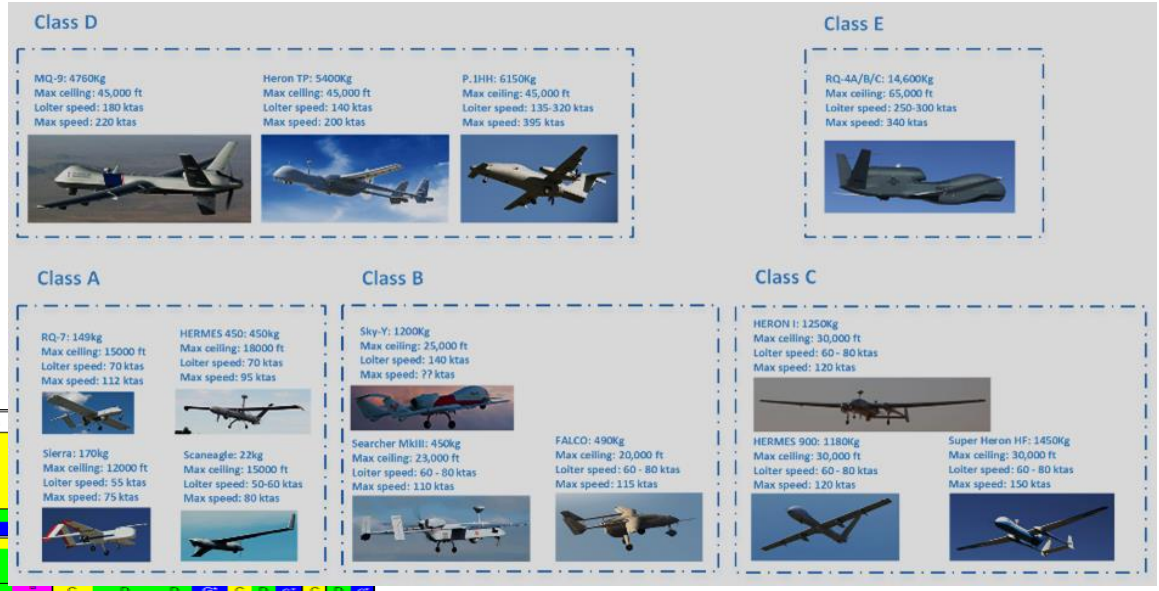


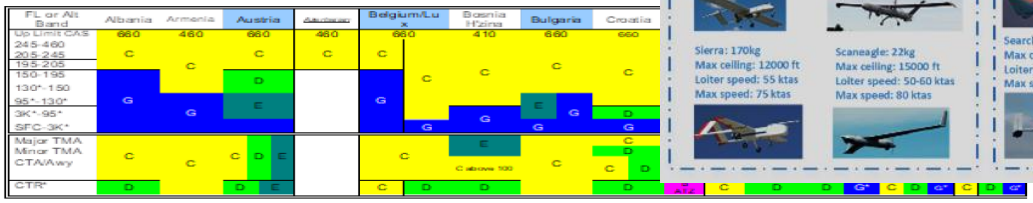
Project Scope

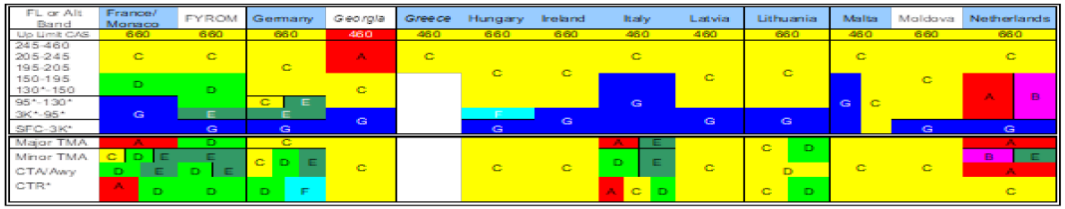
RELEVANT OPERATIONAL FACTORS AFFECTING DAA DESIGN

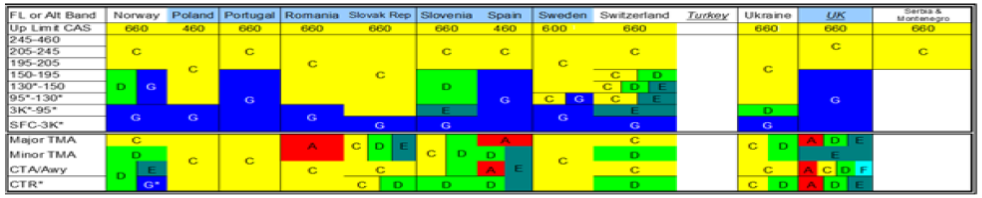
UAS wide ranges on:

- Dimensions
- Speed
- Vertical speed
- Climb/Descent rate
- Turn rate









Differences among European Airspace structure and related applicable Flight Rules

- Fully Controlled Classes A-C
- Not fully controlled (D-G)
- IFR/VFR

Project Scope

STATE-OF-THE-ART IN DAA DEVELOPMENT

Past, complementary and evolutionary projects :

- EDA projects Mid- Air Collision Avoidance System (MIDCAS) / MIDCAS Standardisation Support Phase (SSP)
- NASA/FAA project UAS in the NAS
- SESAR 1 PJ10-05 PROSA Project
- SESAR 1 RPAS Integration Demonstration program
- SESAR 2020 PJ13-ERICA
- EDA European DAA System EUDAAS project

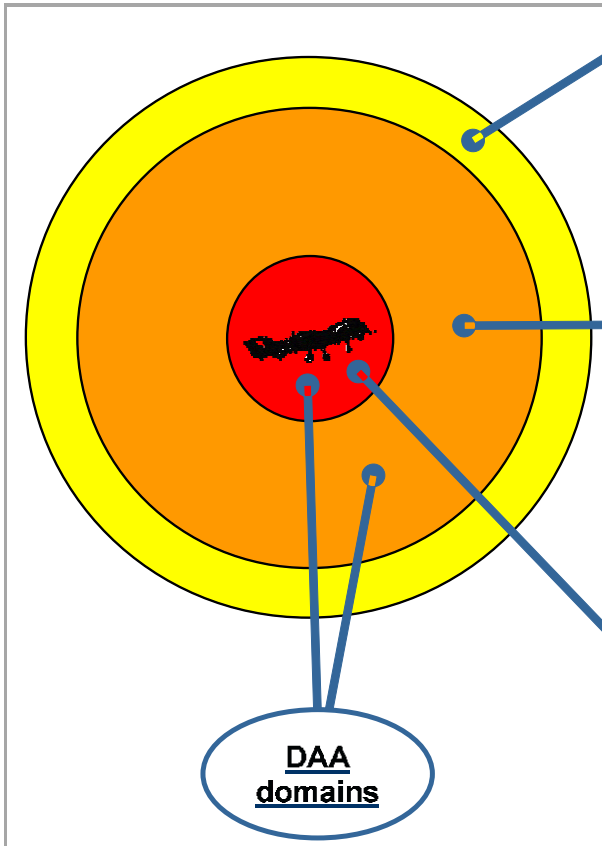
Regulatory activities and applicable standards:

- RTCA SC-228 DO-365, Detect And Avoid (DAA)-MOPS, 31 May 2017.
- RTCA SC-228 DO-365A – MOPS for DAA Systems, Revision A. March 2020.
- EUROCAE WG105 ED-258 - Operational Services and Environment Description for Detect And Avoid In Class D-G Airspaces Under VFR/IFR, Jan 2019.
- RTCA/DO317B, MOPS for Aircraft Surveillance Application (ASA) System, 2014.
- RTCA/DO-185B, MOPS for Traffic Alert and Collision Avoidance System (TCAS II) Airborne Equipment.

Project Scope

Three layers model of conflict management and the DAA domains

Conflict management is the function that aids the ATCO/RP in tasks that are already required of manned pilots in situations where the pilot is responsible for *"not operating [an aircraft] in such proximity as to cause a collision hazard".*



1 Strategic Conflict Management

Strategic process of keeping aircraft away from intruders and other conflict hazards based on:

- airspace organization and management
- demand and capacity balancing
- traffic synchronization components

2 Separation Provision

Tactical process of keeping aircraft away from intruders and other conflict hazards based on:

- traffic control (ATC responsibility) or
- Remain Well Clear (RP responsibility)

Depending on the airspace class and flight rules (IFR/VFR).

3 Collision Avoidance

Emergency process of keeping aircraft away from intruders and other collision hazards based on:

- evasive manoeuvres

The ultimate responsibility for avoiding collisions always remains with the remote pilot.

Project Scope

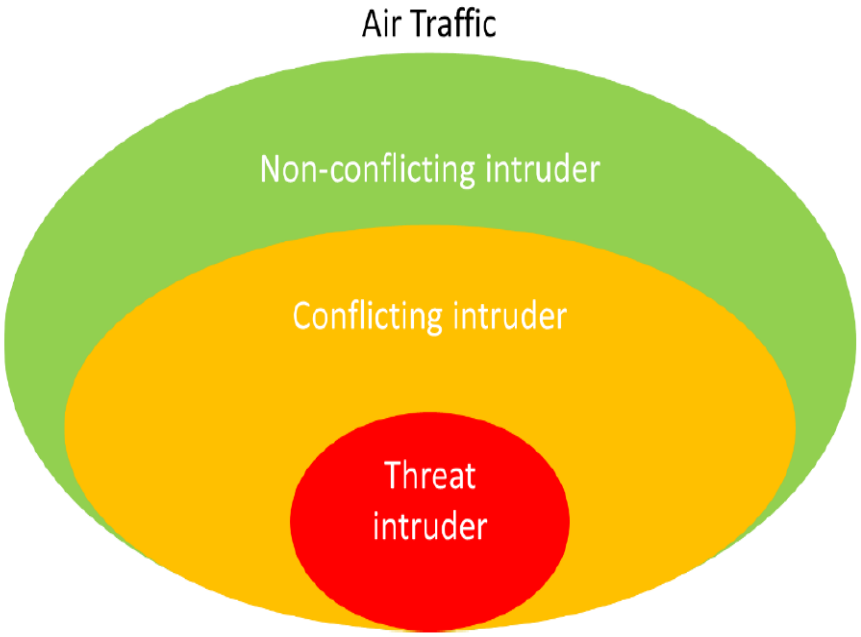
Remain Well Clear applicable definitions

REMAIN WELL CLEAR: THE LAYER 2 ELEMENT OF CONFLICT MANAGEMENT

The URClearED solution is focused on the RWC function to support the remote pilot in her/his responsibilities with regards to the rule of the air - "*An aircraft shall not be operated in such proximity to other aircraft as to create a collision hazard*", as stated in the ICAO Annex II, section §3.2. In this context, the RWC function will support the RPAS pilot to avoid the violation of a well-clear volume for any conflicting intruder.

Conflicting intruder: For each surrounding traffic track, a conflicting intruder is any aircraft for which it is predicted an estimated loss of well clear (LoWC) within a given look ahead time.

Well Clear Volume is a volume around each intruder that shall be not violated to avoid a Loss-of-Well Clear condition. In this context, the Well Clear Volume is quantitatively defined using horizontal, both spatial and temporal, thresholds and a vertical threshold.



Aim of URClearED Exploratory Research project

Investigate the Definition of a Remain Well Clear (RWC) Software module, integrated in a Detect & Avoid (DAA) system, for:

- a RPAS of “Certified” EASA category;
- flying IFR (Instrumental Flight Rules)
- flying into airspace classes D to G

Project Objectives (all related to Classes D to G)

- Define the operating conditions (Operational Scenarios) of a European RWC
- Propose Surveillance Sensors and Data Link performance assumptions
- Propose the functional requirements and capabilities for such RWC
- Propose operational procedures for RWC and the management of IFR RPAS flying in airspace classes D-G, including U-Space interaction
- Develop a baseline RWC prototype algorithm and related HMI to support evaluation of assumptions and requirements
- Assess and refine assumptions, requirements and operational procedures by means of Fast-Time and Real-Time Human in the Loop (including Remote Pilots and ATCOs) Simulations

Detailed Objectives / Features of RWC

1. **System Performance**: The RWC system meets the appropriate and intended function under the stated operating conditions, including completeness and the minimisation of false positives.
2. **Scalability**: The same RWC system could be used for different classes of drones, including, at least, fixed- and rotary-wing tactical and MALE RPAS, with different performance characteristics.
3. **CA Interoperability**: Asses the interoperability of the proposed RWC solution with the Collision Avoidance functionality of the DAA system on which the RWC is run.
4. **ACAS Interoperability**: Asses the interoperability with most common Aircraft Collision Avoidance Systems (ACAS), in particular the assessment will be performed considering TCAS-II equipped aircrafts.

Detailed Objectives / Features of RWC

5. **Compatibility with ATC separation provision services:** Asses the interoperability with the ATC separation function and STCA systems.
6. **Auto-compatible**: Asses system functionality with intruders equipped with the same RWC solution.
7. **No false alarms**: Determine that the ratio of false or spurious alarms is low enough to remain operational.
8. **Bounding of navigation and surveillance sensors performance**: determine the minimum sensor characteristics that do not compromise performance of the RWC solution.
9. **Bounding of C2 data-link performance**: determine that the performance of the RWC solution is not compromised by the C2 communication latency variability.

Detailed Objectives / Features of RWC

10. **Multi-intruder encounters**: Define operational scenarios in traffic conditions, both to check capability of RWC to manage multiple encounters and to check its capability to avoid secondary conflicts.
11. **Airspace impact**: Transition among airspace classes does not negatively impact the RWC capabilities.
12. **Integrity**: RWC system works correctly in alerting the pilot that it is not anymore able to perform its functions.
13. **Impact of Contingency situations** on situational awareness of both Remote Pilot and ATCO, such as:
    - Loss of communication with ATC
    - Temporary Loss of C2-link
    - Failures of navigation and/or surveillance sensors
14. **Compatibility with U-space services and traffic**.

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Enric Pastor - UPC
WP2 Leader – Operational Scenarios

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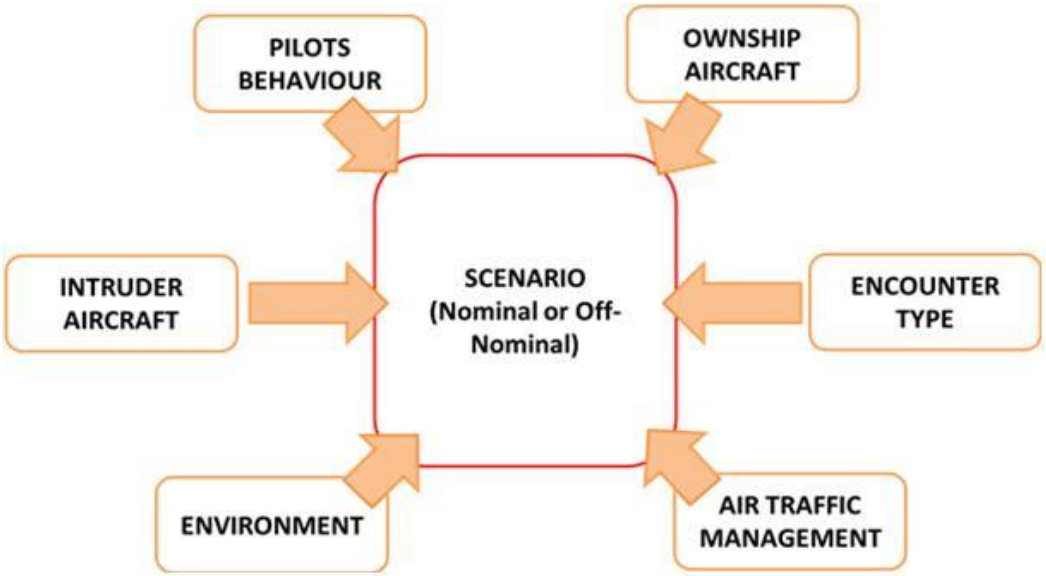
Key Elements in the Operational Scenarios

- Airspace and available Air Traffic Services.
- Ownship / Intruder performance and equipment.
- Encounter Types: geometries, speeds
- Remote Pilot Behavior



Key Elements in the Operational Scenarios

AIRSPACE: AIR TRAFFIC SERVICES

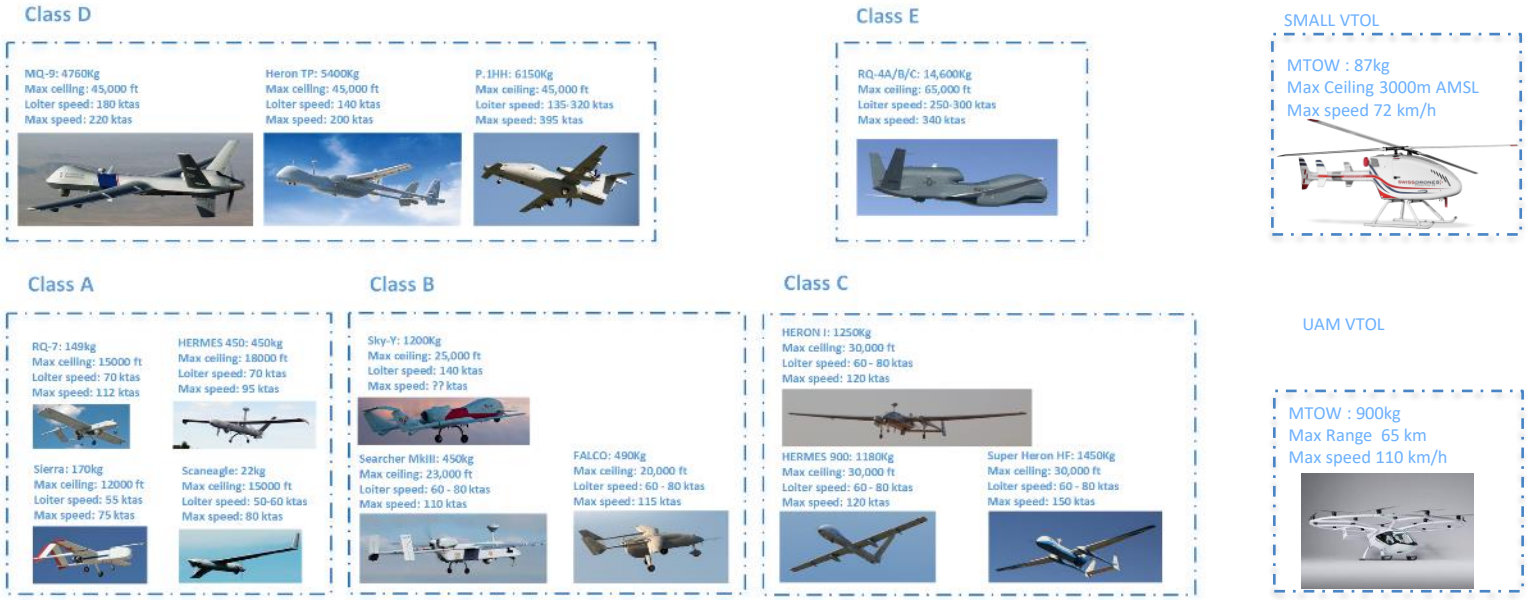
Available air traffic services, separation objectives and potential coordination with ATC depends on the type of airspace.

Airspace Class	D		E		G	
Flight Rules	IFR	VFR	IFR	VFR	IFR	VFR
Permitted	yes	yes	yes	yes	yes	yes
Speed Limitation	< 250 Kts, @ Altitudes below 10.000 feet AMSL					
ATC Clearance	yes	yes	yes	no	no	no
Air-Ground Radio Comm. Requ.	Continuous two ways	Continuous two ways	Continuous two ways	no	Continuous two ways	no
Separation minima	3 nm horizontal 1000ft vertical		5 nm horizontal 1000ft vertical		3 nm horizontal 500ft vertical	
ATC Separation Services	yes only IFR-IFR	no	yes only IFR-IFR	no	no	no
ATC Information	TFCI wrt VFR	TFCI wrt IFR and VFR	TFCI wrt VFR when possible	TFCI when possible	FIS If requested	FIS If requested

Key Elements in the Operational Scenarios

OWNSHIP PERFORMANCE CLASSIFICATION

- Fixed wing ‘certified’ RPAS from class A to E, classified based on engine type / max ceiling.
- Helicopter / VTOL : SMALL VTOL, UAM VTOL
- Operating altitude up to 18500ft
- C2 Link RLOS and BRLOS
- All RPAS Transponder Equipped, with Cooperative Sensors (ADSB-IN + Active Traffic Sensor or Interrogator) and Non-Cooperative Sensor Suite (radar, EO/IR, etc.)



Key Elements in the Operational Scenarios

INTRUDER AIRCRAFT PERFORMANCES

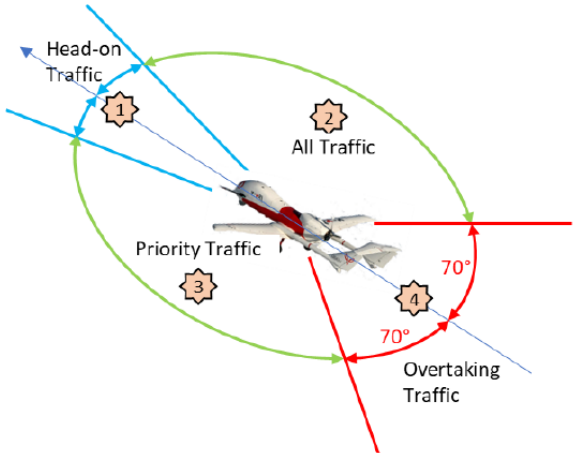
Level	Equipment	Categories	IAS [Kts]	RoC [ft/min]	Max turn rate [deg/s]	Max vert acc [g]
0	Non-cooperative	Piston fixed wing (1)	77-98	-1500/2000	6	0.25
		Piston rotary wing, glider, balloon, airship	0-98	-1200/1200	30	
1	Cooperative without cooperative traffic sensors	Piston fixed wing (1)	77-98	-1500/2000	6	0.25
		Piston rotary wing	0-102	1200/1200	30	
2-3	Cooperative with cooperative traffic sensors	Turboprop < 15000 Kg (2,3)	92-150	-3700/4200	6	0.25
4	Cooperative with ACAS	Turboprop > 5700 Kg (3,4)	110-160	-3510/3550	5	0.15
		Turbojet (6,7,9)	108-210	-4500/4650	5	0.25
		Turbine rotary wing	0-155	-2000/2000	30	0.25
		Tilt Rotor	0-275	-4100/4100		

Key Elements in the Operational Scenarios

ENCOUNTER TYPE

ENCOUNTER TYPE

Conflict Geometry	Complexity of the Encounter



Conflict Geometry (w.r.t. Ownship):

- Head On
- Lateral with Right of Way
- Lateral without Right of Way
- Overtaking

Sector	Situation description
1	Intruder approaching head-on or approximately. Both aircraft are required to give way by turning to the right.
2	Intruder converging from right sector: all intruders have the right of way, the RPA shall give way.
3	Intruder converging from left sector: the RPA has the right-of-way, except for priority intruders.
4	Intruder overtaking: the RPA has the right-of-way.

Complexity of the encounter**:**

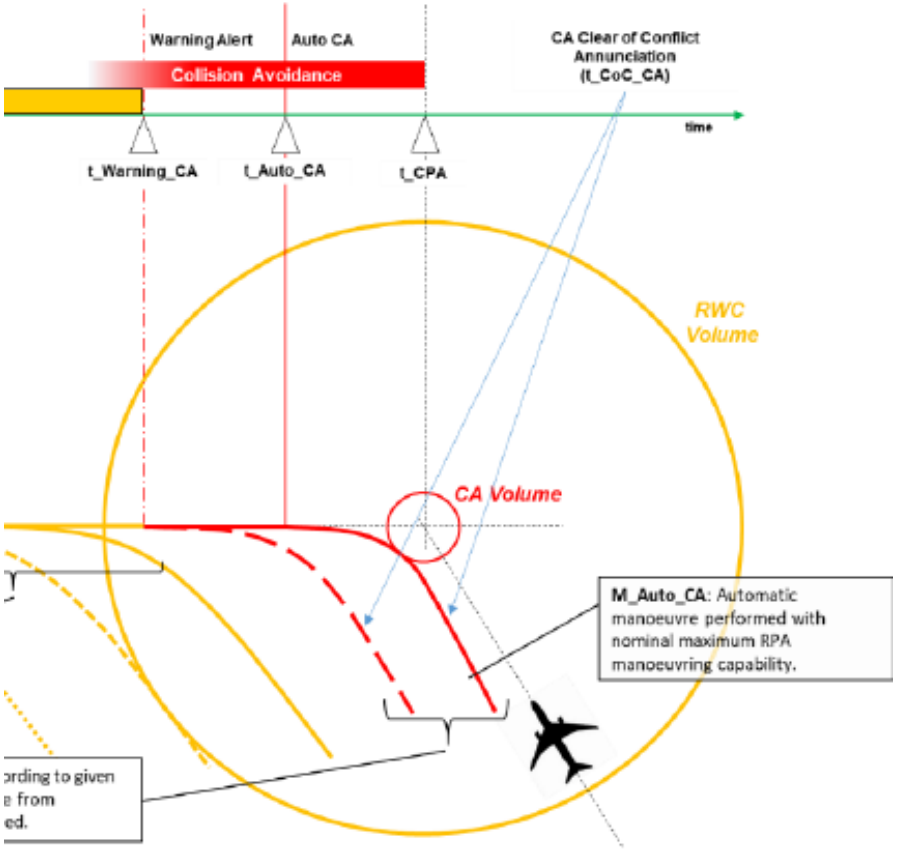
- **Simple Pair Wise:** Straight Trajectories
- **Special Maneuvers**: CAFE' trajectories; RTCA DO 365A trajectories;
- **Multi-intruders**

Key Elements in the Operational Scenarios

PARAMETERS INFLUENTIAL FOR THE PERFORMANCE OF RWC METHODS

1. The horizontal velocity of each vehicle and the relative velocity between vehicles.
2. The rate of climb or descent for each vehicle.
3. The angle of encounter at true CPA.
4. The angle of detection.
5. The distance at CPA (equivalently, time difference at projected CPA or spatial distance at CPA).

Acceleration factors, both in the horizontal and vertical plane, may impact the encounter and may be considered for additional realism of the analysis.



Key Elements in the Operational Scenarios

THE REMOTE PILOT TASK SEQUENCE

Monitor, verifying the state of the surrounding traffic and detecting any potential conflict situation, using the available onboard DAA equipment and associated traffic sensors.

Assess the possible RWC manoeuvre by interacting with ATCo (when available), depending on the role and responsibility in managing aircraft separation, on the airspace class and intruder type (IFR/VFR). Because the RP behaviour depends on the nature of the intruder (IFR or VFR), the RP is always responsible for assessing this info by contacting ATC, when available, or by other means.

Executes the assessed RWC manoeuvre, refers mainly to the available piloting modes for the RP, which impacts the way the manoeuvre could be executed.

Latency type	Distribution Type	Mean [s]	Std dev [s]	Bound @ 95% [s]
Initial Response	Exponential	5	5	<=15
ATC Coordination	Gamma	11	4.7	<=19.7
Execution delay	Exponential	3	3	<=9

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WP3 Leader – RWC Implementation

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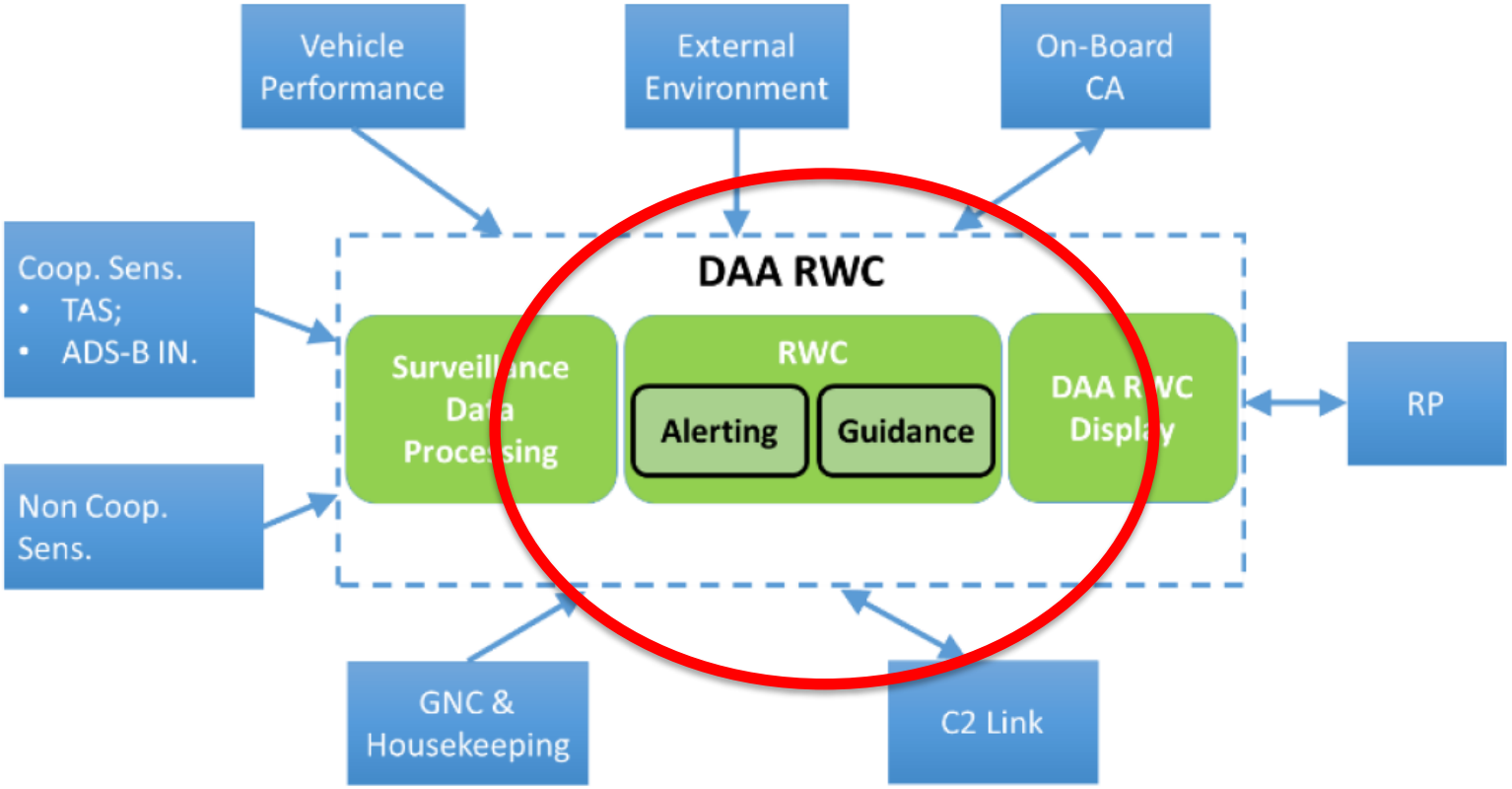
URClearED RWC Functions

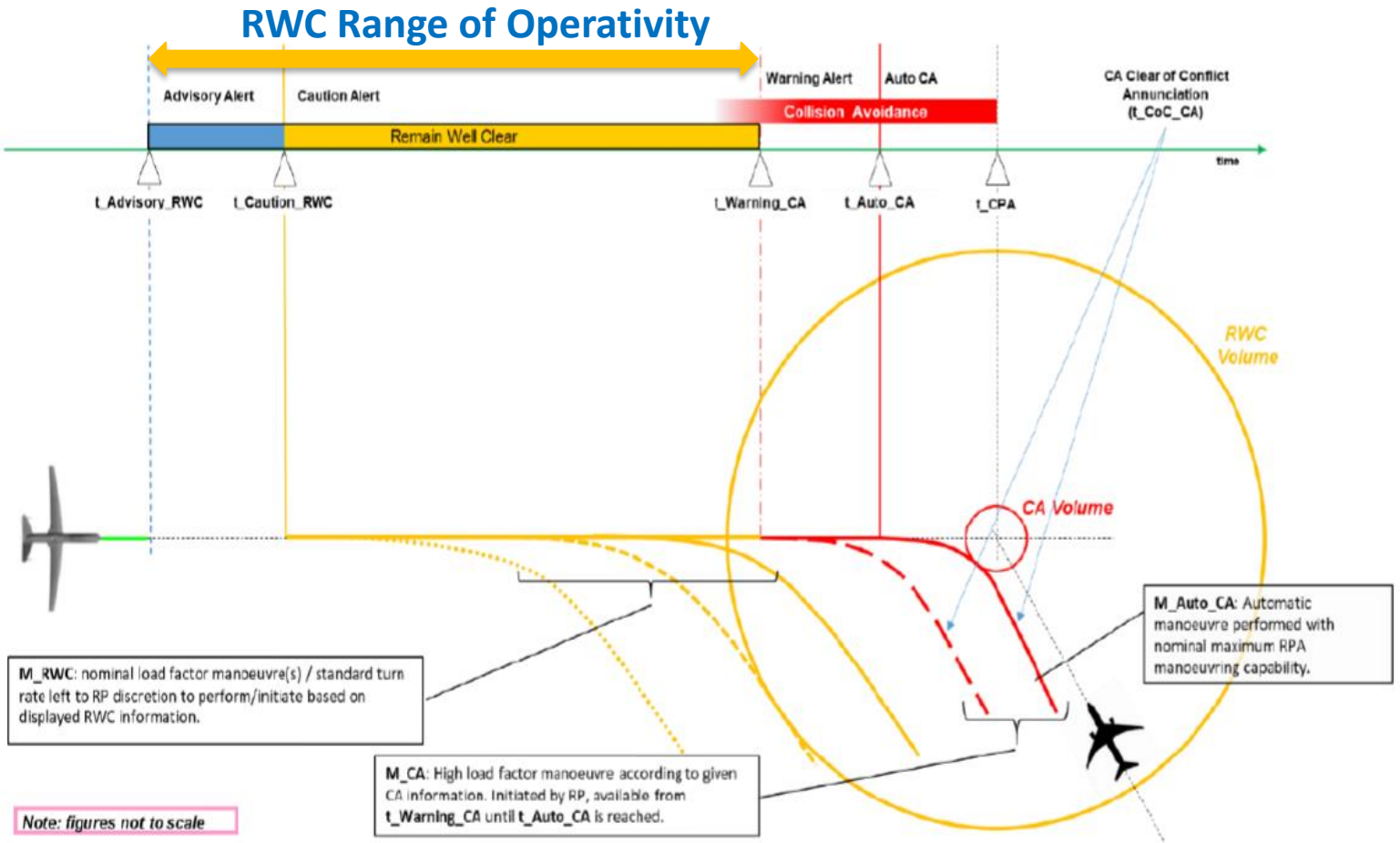
FUNCTIONAL CONTEXT



URClearED RWC Functions

ALERTS

The alerting functionality aims to determine whether an intruder poses enough risk to warrant an alert and, in this case, which alert priority is appropriate.



URClearED RWC Functions

ALERTS

- **ADVISORY**
  - Indicating when a change in current heading/track or altitude by the ownship may immediately trigger a caution alert.
  - The RP response to an advisory level alert is to monitor the designated traffic, by assessing the overall situation of the encounter, and be aware of the risk of inducing a loss of well clear situation, due to possible future manoeuvres or mission constraints.
  - Contacting ATC in response to an advisory alert should be avoided

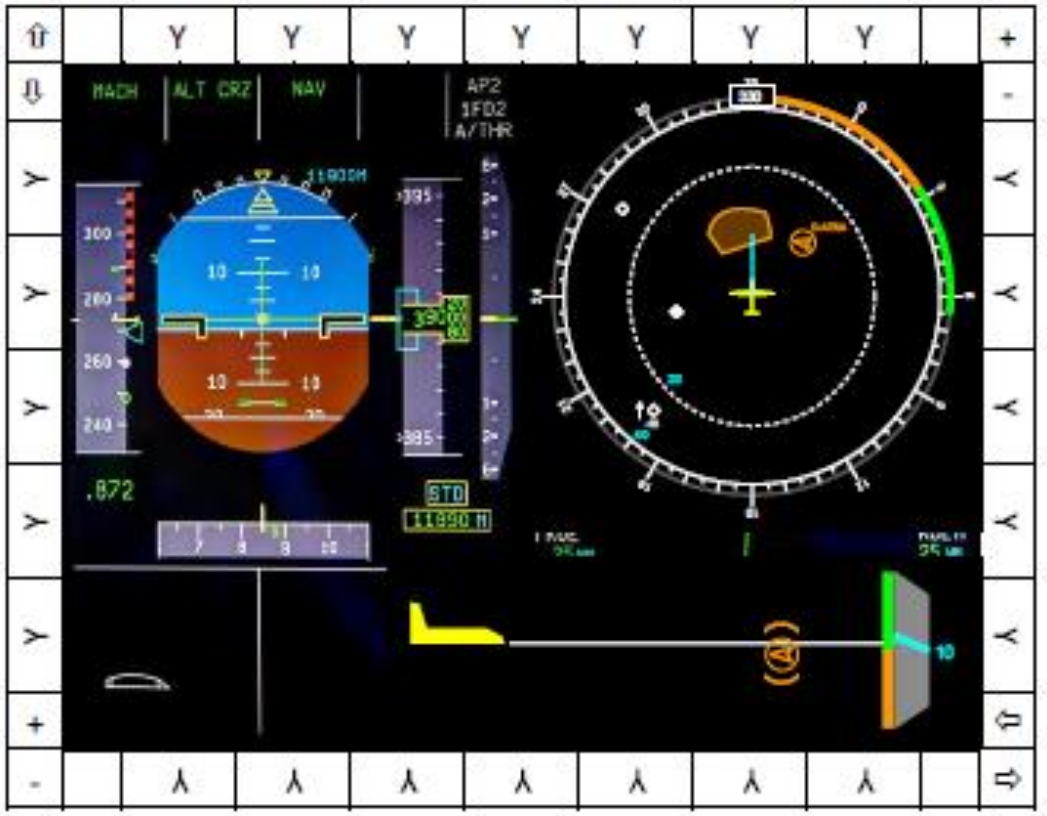
- **CAUTION**
  - Indicating a predicted (within a given look-ahead time) or current loss of well clear situation
  - This alert necessitates immediate awareness of the RP and subsequent actions
  - The RP shall determine whether a manoeuvre is needed and initiate coordination with ATC if available

URClearED RWC Functions

GUIDANCE

Provide indications to support the RP (or other involved operators of the RPAS) decisions in the resolution of a potential conflict.

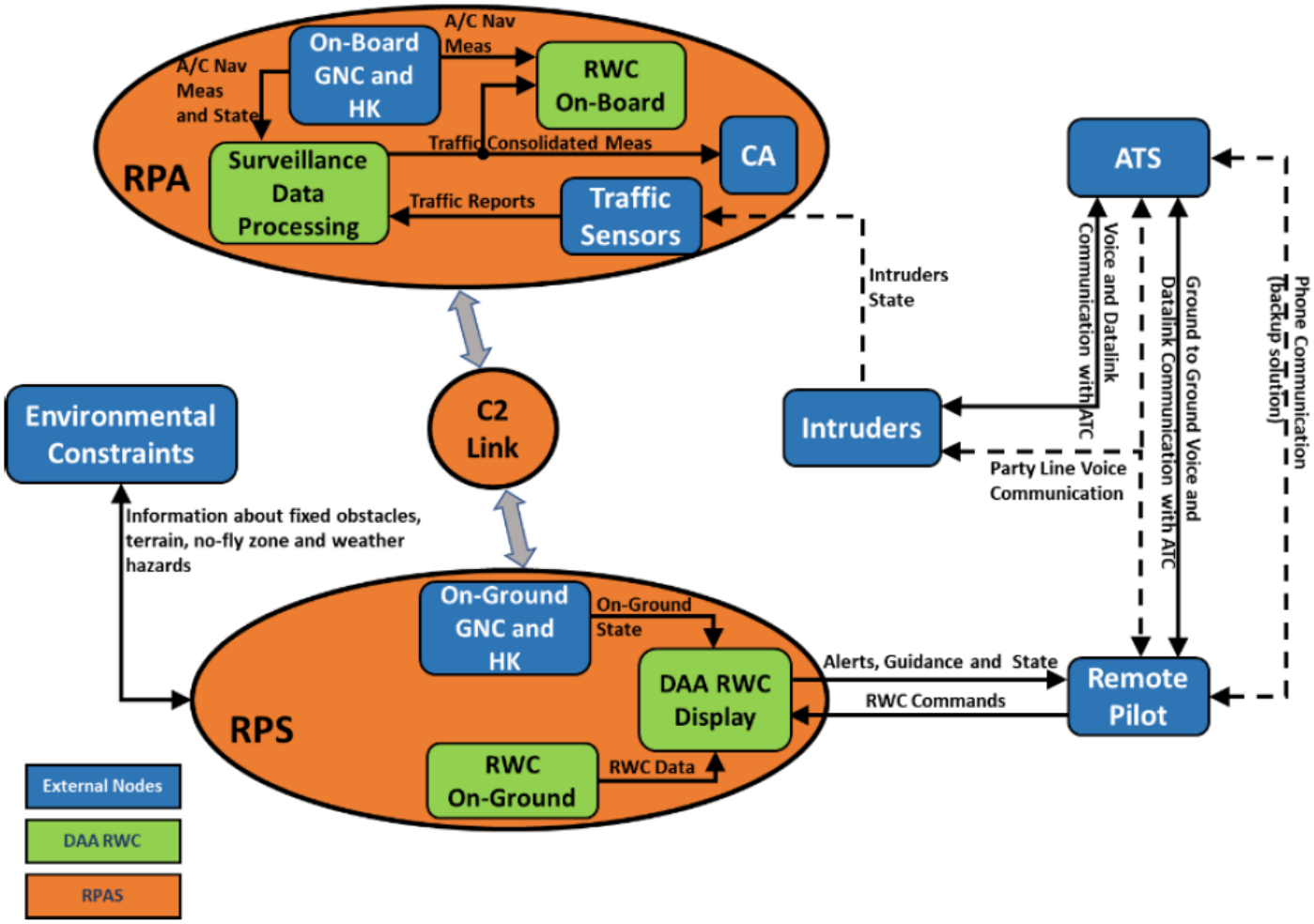
- Computes the range of ownship manoeuvres that would result in an estimated loss of well clear (LoWC) within a given look ahead time.
- Maneuvers are computed only for Horizontal and Vertical Plane separately
- Horizontal maneuvers are computed in track/heading angle
- Vertical maneuvers are computed in altitude or Flight Levels



Not the Real HMI – Only for Reference

URClearED RWC Operating Method

OPERATIONAL CONTEXT



URClearED RWC Operating Method

REMOTE PILOT OPERATIONS

Airspace Class	Intruder Type	RP behaviour during the assessment task
D-E	IFR	• **ATC** provide full separation. Remote Pilot monitor the traffic information and execute the separation instruction provided by ATC. • The **RWC system** would alert and give guidance in case the ATC does not timely provide any information about the type of intruder (IFR/VFR) and/or separation instructions • The **Remote Pilot (RP)** shall contact ATC to inform them and to ask for instructions or clearance for an RWC manoeuvre
D-E	VFR	• **ATC** send traffic info about VFR traffic on a regular basis (in class D), or when possible (in class E). **VFR traffic** shall normally separate • The **RWC system** would alert and give guidance to RP in case the VFR traffic is not separating • The **Remote Pilot** shall interact with ATC to determine a course of action. After clearing the conflict, the RP shall recover the original flight plan by contacting back ATC
G	IFR and VFR	• **ATC** does not provide any separation or traffic information services. The IFR RPAS RP shares separation responsibility with the intruder • The **RWC System** would alert and give guidance to RP in case of conflicting intruders, together with information on type of intruder (coop./non coop, ACAS equip.), as far as practicable • The **Remote Pilot**, using RWC indications, decides the maneuver according to the rules of the air, simply notifying ATC, if available. After clearing the conflict, the RP will contact ATC, if available, in order to return to the original flight path.

Differences with existing operating methods

Current Operations in manned aviation	URClearED expected operations and capabilities
• Responsibility for separation management is assigned to the air traffic controller. However, the pilot is responsible for remaining well clear from other traffic	• In the URClearED operational concept the roles and responsibilities for ATC and remote pilots are the same as current manned aviation operations
• In all the situations in which ATC does not provide the separation service, a manned aircraft can only rely on see-and-avoid capability of the pilot, eventually supported by ACAS-I Traffic advisories (TAs)	• The DAA RWC function issues at most the advisory (for monitoring traffic) and caution alerts (for action). • The RWC gives guidance indications that would support the RP in taking decisions when interacting with ATC, if available, or for maneuvering. • The alerting timeframe of RWC on an IFR RPAS is always sufficient for interacting with ATC, while not conflicting with ATC separation.
• TCAS-I is optional for any aircraft, TCAS-II is mandatory within European Union only for large aircraft. In the airspace classes from D to G, there can be aircraft not equipped by a transponder.	• The URClearED RWC solution is supported by a surveillance function that provides to the RP the surrounding air traffic situation including not transponder or ACAS equipped aircraft

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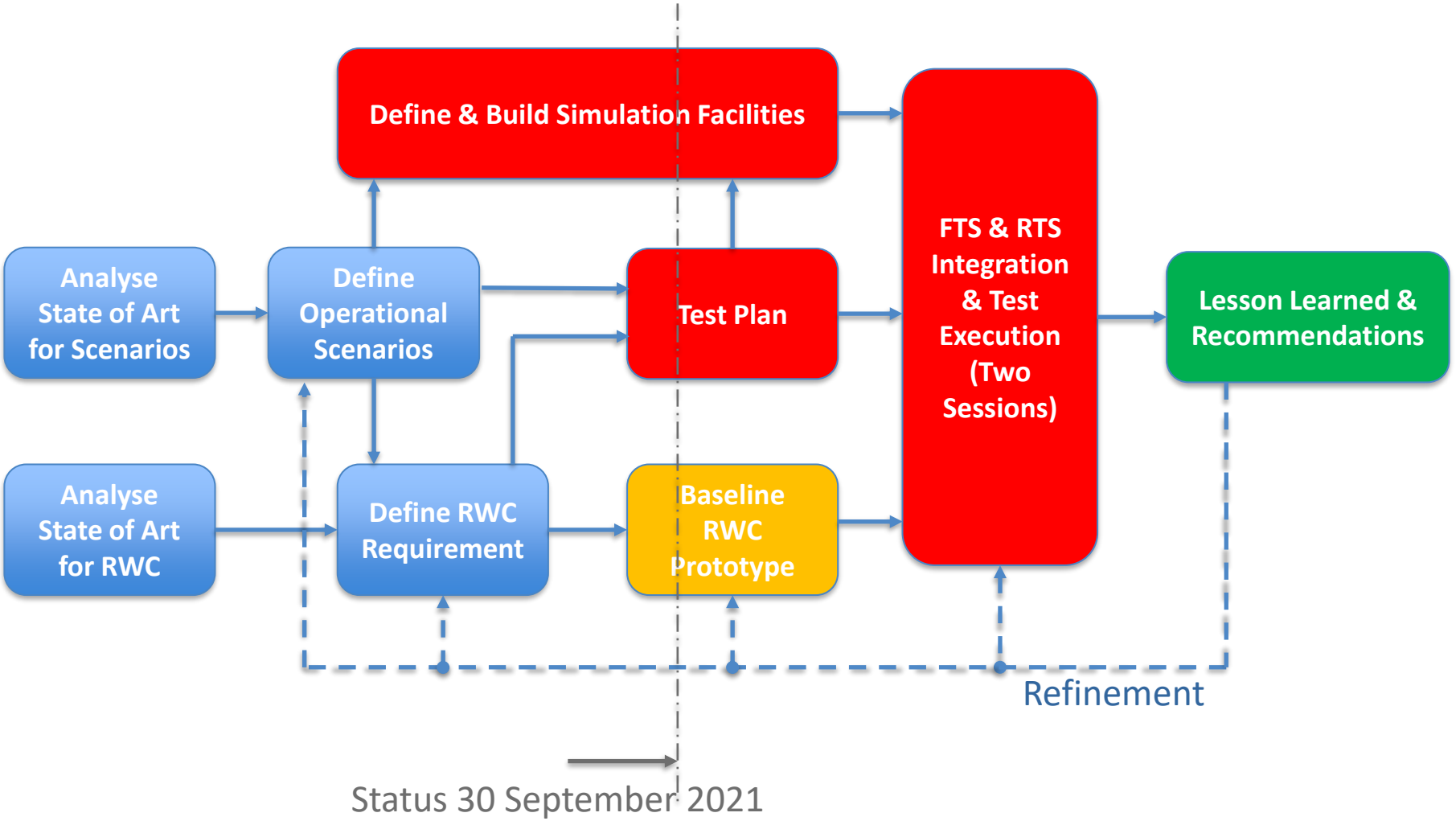
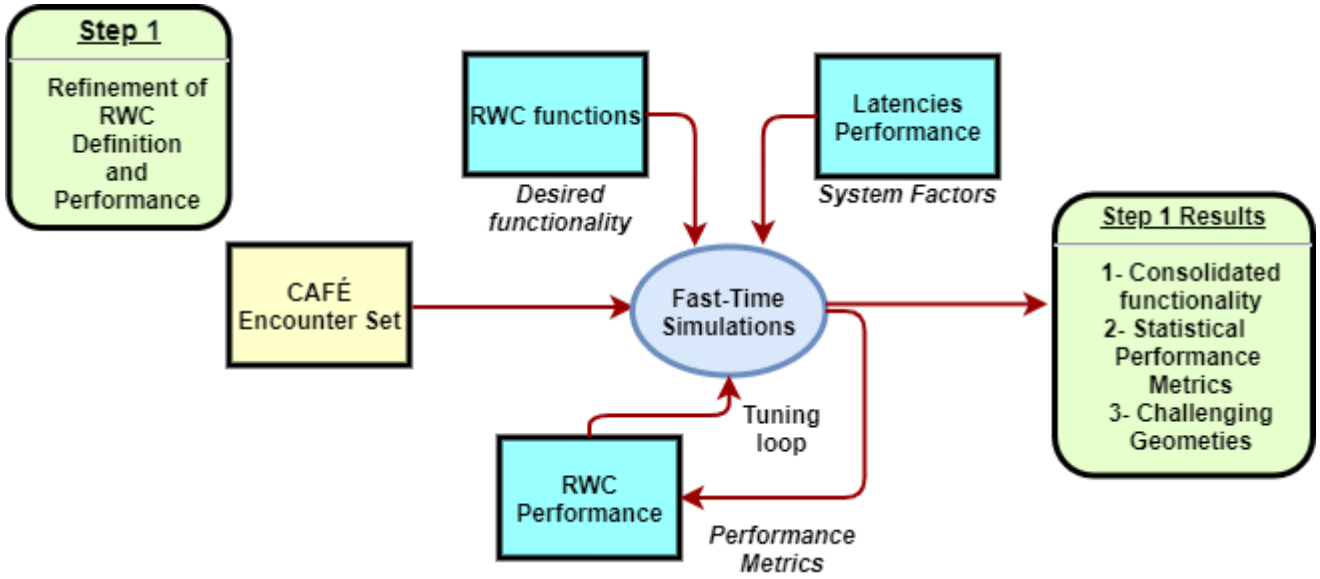
Project WorkFlow and Status



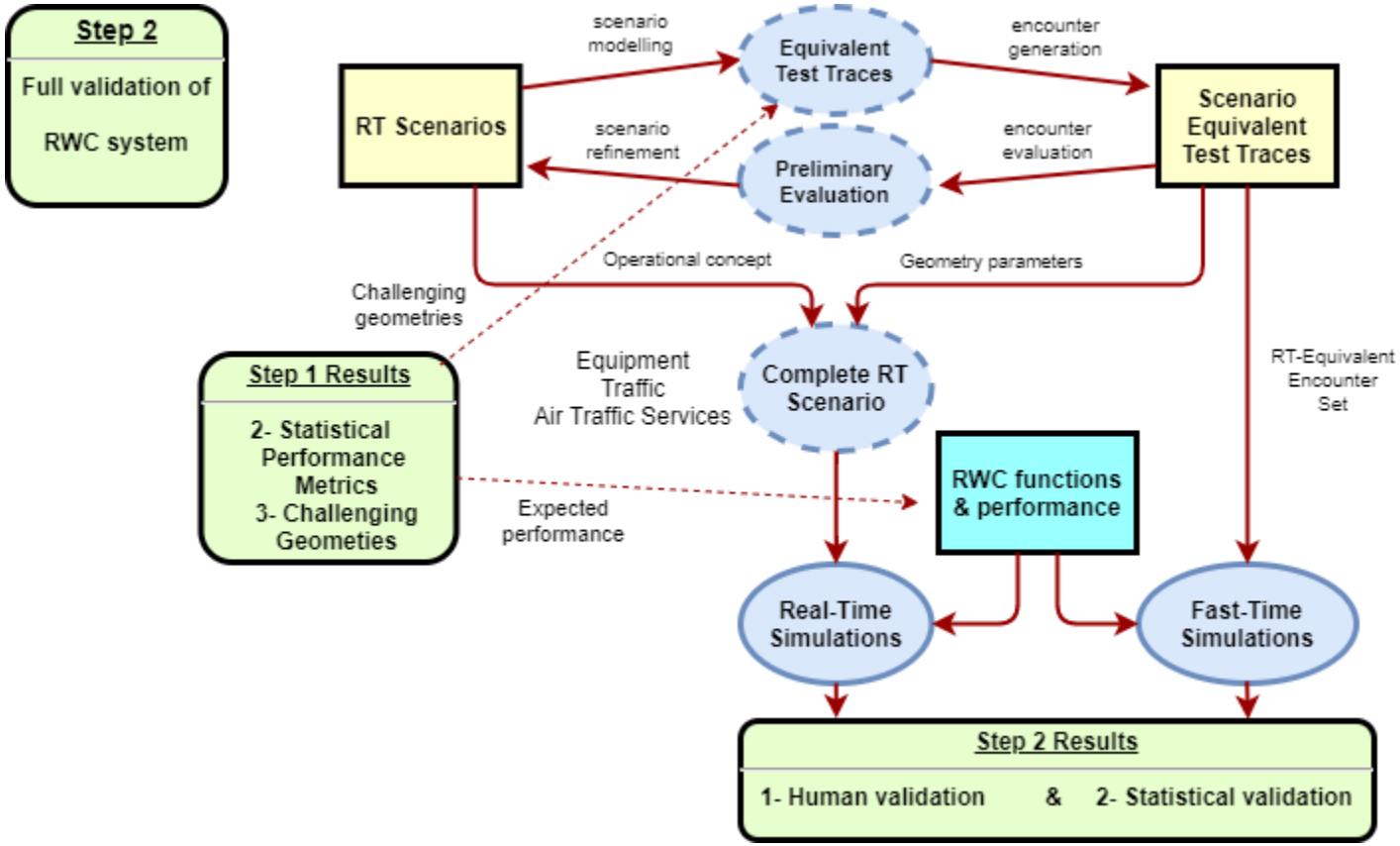
Next Steps: FTS Analysis

1. Fast-time analysis of large encounter set based on probabilistic distributions (Eurocontrol CAFÉ toolset).



Next Steps: RTS Analysis

2. Real-time analysis based on selection of relevant scenarios and selected parameters.



Questions

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Thank you very much for your attention!

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