Industria, Innovazione e Ricerca:
Il controllo remoto dal militare al civile

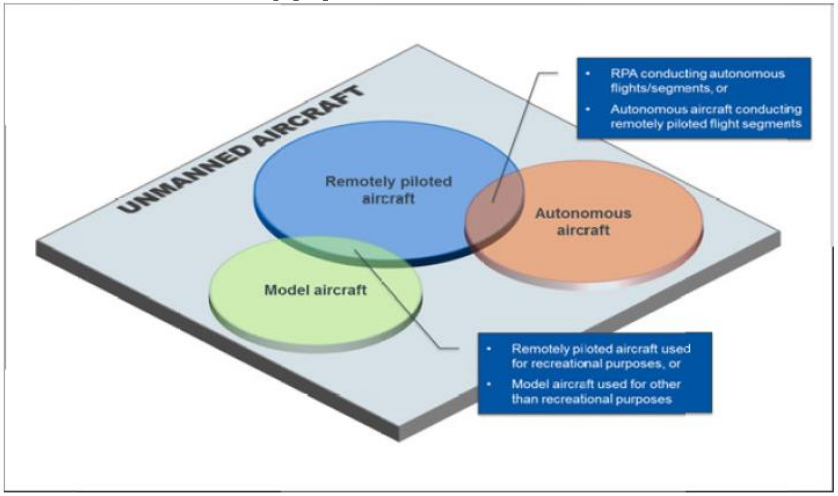
Aniello Cozzolino – Head of Research & Technology Development, Piaggio Aerospace

University of Naples Federico II,
October, 22nd, 2016

Fundamental Principle

- **Unmanned Aircraft** is a powered, aerial vehicle that does not carry a human operator, can fly **autonomously** or be **piloted remotely**.

- **Remotely Piloted Aircraft System (RPAS)** is a type of UAS and is the only one in the rulemaking process ICAO for civil integration.



- **RPAS** or fully autonomous or combination are subject to art. 8 ICAO

*"No aircraft capable of being flown without a pilot shall be flown **without a pilot** over the territory of a contracting State without **special authorization** by that State and in accordance with the terms of such authorization. Each contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft **shall be so controlled** as to obviate danger to civil aircraft."*

RPAS as a System

- RPAS is a system composed by:
  - A Remotely Piloted Aircraft (RPA).
  - A Remote Pilot Station(s) (RPS).
  - Command&Control (C2) Link.

C2 Link

RPA

RPS

Europe stakeholder and Regulatory System

PIAGGIO AEROSPACE

Standard Bodies

ICAO UAS SARPS

JARUS Standards

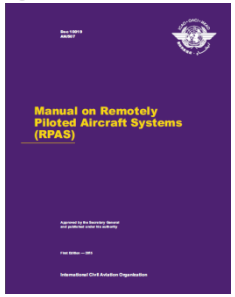
EASA BR Essential Requirements

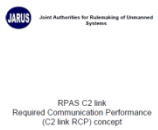
EASA RPAS – Safety Objectives
Part21, Part FCL, CS-XX Book1

EASA – Technical Standards
CS-Book2/OPS/FCL/ORG/C2/D&A

MOPS
MASPS

Standard and Recommended Practices: to provide international legal framework

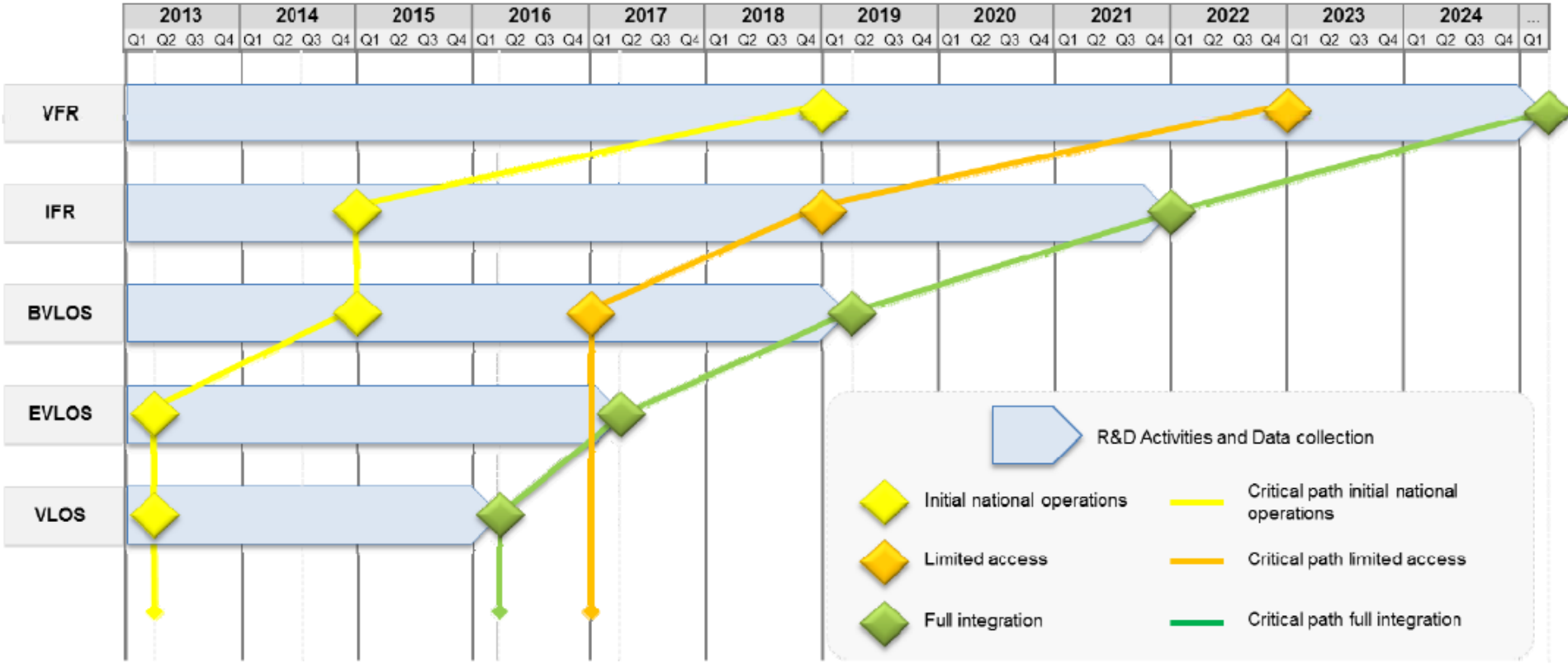




MOPS: Minimum Operational Performance Standards
MASPS: Minimum Aviation System Performance Standards

ERSG Roadmap

- ERSG (European RPAS Steering Group) aims at developing a European civil RPAS integration Roadmap (Regulatory, R&D, Complementary).



Technologies for RPAS

- To compensate for the absence of an onboard pilot enabling unmanned flight, the basic approaches to implementing unmanned flight (autonomy and pilot-in-the-loop) rely predominantly on:
  - Processor Technologies.
  - Communication Technologies.
  - **Detect&Avoid.**

Communication Technology

- Airborne data link rates and processor speeds are in a race to enable future RPAS capabilities.
- Data rates are limited by usable spectrum and by the requirement to minimize airborne system size, weight, and power (SWAP).
- Congestion of S, C and L bands: 1.5 bps/Hz, close to theoretical maximum of 1.92.
- Rely on commercial markets (wireless communications, airliner links, finance) to drive link modulation methods technology, increasing the power of higher frequency (Ka), thus decreasing size, and weight.

Detect&Avoid (DAA)

- ICAO requires a pilot in command of an aircraft to maintain vigilance in order to prevent collision and forbids operations “in proximity” of other aircraft which may cause a collision hazard.
- The same concept is expressed by USA Federal Regulation: *Vigilance shall be maintained by each person operating an aircraft so as **to see and avoid** other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless **well clear**.*
- RPAS have no pilot on-board, thus an automatic system to fill this void is mandatory. Such a system is known as **Detect and Avoid** (DAA), which acts in the place of a human pilot to detect and avoid hazards to safe flight.

DAA: “well clear definition”

- One of the main obstacles in applying manned aviation rules to UAVs is the lack of quantitative definitions for some requirements, which are typically left to the pilot’s judgment. The “well clear” condition is definitely one of those.

- When a function is not specified by a clear and quantitative requirement, it is very hard to design an automatic system that performs it, therefore before tackling the DAA problem, the international community had to agree on a precise definition of “well clear” condition.

DAA: "well clear situation"

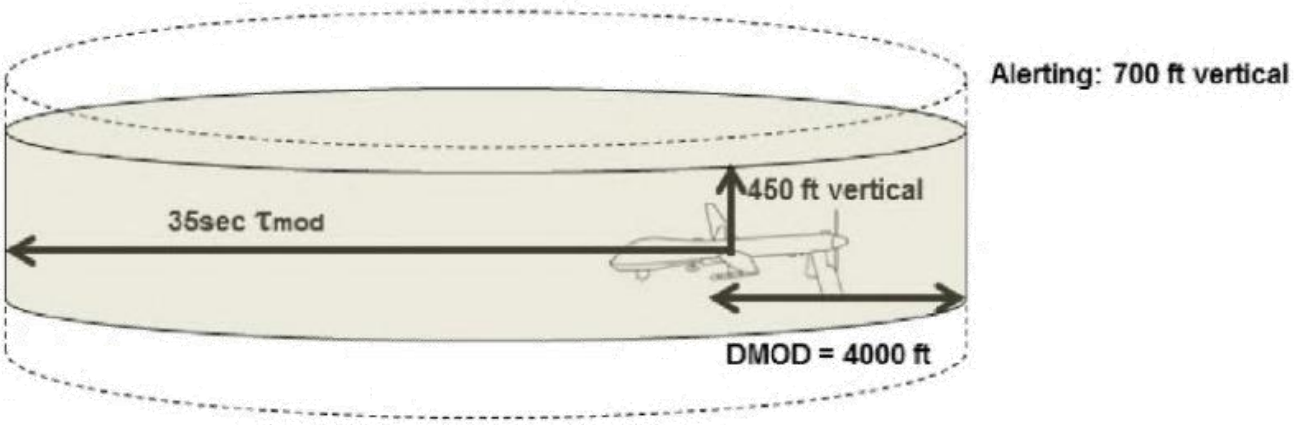
- According to DAA MOPS for the purpose of DAA the loss of "well clear" is defined as:

$$0 \le \tau_{mod} \le \tau^*_{mod} \quad \textbf{and} \quad HMD \le HMD^* \quad \textbf{and} \quad -h^* \le dv \le h^*$$

$$\tau_{mod} = (DMOD^2 - \mathbf{r}^2)/\mathbf{rr}$$

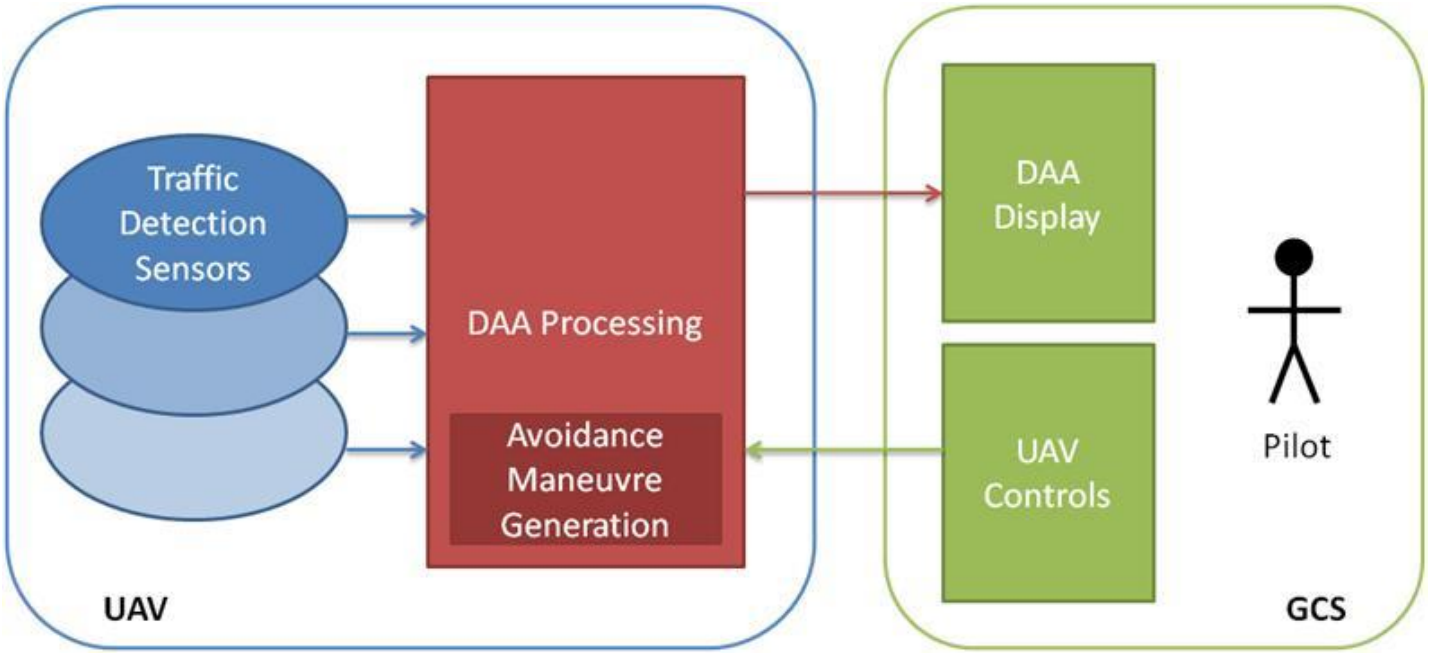
Parameter	Symbol	Threshold
Horizontal range between aircraft	**r**	-
Time to loss of separation (1)	τ_{mod}	τ^*_{mod} = 35 s
Modified distance threshold (1)	DMOD	DMOD = 4000 ft
Horizontal Miss Distance at CPA (2)	HMD	HMD* = 4000 ft
Vertical Separation	d_h	h* = 450 ft

- The "well clear" volume is the following:

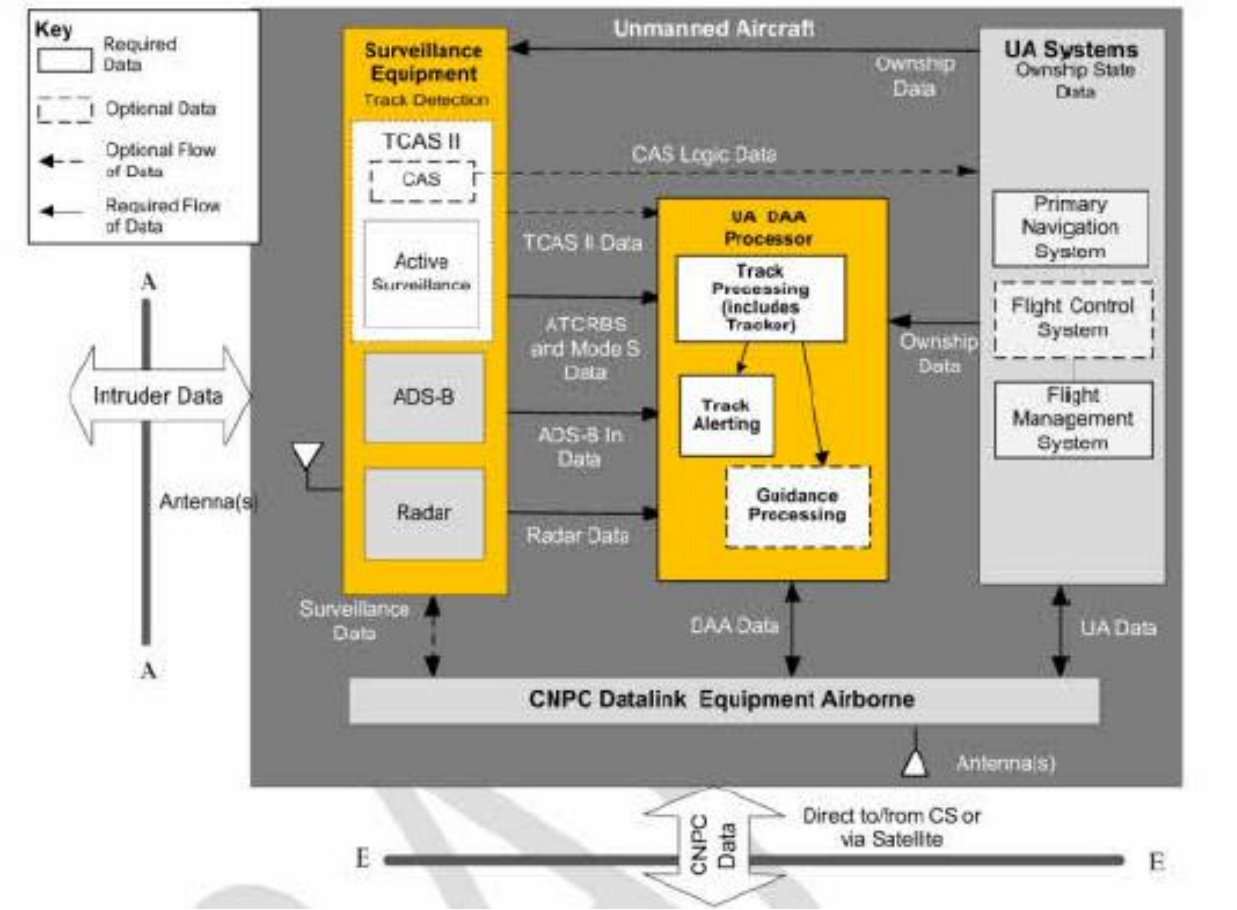


DAA: functional architecture

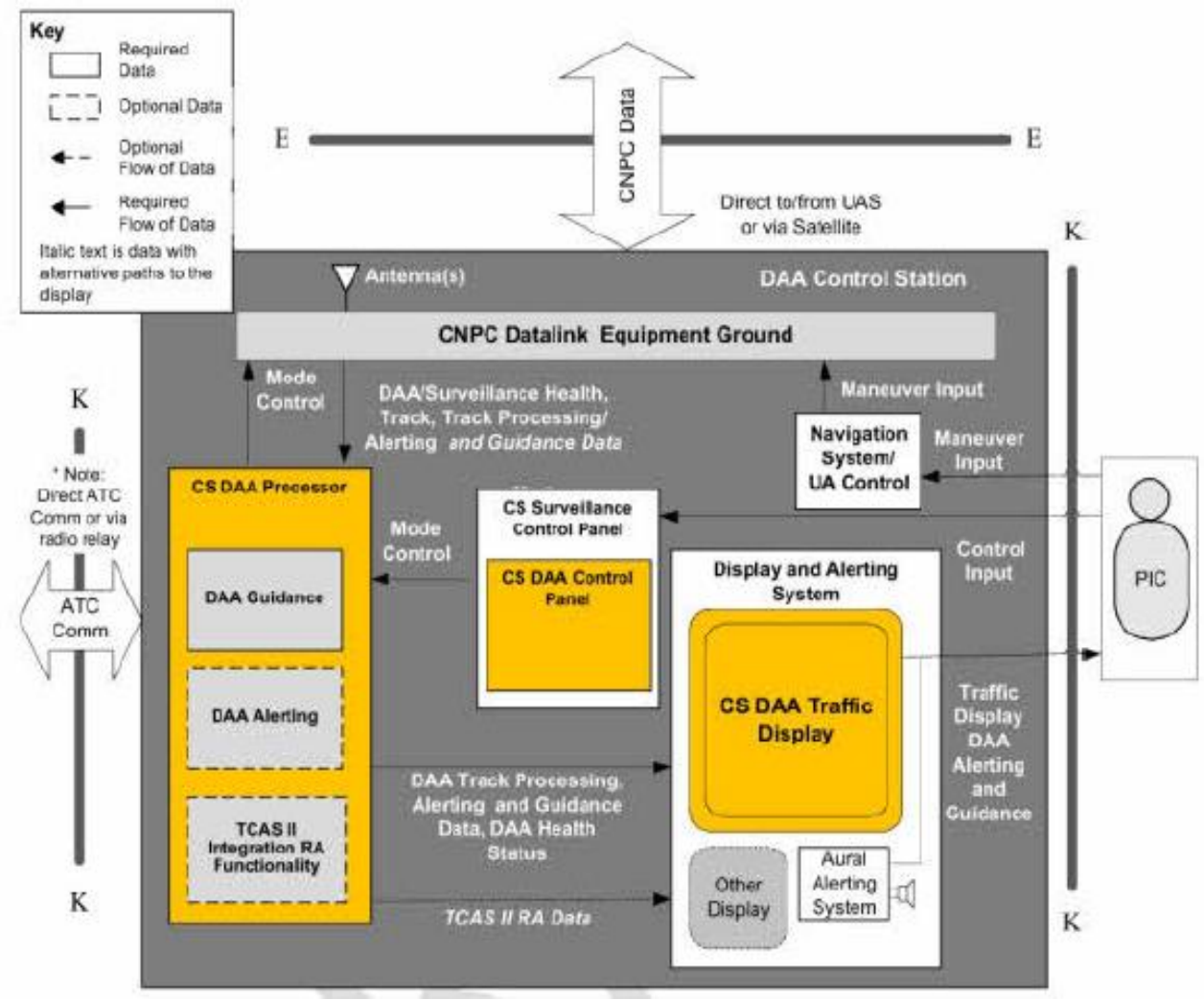
- DAA should provide two different functionalities:
  - Traffic Separation service: to provide separation to obstacles and other aircraft. It may require manual remote intervention.
  - Collision Avoidance service: to protect RPA from collision threats. It should be autonomous and can be coordinated among all the aircraft involved (TCAS – Traffic Collision Avoidance System – II RA) or uncoordinated.



Airborne DAA System Components



Ground DAA System Components



DAA sensors

- DAA suite of traffic detection sensors determines the capability of the systems in terms of detection range, accuracy and detectable classes of vehicles, thus the operational environment where the RPA could safely be inserted.
- Traffic detection sensors can be classified in four categories.

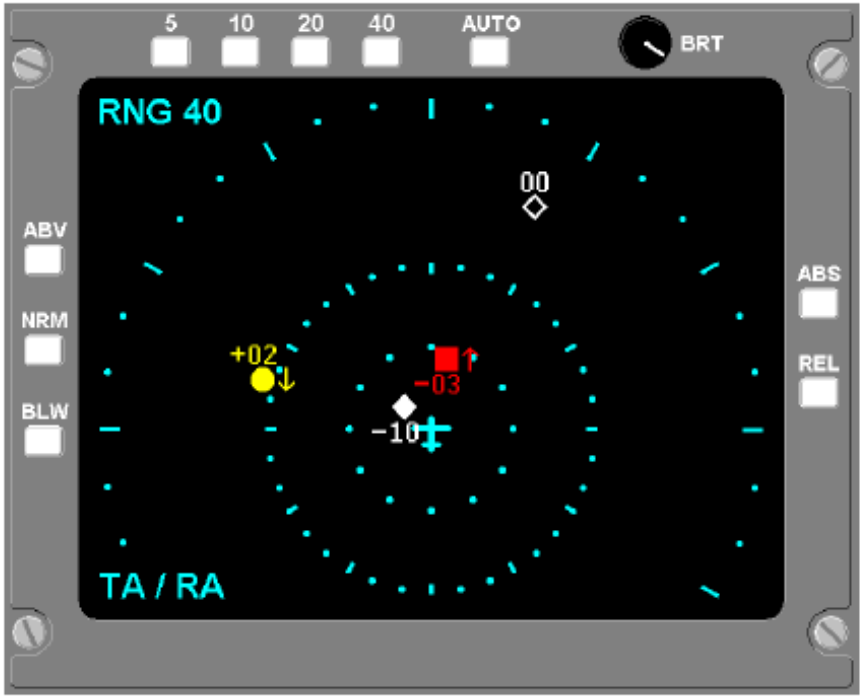
	Modality	Range	Bearing (Azimuth)	Bearing (Elevation)	Trajectory
Mode A/C Transponder	Cooperative	Accurate; 10s of miles	Calculated	Calculated based on pressure altitude	Derived
ADS-B	Cooperative	Accurate; 10s of miles	Calculated based on GPS	Calculated based on pressure altitude	Provided
Optical	Non-Cooperative, Passive	Not sensed	Accurate	Accurate	Derived
Thermal	Non-Cooperative, Passive	Not sensed	Accurate	Accurate	Derived
Laser/LIDAR	Non-Cooperative, Active	Accurate; 1000 ft	Narrow	Narrow	Derived
Radar	Non-Cooperative, Active	Accurate; 1 mile	360 degrees	360 degrees (Depends upon antenna mounting)	Derived
Acoustic	Non-Cooperative, Active	Accurate; 100 ft	360 degrees	360 degrees	Derived

DAA: hazards to limit

- DAA capabilities are required for RPAS to limit risks of following hazards:
  - Conflicting traffic.
  - Terrain and obstacles.
  - Hazardous meteorological conditions.
  - Ground operations.
  - Other airborne hazards, including wake turbulence, wind shear etc..

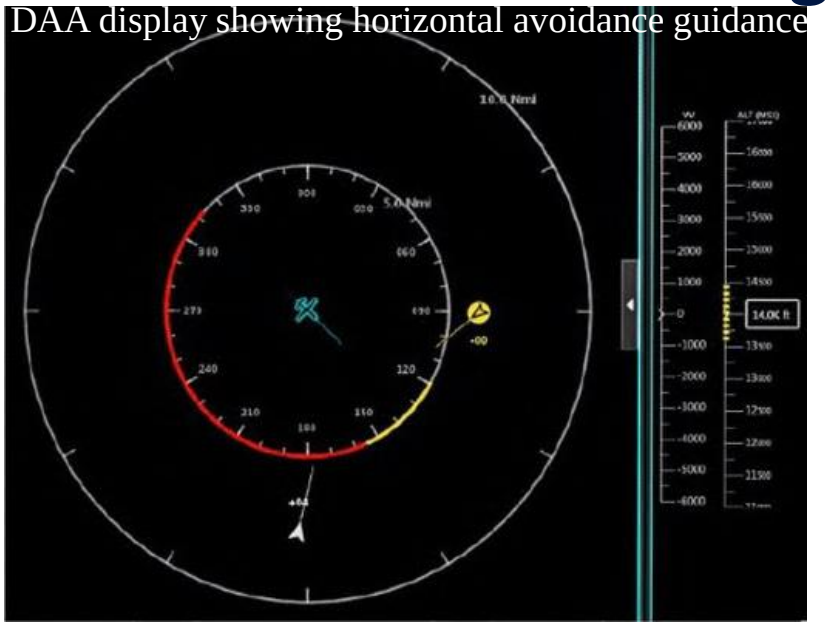
DAA display and pilot interface

- DAA functions allocated to GCS (Ground Control Station) are:
  - Traffic display.
  - Central processor.
  - Aural warning.
  - Control panel.

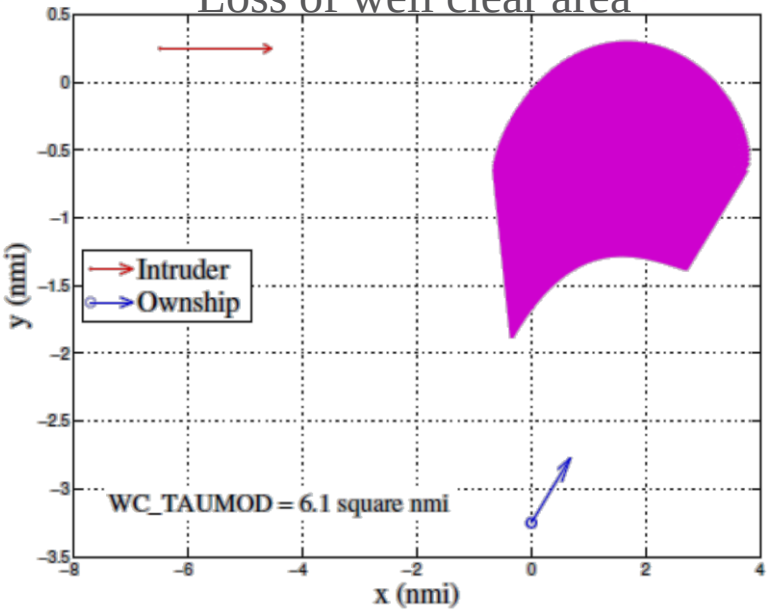


Data traffic alerting

DAA display showing horizontal avoidance guidance



Loss of well clear area



ALERT LEVEL	SEPARATION CRITERIA	TIME UNTIL LOSS OF WELL CLEAR	ICON	AURAL ALERT VERBIAGE
DAA WARNING ALERT	DMOD = 0.75 nmi HMD = 0.75 nmi ZTHR = 450 ft	25 sec		"Traffic, Maneuver Now"
CORRECTIVE DAA ALERT	DMOD = 0.75 nmi HMD = 0.75 nmi ZTHR = 450 ft	75 sec		"Traffic, Separate"
PREVENTIVE DAA ALERT	DMOD = 0.75 nmi HMD = 1.0 nmi ZTHR = 700 ft	75 sec		"Traffic, Monitor"
DAA PROXIMATE ALERT	DMOD = 0.75 nmi HMD = 1.5 nmi ZTHR = 1200 ft	85 sec		N/A
NONE (TARGET)	Within surveillance field of regard	N/A		N/A

Traffic alert and display symbol

Conclusions

- RPAS are a **new component** of aviation system and are based on cutting-edge development in aerospace technologies.

- The **integration** of RPAS into **non-segregated airspace** is a **long-term activity**, requiring advanced technology for DAA, as well as robust regulatory framework.

- Italy can play an important role in the **European technology non-depen**

Thank you for your attention!

Any question?