



International Technical
Symposium on Navigation
and Timing

RPAS Management in Civil Airspace

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Direction Générale de l'Aviation Civile

Ministère de l'Environnement, de l'Énergie et de la Mer

DGAC /DSNA /DTI

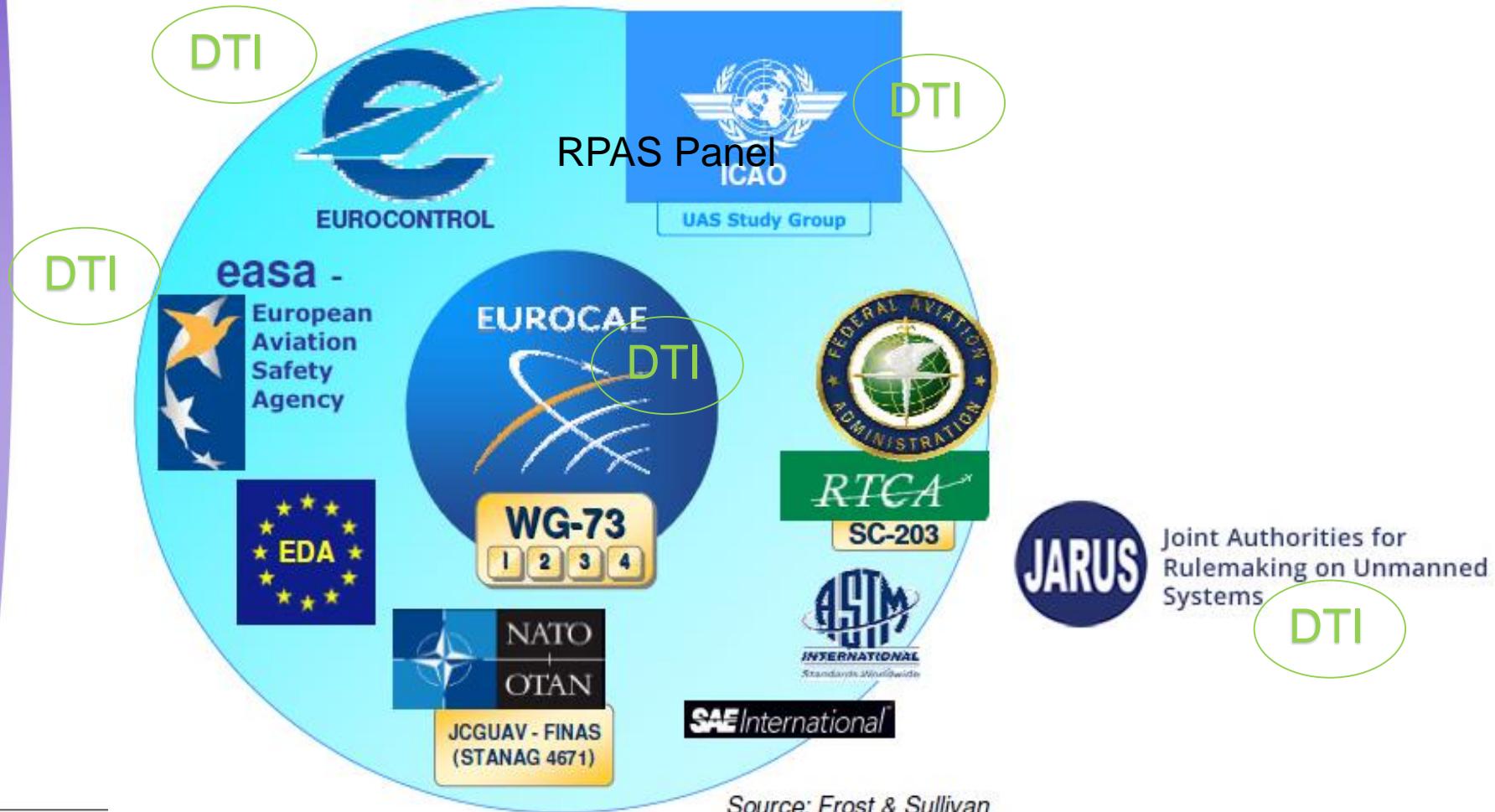
- French Air Navigation Service Provider
 - is responsible for delivering Air Traffic control services within the French metropolitan airspace (800.000 km²) and overseas dependencies
 - handles roughly 2.8 million flights a year more than 80 control towers, 7 ACC (2 overseas, 5 in ECAC airspace).
- DTI (DSNA technical center)
 - contributes to the definition and upgrade of CONOPS, associated systems and services
 - has participated as a leader or contributor in more than 70 projects during SESAR steps 1&2 (2009/ 2013)



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RPAS: Main stakeholders



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OUTLINE

- Introduction
- Air Traffic Management Principles (large RPAS)
- RPAS activity monitoring (small RPAS)
- RPAS systems: State of the art
 - C2Link,
 - DetectAndAvoid, ACAS Xu
- Perspectives and conclusion



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INTRODUCTION: Vocabulary

UAS : Unmanned Aircraft System



RPAS : Remotely Piloted Aircraft System

(ICAO 2011 Circular 328)

Remotely piloted aircraft (RPA) – an unmanned aircraft which is piloted from a remote pilot station.

Remotely piloted aircraft system (RPAS) – a remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design.

Remote pilot station (RPS) – the component of the RPAS containing the equipment used to pilot the RPA.

Remote pilot – a person charged by the operator with duties essential to the operations of an RPA and who manipulates the flight controls, as appropriate during flight time.

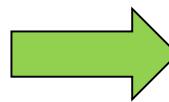


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INTRODUCTION: An RPAS is an aircraft but ...

- The pilot-in-command is on the ground : there is a need of specific functionalities
- Different sizes, different missions :
 - HALE, High Altitude Long Endurance
 - MALE, Medium Altitude Long Endurance
 - Mini, <150 kg
 - Micro, <2 kg



Quadrotor, 250g,
20min, max 150m



Global Hawk, 15t, 36h, FL600



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INTRODUCTION: VLOS and BVLOS

- Visual Line-Of-Sight (VLOS), for RPAS operations in which the vehicle remains always visually monitored by the pilot.
 - The remote pilot is able to see and avoid obstacles, hazards and other aircraft.
- Beyond Visual Line-Of-Sight (BVLOS), for RPAS operations in which the Remote Pilot doesn't keep the vehicle in visual line of sight at all times. Instead, the Remote Pilot flies the aircraft by instruments from a Remote Pilot Station (RPS).
 - There is a need for specific capabilities in order to detect and avoid obstacles, hazards and other aircraft.



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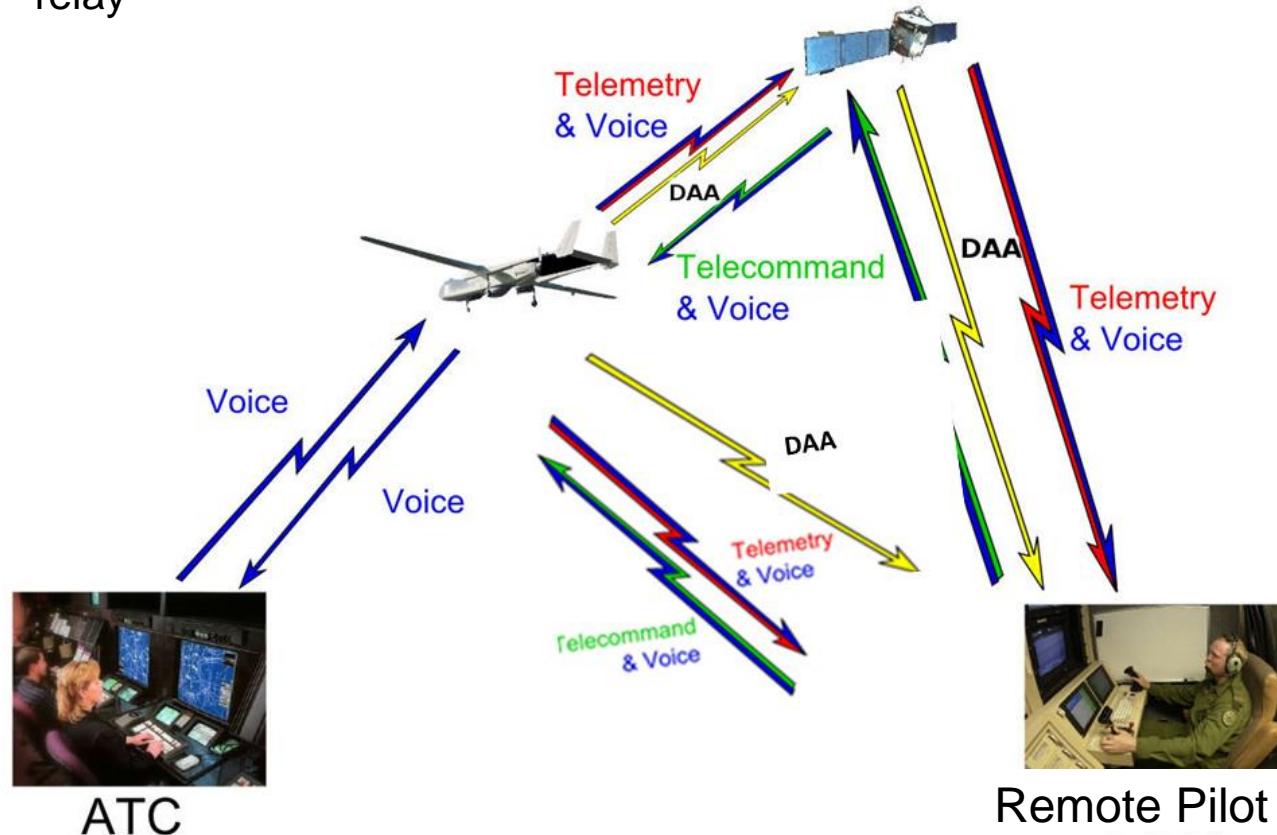


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INTRODUCTION: Communication components

C2Link: Command&Control Link

- ATC Communications use the C2Link
- Beyond Radio Line-Of-Sight (BRLOS) : there is a need for an external relay



Source : ICONUS

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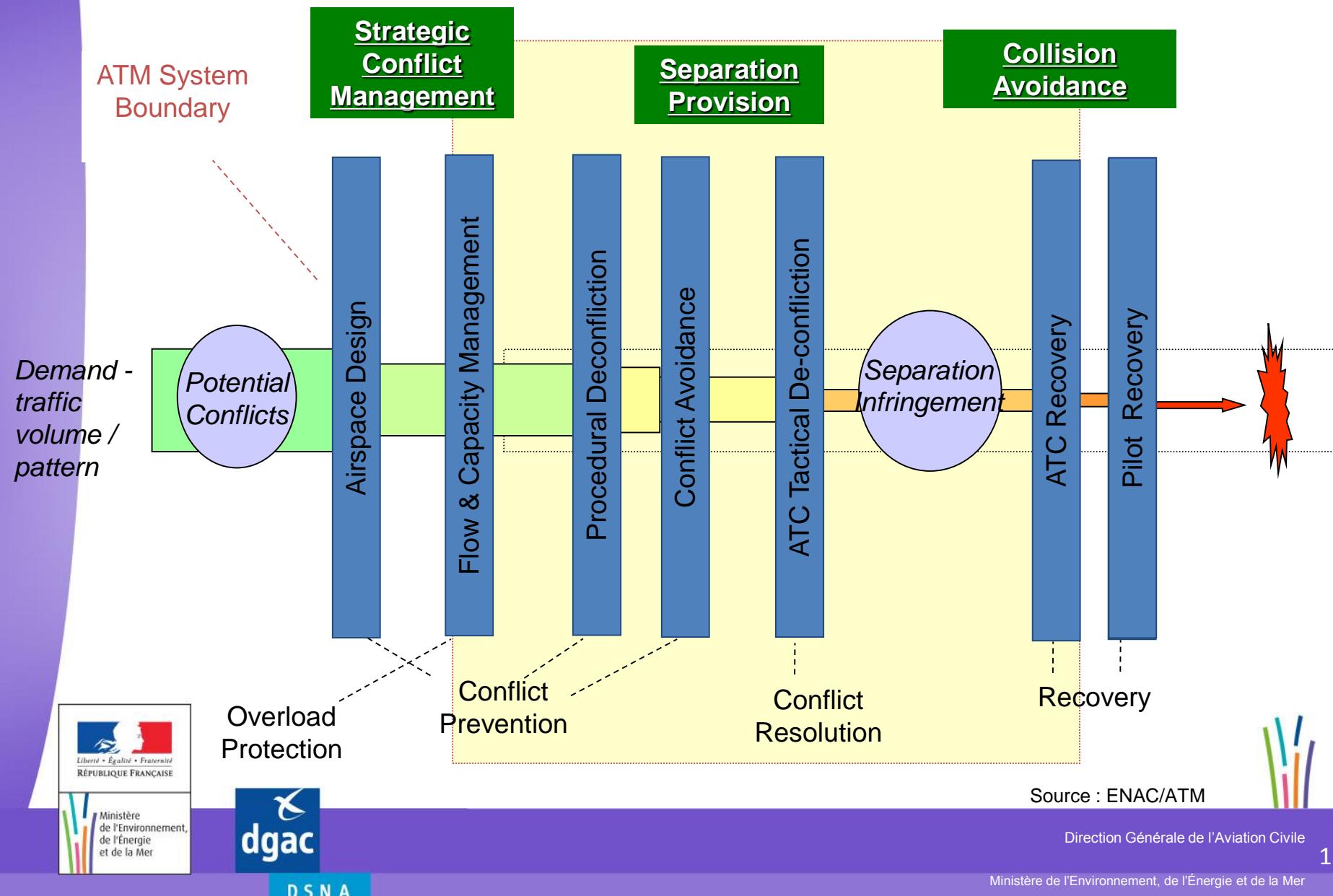
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ATM principles



ATM for large RPAS

ATM LAYERS	DESCRIPTION	ACTORS
Strategic	Airspace design Flight planning Flow Control	RPAS Pilot submitting Flight Plan ATC processing of flight plans
Separation	Aircraft-to-aircraft separation between RPAS and other traffic	ATC providing separation service RPAS maintaining self separation when ATC separation service is not provided (DetectAnd Avoid)
Collision avoidance	« Last resort » collision avoidance alert and maneuver	RPAS DetectAndAvoid -> collision avoidance resolutions and manœuvres ACAS Compatibility



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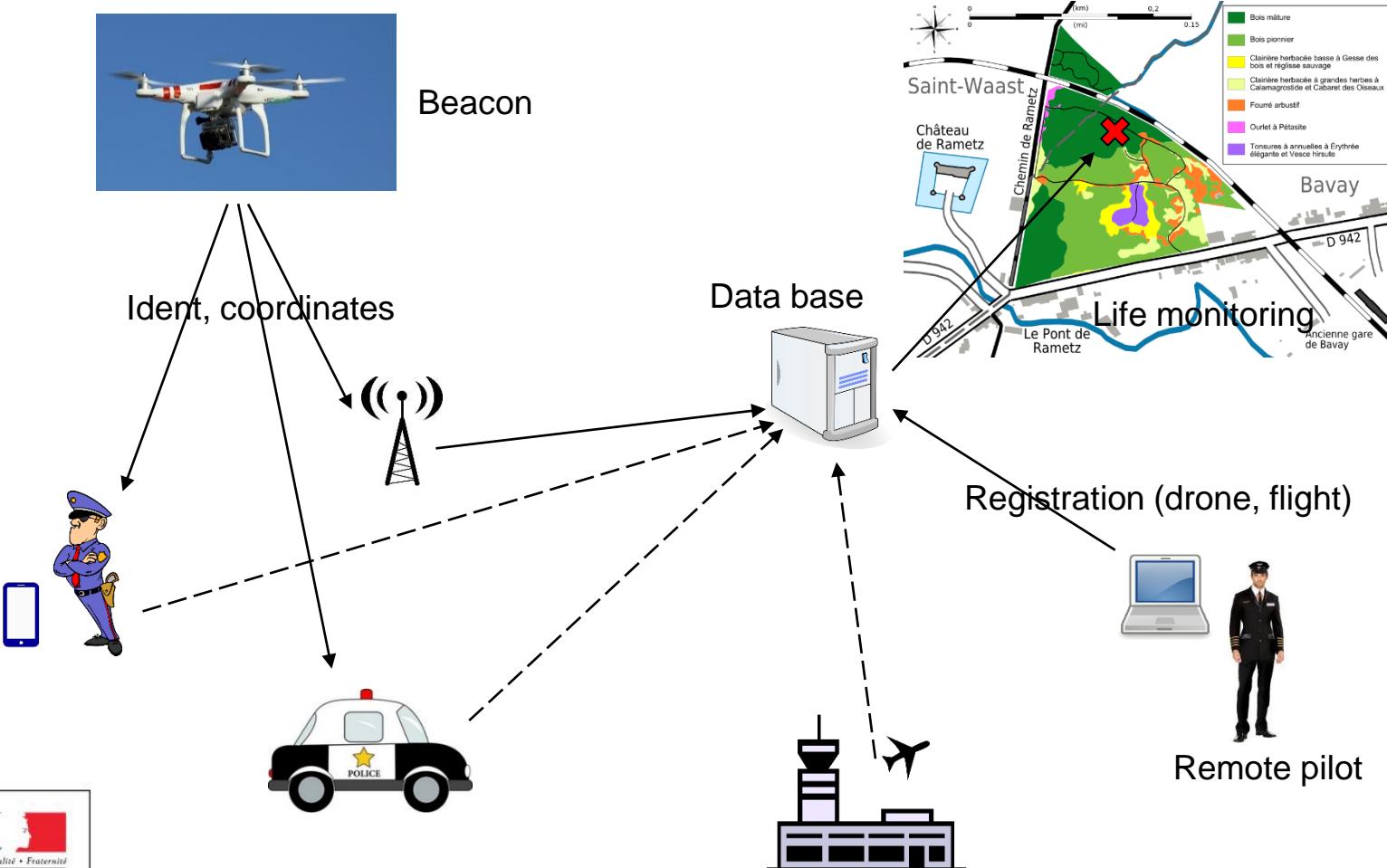


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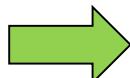
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Small RPAS activity monitoring < 150m (500 ft)



Small RPAS: Different tools

- RPAS registration (web site)
- Pre-flight registration – strategic deconfliction
- RPAS identification
 - VLOS : Remote Pilot Station (through internet ?)
 - BVLOS : Electronic device (GSM, SIGFOX, satellite based, ADS-B ?)
- RPAS localization
 - GPS coordinates (from the RPAS system or from an electronic device)
- HMI to display the information towards Police and CAAs
- Real Time deconfliction



Towards an UTM (UAS Traffic Management)
and European CONOPS
Which business model ?



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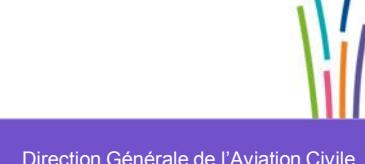
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C2Link requirements

- C2 Link availability must be comparable with VHF link availability
 - On board and RPS C2Link systems certification
 - Quality of service and integrity of transmissions monitored in real time
 - Use of Fixed Satellite Services ?
 - Backup, Failsafe procedures
- Use of C band (5030-5091 MHz) for large RPAS
 - In 2012, ITU allocated frequencies for RPAS C2Link (confirmed in November 2015)
 - Need to define Standard and Recommended practices (SARPs) at the ICAO level
 - Need to define operational rules in each country
- Small and very small RPAS
 - Frequencies ? Range (technology, emission power) ?
 - Backup, Failsafe procedures ...

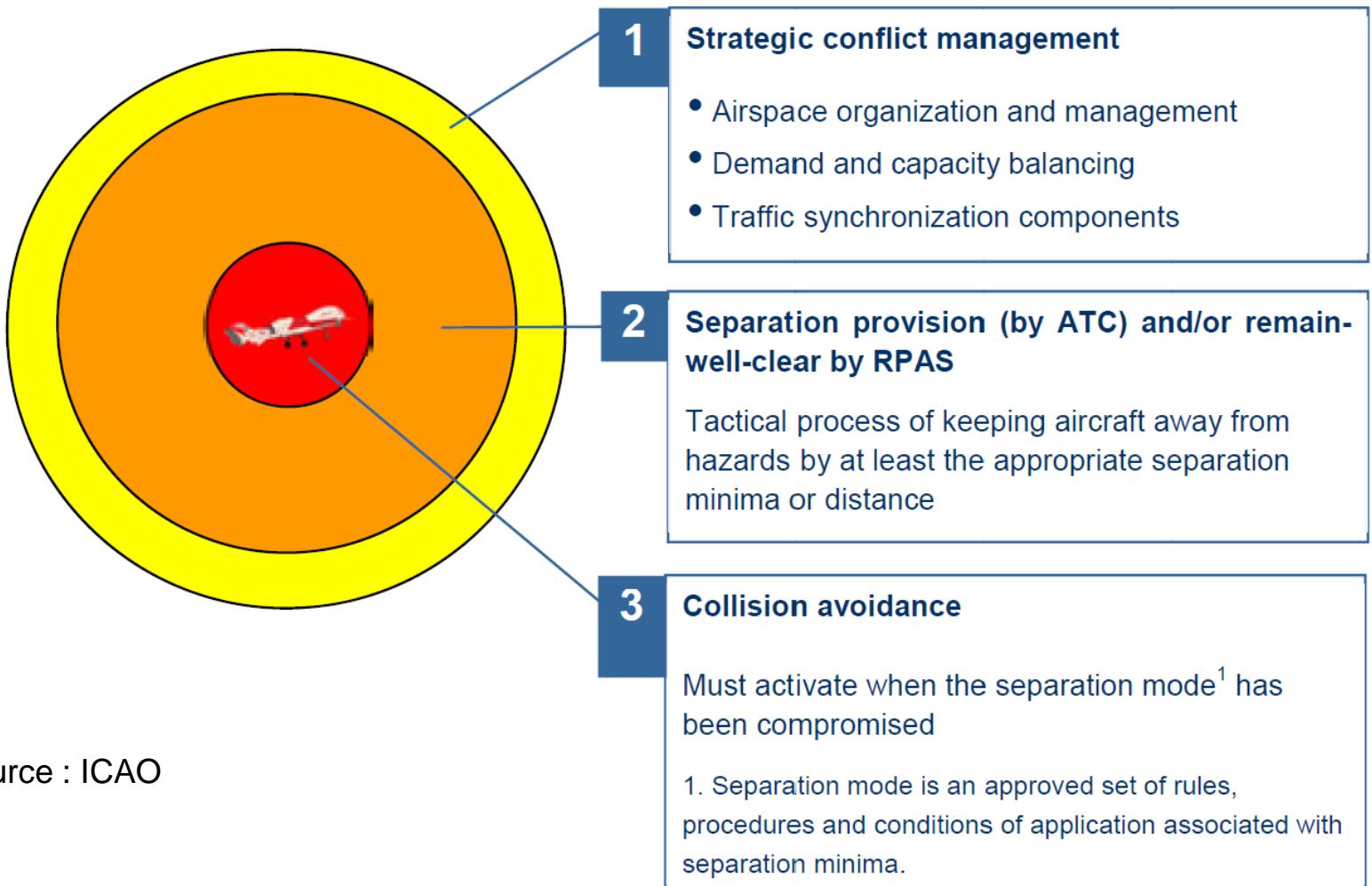


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Detect And Avoid (DAA)



Source : ICAO



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DAA requirements

- Airborne Collision Avoidance Systems
 - Detect
 - Be equal or better than the theoretical « see and avoid » capability of a human pilot (that's not only the eyes !)
 - Have the reliability of a flight-critical system: autonomous RPAS decision or reliability & reaction-time of the datalink
 - Provide separation
 - Perform an avoidance maneuver
- Ground and Obstacle DAA
- Weather DAA
- Wake vortex and other hazard DAA



Ground-based DAA Systems



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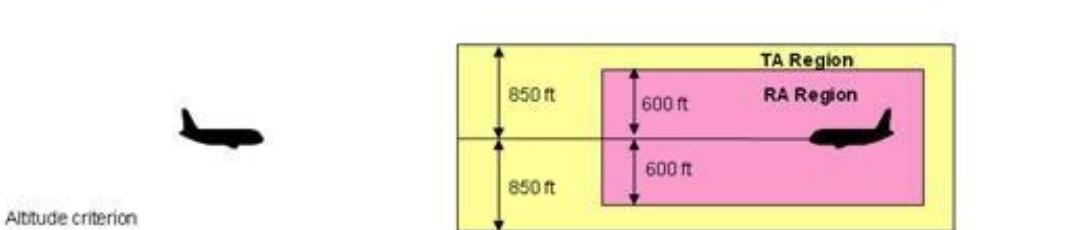
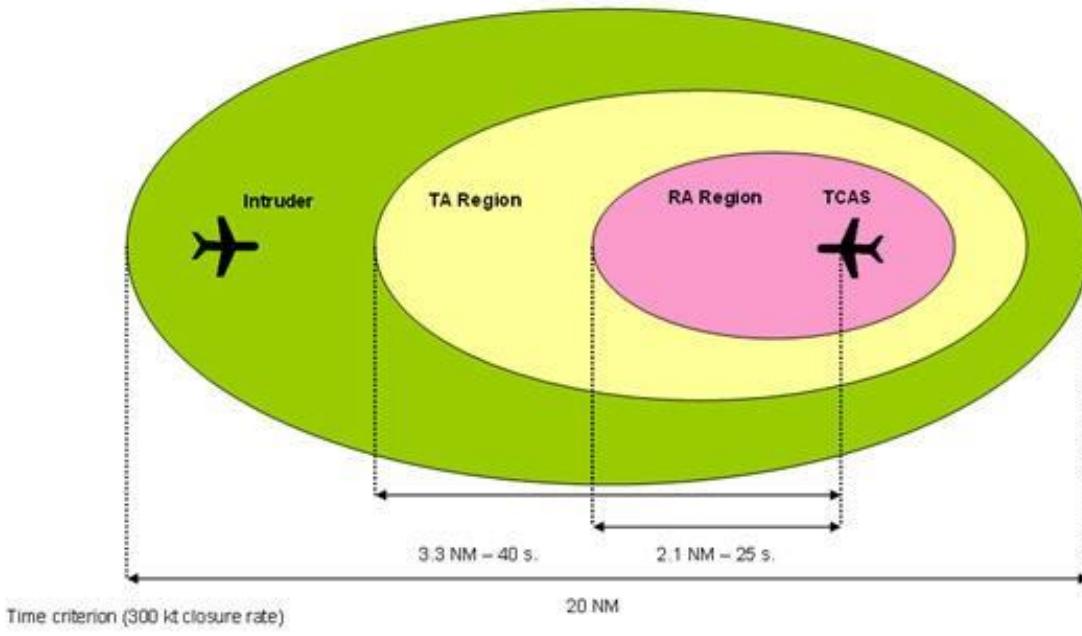


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ACAS X, ACAS Xu

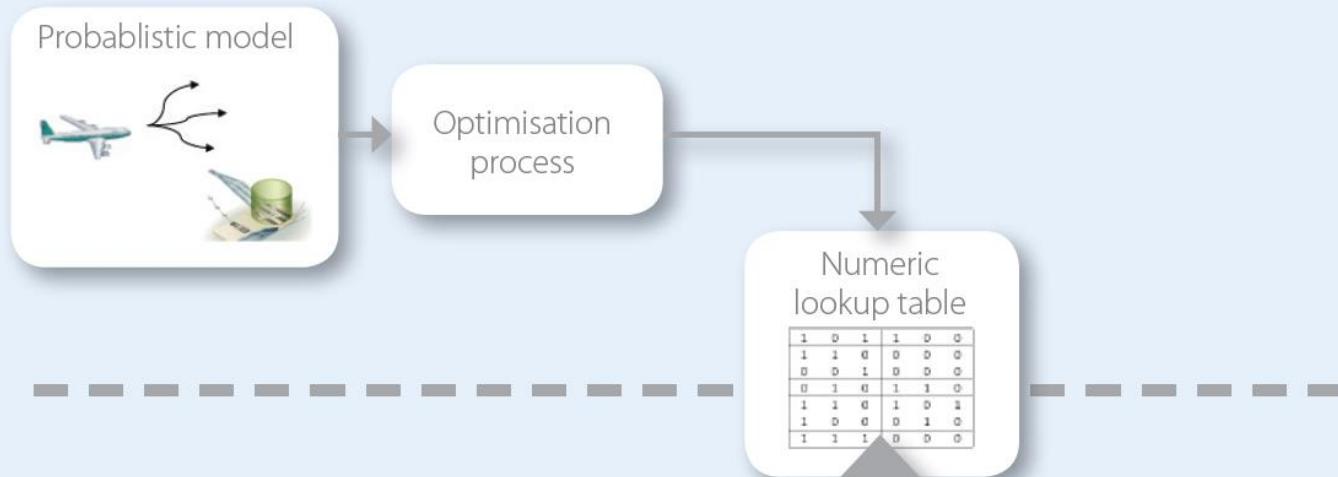


Example of ACAS Protection Volume between 5000 and 10000 feet

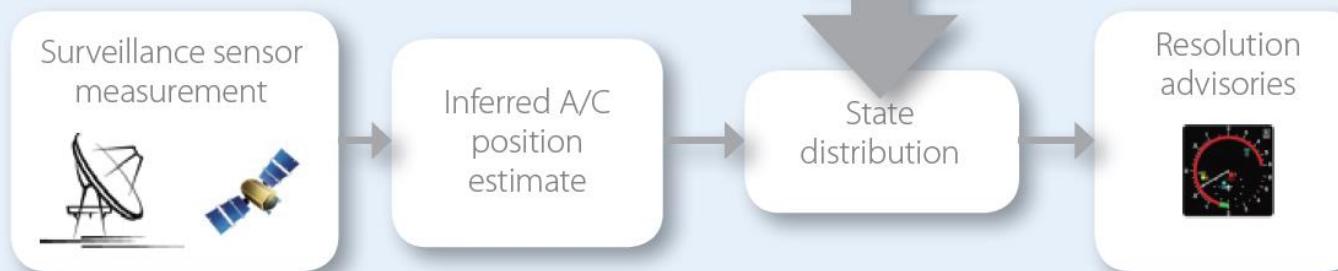
Source: Eurocontrol

ACAS X principles

Offline development



Real-time implementation



Source: Eurocontrol



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Perspectives: Large RPAS

- A step by step integration ...

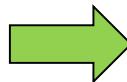
Where all the traffic is known by ATC (A to D Class Airspace)

- C2Link frequency
- DAA systems with co-operative sensors
- ACAS Xu compatibility
- Operational procedures normal, abnormal, emergency
- Certified systems...

- In addition,

Where ATC may ignore some traffic (E to G Class Airspace)

- Non co-operative sensors
- Adapted « rules of the air » for RPAS and other aircraft
- Failsafe procedures and systems ...

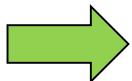


In Europe, SESAR2020 Projects wave1 and wave2



Perspectives : Small RPAS

- French regulation of 2012 (updated in 2015) allowed the rise of the activity
 - Ensure safety of third parties on the ground and of other airspace users
 - On going work for new provisions concerning pilot training and competencies
- Very Low Level Operations : Concept of operations to be developed
 - C2Link frequencies
 - Safety of the systems
 - UTM (UAS Traffic Management)



Time is critical !

European regulation: Open, Specific, Certified categories
European UTM (SESAR JU ER UTM Concepts)



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Conclusion

- Manned and unmanned aviation shall coexist in a common airspace with the same level of safety.
- In 2035, according to Volpe National Transportation study 245,000 RPAS will fly, among them 175,000 for aerial work.
- Need for R&D in ATM and tight collaboration between CAA, laboratories, Industry, EASA, JARUS and ICAO.
- Global guidance is needed !



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Thank you for your attention

Questions ?



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Human factors

From an ATC perspective

- Need for demystification of RPAS towards CAA, pilots and ATCos
- Insertion of RPAS into airspace will be a continuous process. Segregation is the beginning, full insertion is the aim, but various intermediate steps may be taken (for example: increased vertical or lateral separation standards for RPAS).
- Emergency procedures must be clearly defined and ATC must be aware of RPAS trajectory when the machine flies in an « autonomous » mode.



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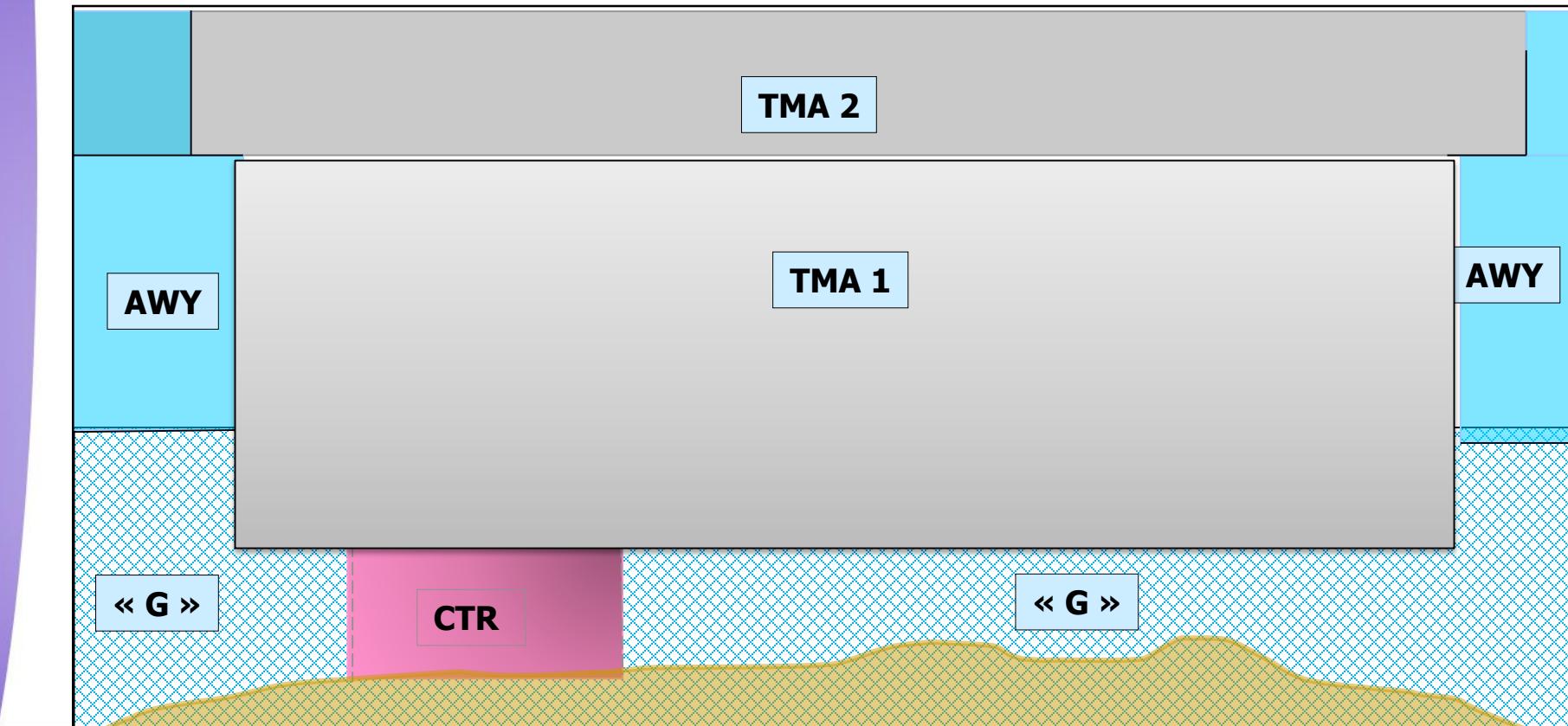


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Controlled and non controlled airspace



Controlled airspace – Classes A B C D E -
Non Controlled airspace – Classe G

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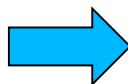
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ATC services

Airspace Feature	A	B	C	D	E	G
Entry Requirements	ATC Clearance	ATC Clearance	Prior Two-way com.	Prior Two-way com.	None	None
Two-way radio Com.	Yes	Yes	Yes	Yes	Not required	Not required
Special VFR allowed	No	Yes	Yes	Yes	Yes	N/A
Aircraft separation	N/A	All	IFR	Runway operations	None	None
Traffic advisories	Yes	Yes	Yes	Workload permitting	Workload permitting	Workload permitting

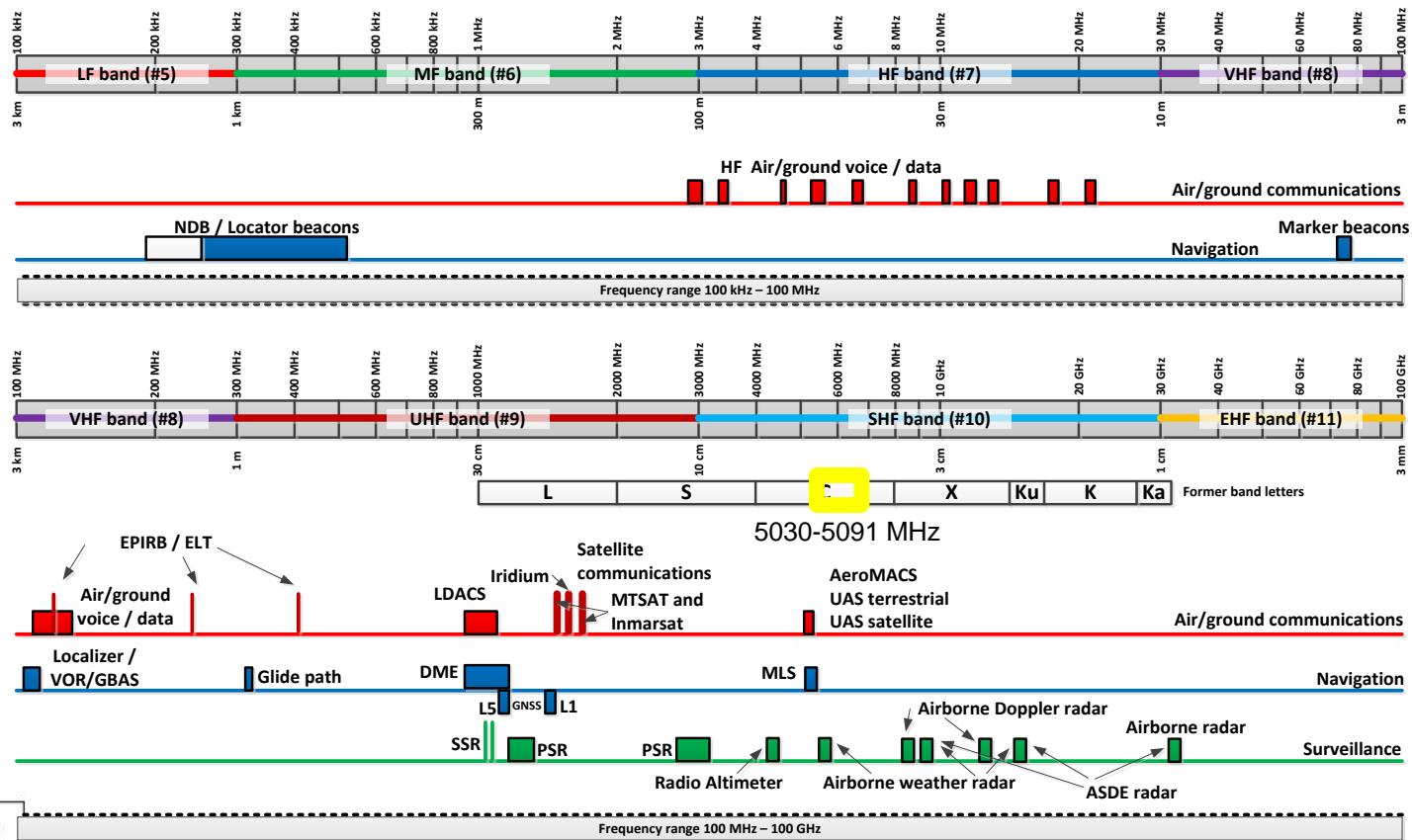


There is a need to distinguish areas where all the traffic is known (classes A, B, C, D) from areas where not all the traffic is known (classes E,G)



C2Link frequency: A key issue

Aeronautical Frequency Spectrum Management



C2Link parameters

- Communication transaction time : The maximum time for the completion of the operational communication transaction after which the initiator should revert to an alternative procedure
- Continuity : The probability that an operational communication transaction can be completed within the communication transaction time
- Availability : The probability that an operational communication transaction can be initiated when needed
- Integrity : The probability of one or more undetected errors in a completed communication transaction



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EASA A-NPA

(draft document July,2015)



OPEN:

Low risk
No involvement of Aviation Authority
Limitations : Visual line of sight, Maximum Altitude, distance from airport and sensitive zones

SPECIFIC

Increased risk
Operations Authorisation with operations manual
Specific qualification of drone, personnel, equipment based on safety assessment

CERTIFIED

Regulatory regime similar to manned aviation
EASA and Authority Certificates



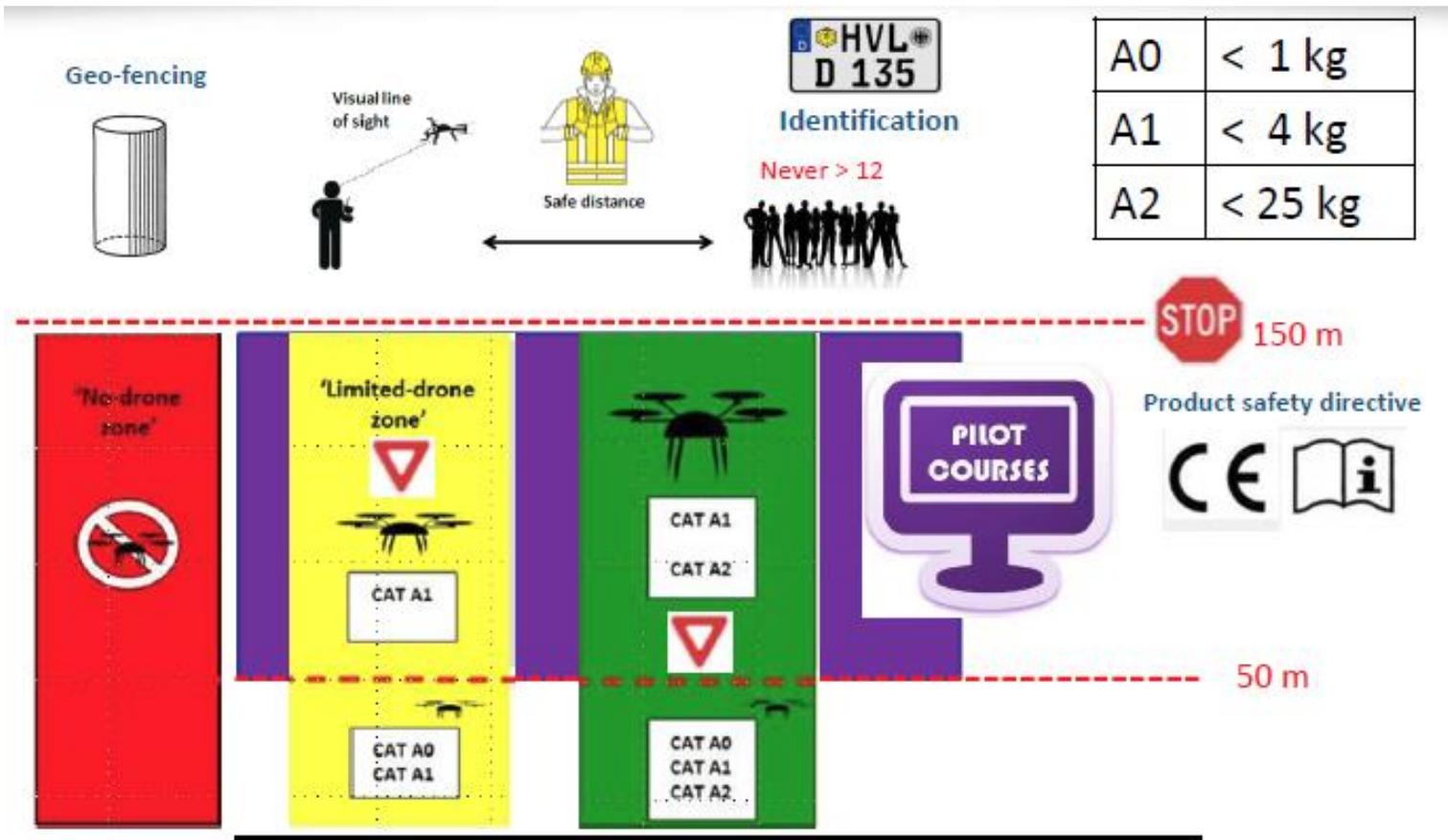
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Yves Morier, EASA

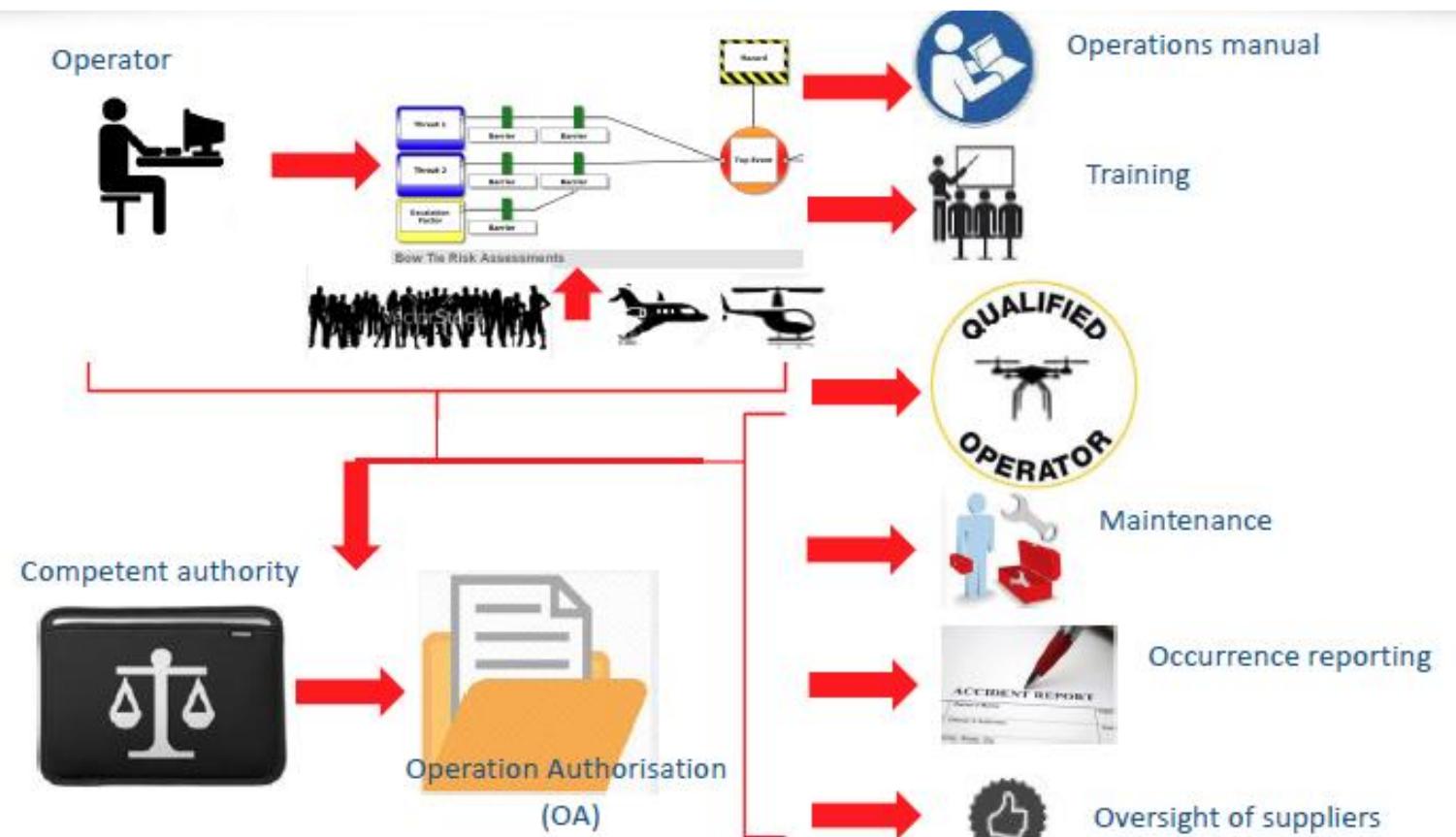


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EASA : Open category

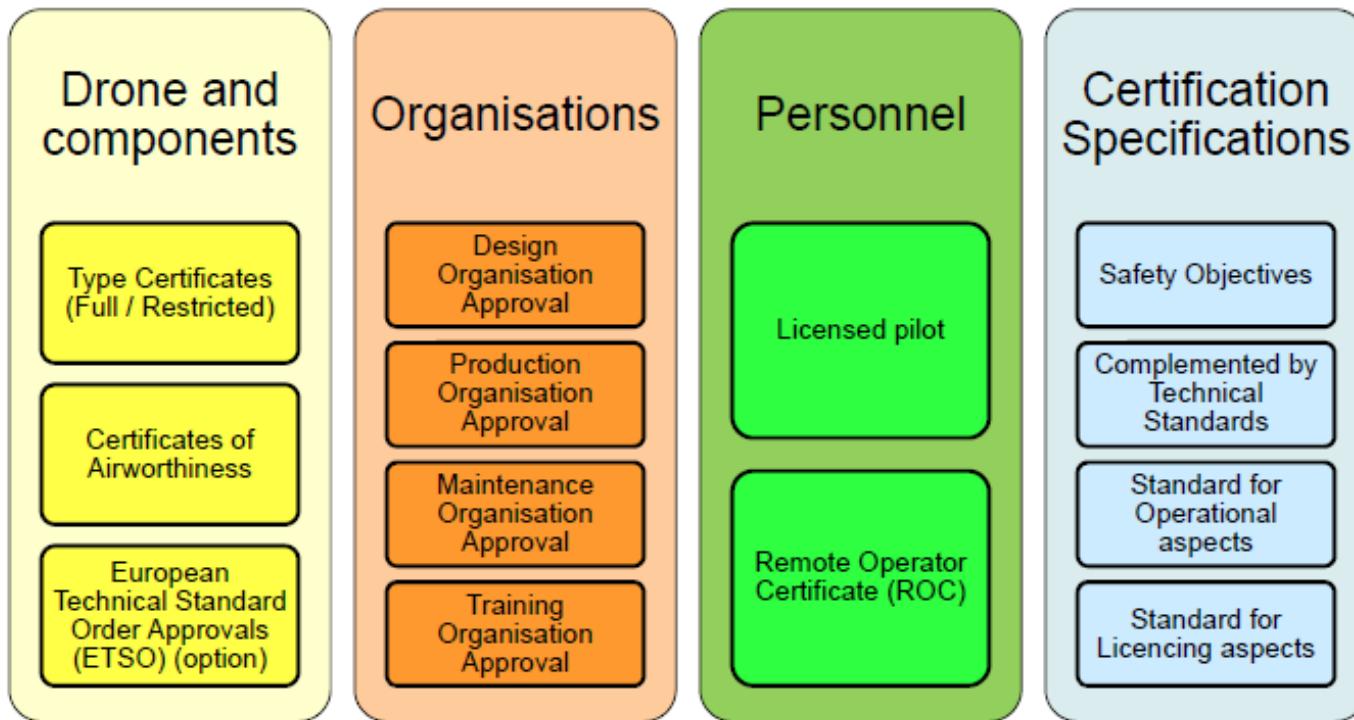


EASA : Specific category



EASA : Certified category

Implementing rules included in existing rules for manned aviation



Yves Morier, EASA



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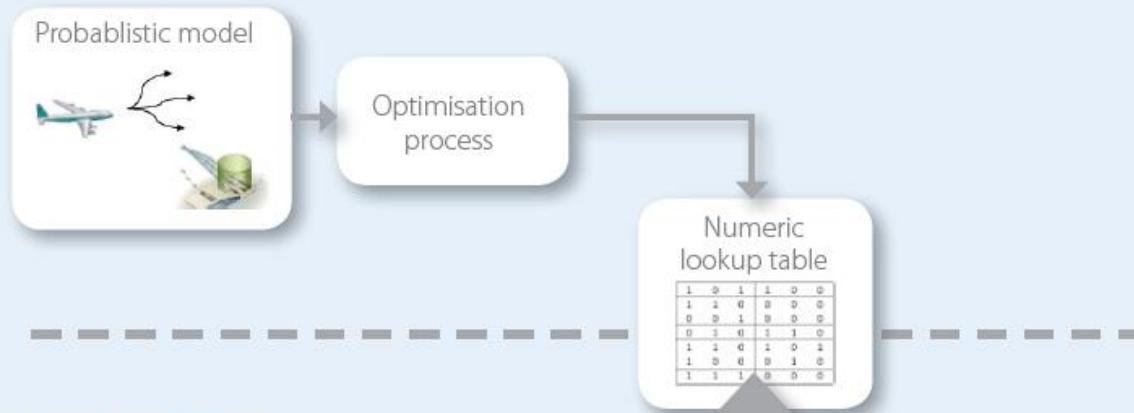
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ACAS X

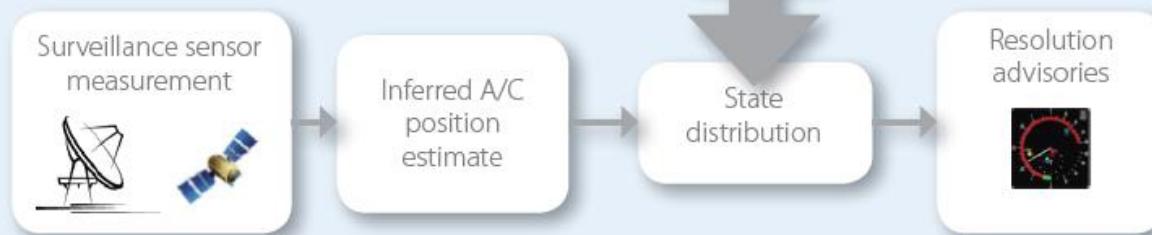
Inside ACAS X

ACAS X collision avoidance logic is best explained in two distinct phases, offline development and real-time operation.

Offline development



Real-time implementation



Source : Eurocontrol