COLLISION AVOIDANCE FOR RPAS

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CONTENT

- Safety layers in manned aviation
- Airspace structure and operations
- RPAS operational scenario and encounter timeline
- DAA system overview
- Top requirements for collision avoidance systems
- Standards development

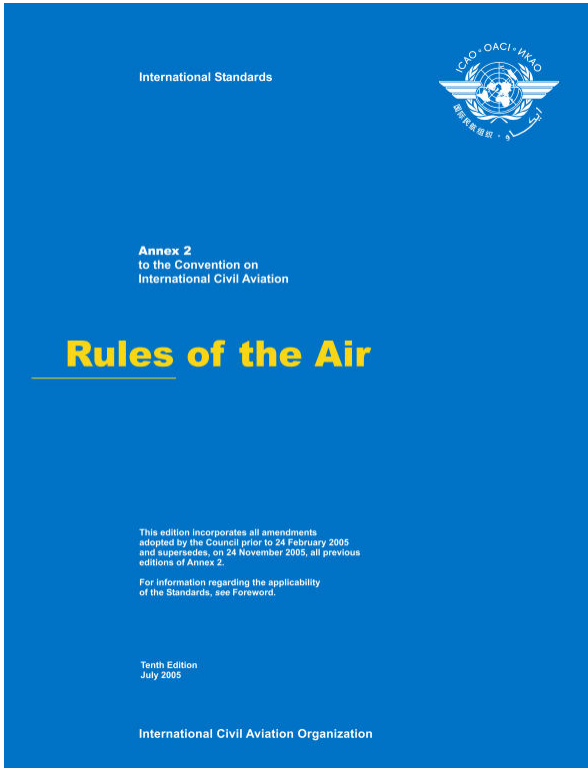
MID-AIR COLLISIONS – A REAL THREAT

ICAO ANNEX 2 RULES OF THE AIR

3.2 Avoidance of collisions

Nothing in these rules shall relieve the pilot-in-command of an aircraft from **the responsibility of taking such action**, including collision avoidance manoeuvres based on resolution advisories provided by ACAS equipment, **as will best avert collision**.

*Note 1.— It is important that **vigilance for the purpose of detecting potential collisions** be exercised on board an aircraft, regardless of the type of flight or the class of airspace in which the aircraft is operating, and while operating on the movement area of an aerodrome.*



MAIN LAYERS OF PROTECTION AGAINS MID-AIR COLLISIONS

1.

Strategic Conflict Management

- Airspace design
- Procedures and Regulations
- Flight plans

2.

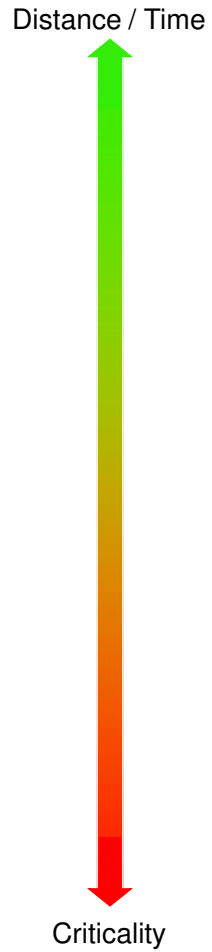
Separation Provision

- Responsibility of ATC or the Pilot depending on airspace class and flight rules (IFR/VFR)
- ***"Don't scare others!"***

3.

Collision Avoidance

- This ultimate responsibility for avoiding collisions always remains with the pilot
- Mainly performed by the pilots ability to "**See & Avoid**", i.e. the pilots eyes and ability to perform the correct decision and correct action
- ***"Don't scrape paint"***



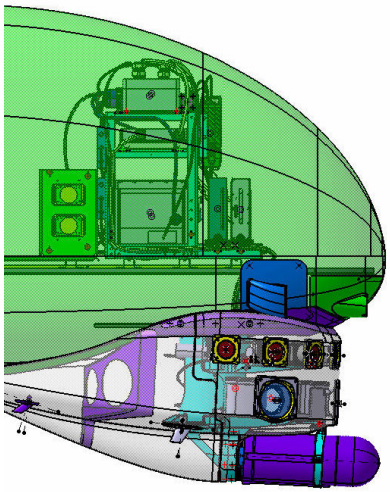
AIRSPACE CLASSES A-G

- Airliners
  - Operates in class A-C
  - Flying according to Instrument Flight Rules (IFR)
  - Equipped with Transponder/ADS-B, i.e. are Cooperative
  - Equipped with TCAS collision avoidance system
  - Separated from all other traffic by ATC
  - **Pilot responsible for Collision Avoidance** (aided by TCAS)
- General Aviation aircraft
  - Operates mainly in the ”lower” airspace classes incl uncontrolled
  - Operates at lower altitudes below 10 000 ft (max speed 250 kts)
  - Large portion of flights according to Visual Flight Rules (VFR)
  - Many without Transponders/ADS-B, i.e. Non-cooperative
  - Limited or no ATC separation
  - **Pilot responsible for Remaining Well Clear and Collision Avoidance**

	Class	Type of flight	Separation provided	Service provided	Radio communication requirement	Subject to an ATC clearance
Controlled Airspace	A	IFR only	All aircraft	Air traffic control service	Continuous two-way	Yes
	B	IFR	All aircraft	Air traffic control service	Continuous two-way	Yes
		VFR	All aircraft	Air traffic control service	Continuous two-way	Yes
	C	IFR	IFR from IFR IFR from VFR	Air traffic control service	Continuous two-way	Yes
		VFR	VFR from IFR	1) Air traffic control service for separation from IFR; 2) VFR/VFR traffic information (and traffic avoidance advice on request)	Continuous two-way	Yes
	D	IFR	IFR from IFR	Air traffic control service, traffic information about VFR flights (and traffic avoidance advice on request)	Continuous two-way	Yes
		VFR	Nil	IFR/VFR and VFR/VFR traffic information (and traffic avoidance advice on request)	Continuous two-way	Yes
	E	IFR	IFR from IFR	Air traffic control service and, as far as practical, traffic information about VFR flights	Continuous two-way	Yes
		VFR	Nil	Traffic information as far as practical	No	No
Uncontrolled Airspace	F	IFR	IFR from IFR as far as practical	Air traffic advisory service; flight information service	Continuous two-way	No
		VFR	Nil	Flight information service	No	No
	G	IFR	Nil	Flight information service	Continuous two-way	No
		VFR	Nil	Flight information service	No	No

DAA FOR RPAS

- Removing the pilot from the aircraft requires a capability to detect and avoid other aircraft – Detect and Avoid system (DAA) for conflicting traffic
- Note that full DAA includes to avoid several hazards (according to ICAO definition):
  a) conflicting traffic
  b) terrain and obstacles
  c) hazardous meteorological conditions (i.e. thunderstorms, icing, turbulence)
  d) ground operations (aircraft, vehicles, structures or people on the ground)
  e) other airborne hazards, including wake turbulence, wind shear, birds or volcanic ash
- Some of these hazards can be mitigated with procedures and planning, i.e. may not require systems



OPERATIONAL CATEGORIES FOR RPAS

- Three different categories of RPAS operations are foreseen:
  - **Open**: VLOS, low altitude (500 ft AGL)
  - **Specific**: Operation based on risk assessment
  - **Certified**: ATM operation, mixing with manned aviation
- DAA for conflicting traffic is mainly applicable for the Certified category but also to some extent for Specific category depending on the risk assessment

OPEN:

Very low risk operations

No involvement of Aviation Authorities, No airworthiness approval

Limitations: VLOS (500m), below 150m altitude, outside cartain areas (e.g. airport & sensitive areas), no overflying of crowds

Industry standards (not for toys <500g)

SPECIFIC

Increased risk

Safety risk assessment required

Approved by Aviation Authorities required

Airworthiness and staff competence – case-by-case

CERTIFIED

Comparable to manned aviation

Limit between specific and certified not yet defined

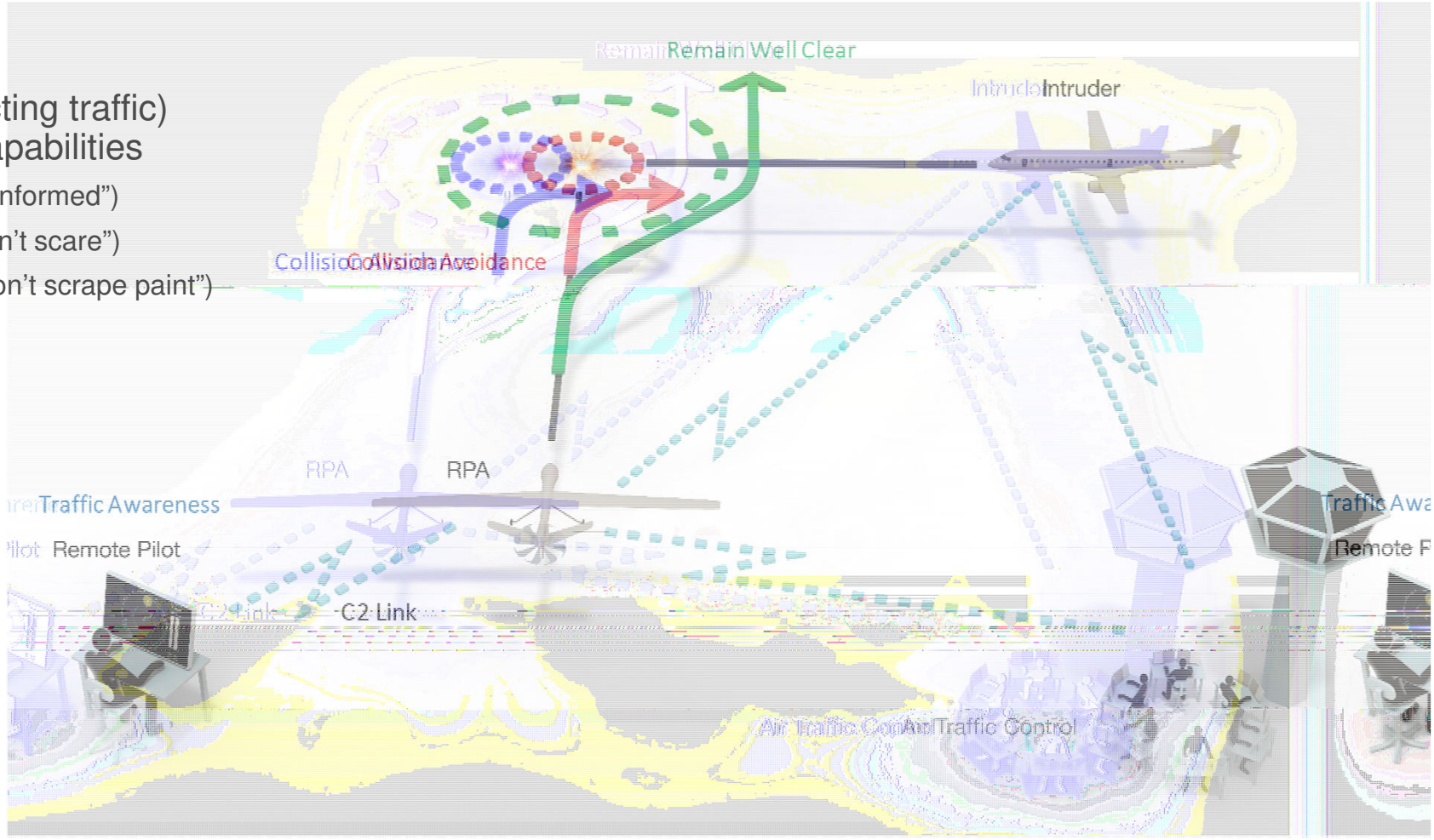
Pending criteria is defined, EASA accept application MTOW 150kg

C2 and Detect &Avoid can receive an independent approval

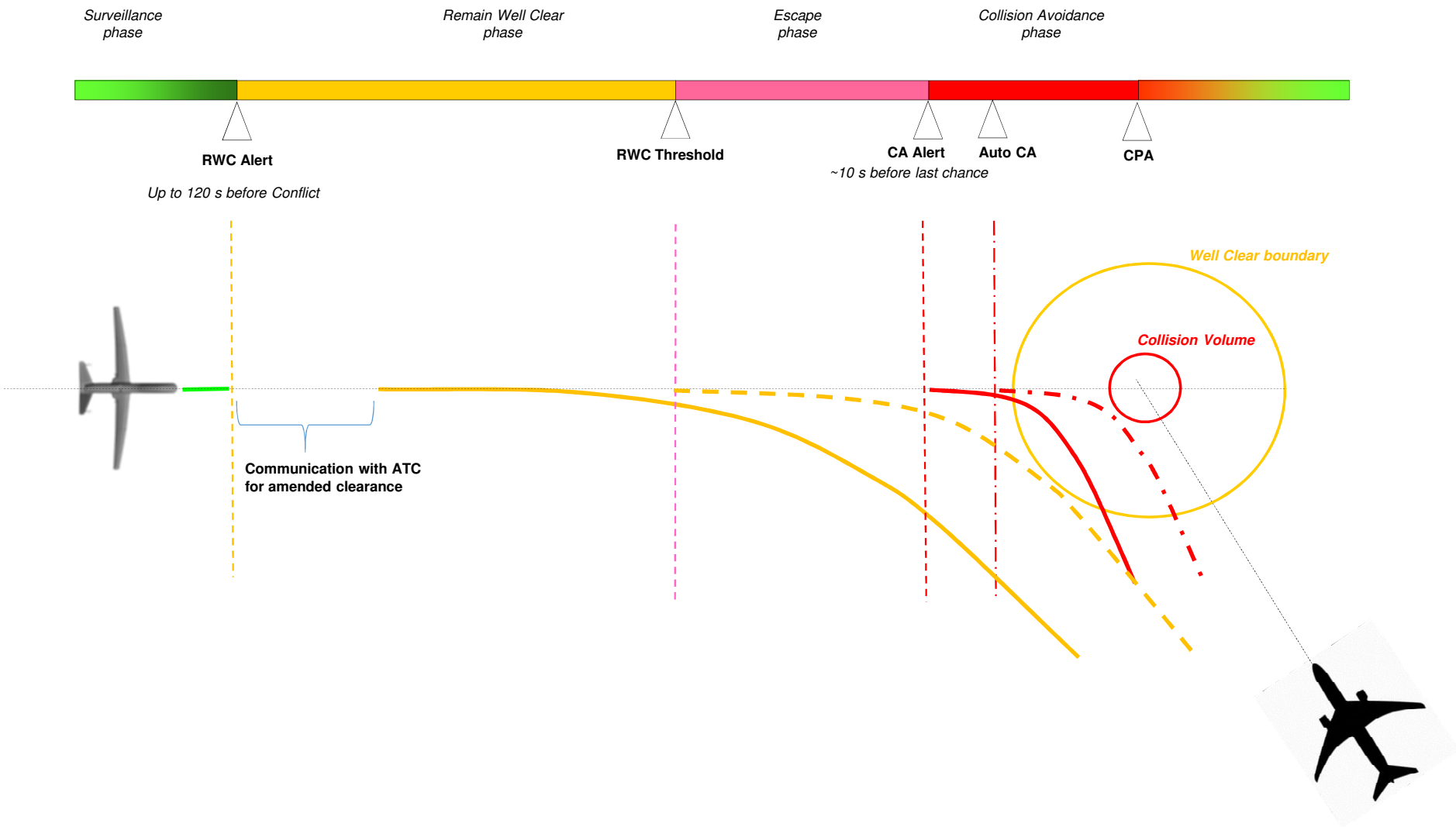
DAA OPERATIONAL SCENARIO

Detect and Avoid (conflicting traffic) consists of three main capabilities

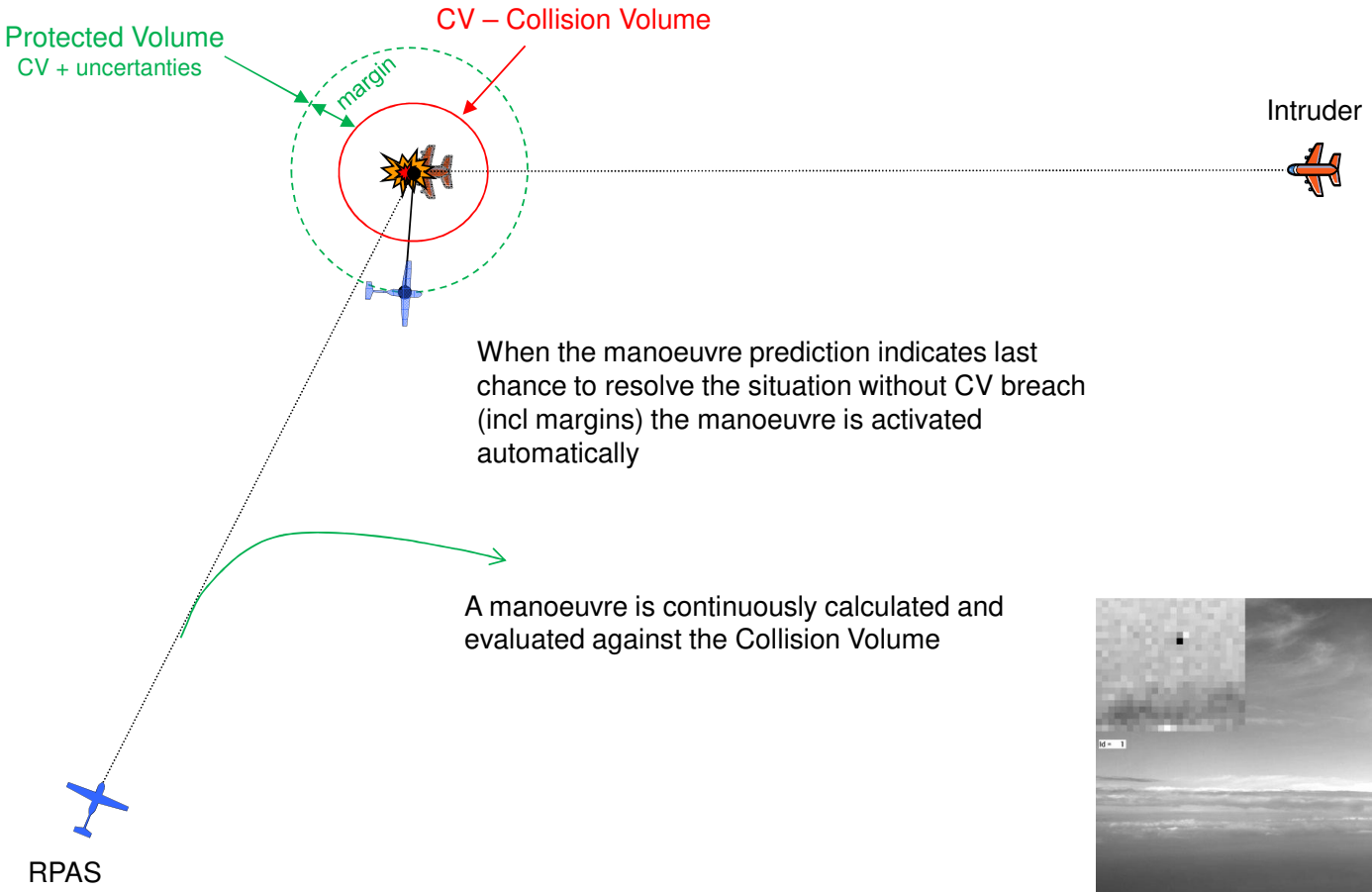
- Traffic Awareness (”be informed”)
- Remain Well Clear (”don’t scare”)
- Collision Avoidance (”don’t scrape paint”)

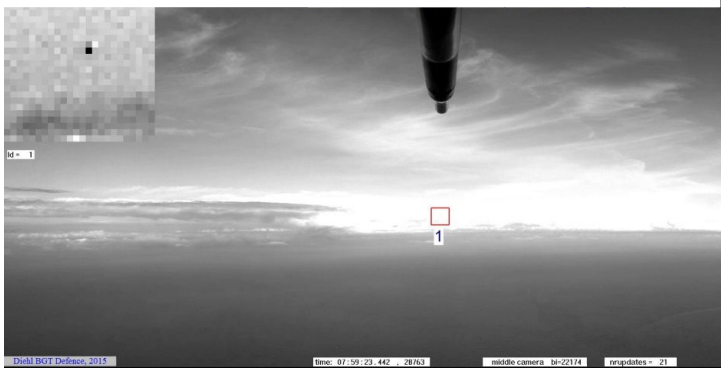


DAA TIMELINE



DAA COLLISION AVOIDANCE CONCEPT

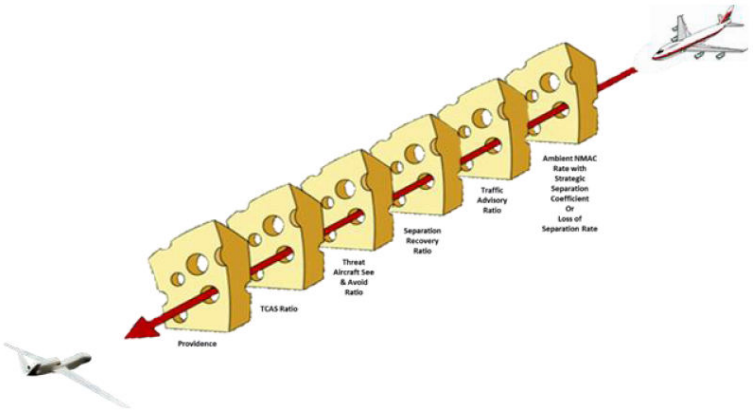


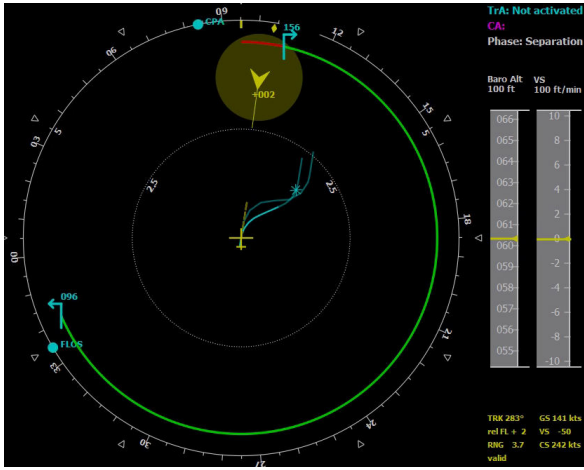


MAIN TOP REQUIREMENTS

- Be at least as safe as manned flights (low MAC probability)
  - Historical rates for MAC
    - $3.67e^{-8}$ per flight hour for Large aeroplanes (airliners) ($\sim 1e^{-9}$ fh)
    - $7.15e^{-8}$/fh for GA under IFR ($\sim 1e^{-7}$ fh)
    - $1.41e^{-7}$/fh for GA under VFR, filing flight plan ($\sim 1e^{-7}$ fh)
    - $1.47e^{-6}$/fh for GA not filing flight plan ($\sim 1e^{-6}$ fh)

    => Acceptable risk for MAC depends on intruder type and possibly airspace class
- Not impair safety to other airspace users
  - Manoeuvres performed due to DAA system needs to be safe relating to all other airspace users.
- Be seamlessly integrated in the airspace
  - Limit unjustified avoidance manoeuvres
  - Not increase workload for ATCo, e.g. not increase communication
  - Follow Right of way rules
- Be interoperable
  - The DAA system shall be interoperable with established collision avoidance systems





DAA STANDARDS

- Work to define standards for DAA is ongoing in several different groups
- ICAO RPAS Panel
  - Updating ICAO Annexes to integrate RPAS (e.g. Airworthiness, C2 Link, DAA, …)
- EUROCAE and RTCA
  - Developing industry standards, MASPS/MOPS
- JARUS
  - Defining technical, safety and operational requirements

In parallel to developing standards there are several projects developing technology to ensure e.g. feasibility

International Civil Aviation Organization

FEDERAL AVIATION ADMINISTRATION

EASA European Aviation Safety Agency

EUROCONTROL

EUROCAE

RTCA

JARUS

DAA SYSTEMS ARE RELEVANT ALSO FOR MANNED AVIATION …

Thank you for your attention !