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AIR NAVIGATION WORLD

COMMUNICATIONS, NAVIGATION, SURVEILLANCE, AND SPECTRUM

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Mr. Stuart McKay



CNS Policy Principal UK CAA/ Chair, ICAO SP

Stuart McKay is a CNS Policy Principal at the UK Civil Aviation Authority, with expertise in air traffic management, communications, navigation, surveillance systems and aviation policy. Drawing on experience within both the aviation regulator and an Air Navigation Service Provider, he brings practical operational insight and strategic policy expertise to future surveillance capabilities, separation standards, performance requirements and international aviation regulation.

Mr. McKay also serves as Chair of the ICAO Surveillance Panel, leading international collaboration on global surveillance standards and guidance and supporting the safe integration of new capabilities across the global air navigation system.

Session 16

From Seeing to Avoiding: The Evolution of Airborne Surveillance

Presentation roadmap

Airborne applications | From awareness to avoidance

Bogdan Petricel

ADS-B IN applications and Interval Management

Matt Haskin

From TCAS to ACAS X, including ACAS Xu and DAA

MODERATED DISCUSSION

Where does surveillance end and separation/avoidance begin?

Mr. Bogdan Petricel



Manager, Radio Frequency Function EUROCONTROL/ Chair, EUROCAE WG-51 SG-3

Bogdan Petricel is a former Air Traffic Controller with a background in Aeronautical Engineering and 10 years of operational experience in air traffic management. He has contributed for 25 years to the development, validation and standardization of ADS-B IN applications, supporting the advancement of airborne surveillance and operational concepts.

He is currently Manager of EUROCONTROL's Radio Frequency Function, supporting aviation spectrum strategy, frequency planning, regulatory harmonization and the protection of aviation radio services at European and international levels. He is also active in international ADS-B standardization and serves as Chair of EUROCAE WG-51 SG-3.

Bogdan Petricel

EUROCONTROL

From situational awareness to airborne separation

Evolution of ADS-B IN airborne surveillance applications

The evolution is adding new functionalities

1

Traffic awareness

AIRB • ITP • SURF

Pilot gains an enhanced traffic picture. Current responsibilities remain unchanged.

2

Procedure support

VSA • CAVS

Traffic information supports defined procedures and clearances.

3

Assigned spacing

IM

Pilot follows avionics-generated guidance to achieve an ATC-assigned spacing interval.

4

Airborne separation

Future goal

The aircraft would assume a defined separation function. Not achieved operationally.

Each stage adds processing and pilot support, but does not necessarily transfer separation responsibility.

ADS-B IN is the common airborne surveillance enabler

ADS-B OUT	Position • altitude • velocity • identity
ADS-B IN / (TIS-B)	Receive and decode surveillance reports
ASSAP	Application-specific processing and validation
CDTI	Traffic picture, cues, alerts and guidance



Navigation quality, equipage, link compatibility and data validity constrain what each application can safely support.

Airborne traffic situational awareness



AIRB / ATSA-AIRB

Surrounding traffic position, altitude and trend support mental integration of visual scan and radio information.

ATAS / TSAA

Adds aural and visual traffic indications for aircraft without ACAS. No resolution advisory is provided.

VSA / CAVS...CAS

Supports visual acquisition and continued visual separation on successive approaches. Continuous visual contact remains required.

Operational boundary

Displayed traffic supplements visual scan and communications. It must not be used to anticipate ATC or self-separate.

An enhanced traffic picture improves understanding without authorising manoeuvres based solely on the display.

Traffic situational awareness on the surface



SURF / ATSA-SURF

Own position and surrounding aircraft or vehicles are shown over an aerodrome moving map. Visual information remains the primary basis for surface operations (including navigation).

SURF-IA / SURF A

Adds runway status indications, traffic indications, cautions and warnings. Alerts are not directive; pilot and controller responsibilities remain unchanged.

SURF-IA as an advanced application with technical issues still to be resolved before wider implementation.

SURF establishes the surface traffic picture; SURF-IA/A adds indications and/or alerts for runway collision hazards.

Procedure-based transition: In-Trail Procedure

1. **Detect** — ADS-B IN identifies suitable reference aircraft.
2. **Assess** — On-board equipment checks ITP geometry and closure criteria.
3. **Request** — Pilot sends a specific climb or descent request via CPDLC.
4. **Clear** — Controller applies ITP separation minimum and retains separation responsibility.



ITP is not self separation procedure

ITP uses airborne ADS-B processing to enable pilot requests for climb or descent in procedural airspace. ITP separation is applied only during the level crossing, until the procedural separation is achieved

Stage 3: Interval Management moves from awareness to active spacing



ATC assigns
Target aircraft, spacing goal, achieve-by point and planned cancellation point.

FIM computes
Speed guidance using ADS-B IN, designated aircraft intended route and own-ship data.

Pilot executes
Selects the designated traffic, enters clearance parameters and flies the IM commanded speed.

ATC separates
Controller retains responsibility for separation.

IM clearance types include achieve-by-and-maintain, capture-then-maintain, maintain current spacing, IM turn and final-approach spacing.

FIM avionics generate speed guidance to achieve or maintain an ATC-assigned spacing goal.

AIRS I-IM operational evaluation: real-world spacing performance confirmed

AIRS demonstrated that flight-deck interval management can deliver standards-level precision in revenue operations

>1,475	1,398	0	298
IM clearances issued	relevant IM events	losses of separation	A321 aircraft equipped

Measured spacing performance at the Cross Point

0.2 NM

Distance-based mean error

95% of flights were within ±1 NM of the mean.

-1 sec

Time-based mean error

93% of flights were within ±10 seconds of the mean.

Operational conclusion

- **Precision** — IM achieved smaller mean values and variability than non-IM operations.
- **Safety** — The evaluation maintained a low-risk profile with no loss of separation.
- **Usability** — Most crews found IM straightforward as familiarity increased.
- **Deployment needs** — ERAM support, concise phraseology and hands-on pilot training are essential.

Revenue-service evaluation in Albuquerque ARTCC airspace, November 2022 to November 2024.
https://www.faa.gov/air_traffic/technology/adsb/documents

Towards airborne self-separation



What exists today

Situational awareness, alerting, procedure support and controller-assigned spacing applications with defined operational boundaries.

ATC retains separation responsibility

For ITP and IM, the controller retains separation responsibility. Displays do not authorise pilots to self-separate.

What the future stage implies

Validated airborne separation functions, compatible procedures, robust assurance, collision-avoidance integration and global interoperability.

The trajectory points toward airborne separation, but today's documented applications stop short of general self-separation.

Thank You


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Mr. Matt Haskin



Matt Haskin is an Aerospace Engineer within the U.S. Federal Aviation Administration's Aircraft Certification Service. He serves as the Government Authorized Representative to RTCA committees developing standards for ADS-B, transponders and collision avoidance systems, and is responsible for related Technical Standard Orders and Advisory Circulars. He also participates as a subject matter expert on the ICAO Surveillance Panel.

Before joining the FAA in 2018, Mr. Haskin worked for the U.S. Department of Defense for 15 years, participating in certification efforts for Identification Friend or Foe systems and developing technical specifications and test procedures used by NATO countries and partner nations.

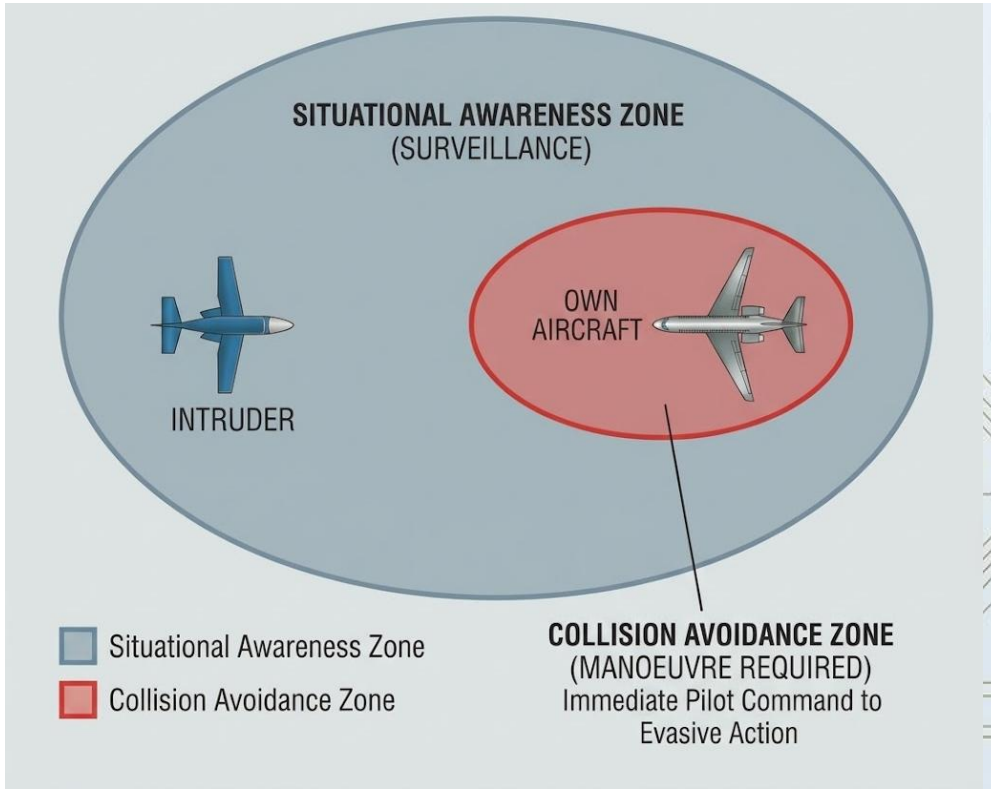
Matthew Haskin

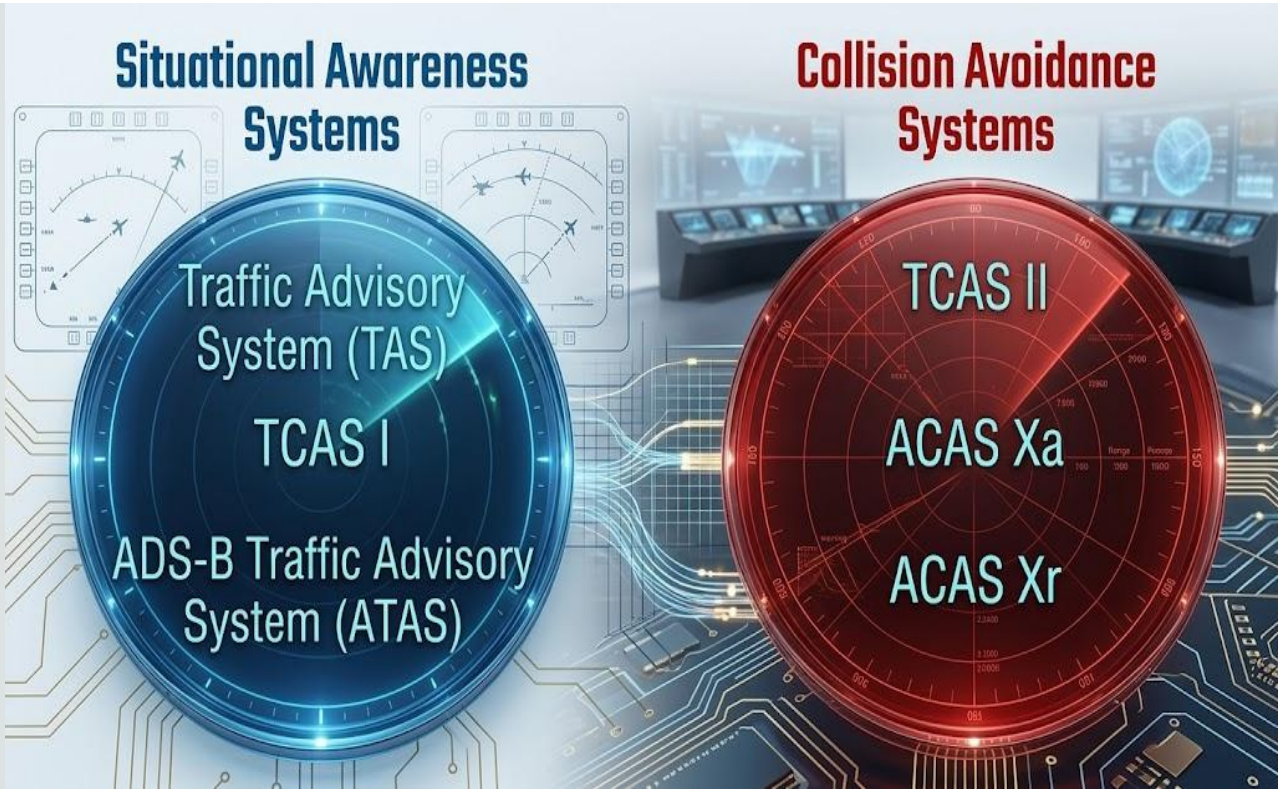
Federal Aviation Administration

The Evolution of Collision Avoidance

From TCAS to ACAS X

Traffic Display Systems for Crewed Aircraft





Collision Avoidance System (CAS). An implementation of a Collision Avoidance Function.
Collision Avoidance Function. A function used to provide alerts to indicate the need to take immediate action by generating a recommended manoeuvre to limit the risk of collision with all threats.

ACAS Variants



ACAS I. An ACAS which provides information as an aid to “see and avoid” action but does not include the capability for generating resolution advisories (RAs).

ACAS II. An ACAS which provides vertical resolution advisories (RAs) in addition to caution level alerting in the form of traffic advisories (TAs).

ACAS III. An ACAS which provides vertical and horizontal resolution advisories (RAs) in addition to caution level alerting.

The Need for Collision Avoidance

- (1956) TWA Flight 2 and United Airlines Flight 718 collided over the Grand Canyon
  - Led to the creation of the US Federal Aviation Administration (FAA)
  - Research begins on automated collision avoidance technology
- (1978) Pacific Southwest Airlines (PSA) Flight 182 collided with a Cessna 172 while near San Diego Airport
  - FAA funded the work to develop the Traffic Alert and Collision Avoidance System (TCAS)
- (1986) Aeroméxico Flight 498 collided with a Piper Archer over Cerritos, California
  - US Congress mandated TCAS II

Evolution of TCAS II: Key Milestones

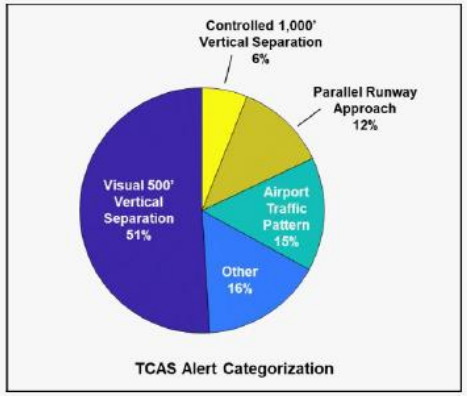


TCAS II Performance Review

Objective: Mitigate TCAS II Shortcomings

Operational Suitability

- >80% of alerts in intentional, safe operations
- E.g., landings on parallel runways



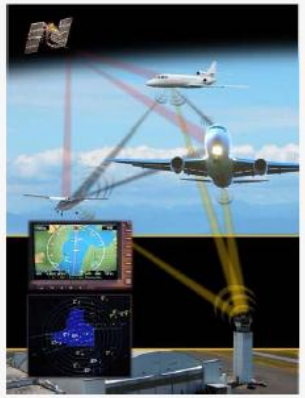
Environment

- ICAO predicts 4.6% annual growth in air traffic
- New entrants: uncrewed aircraft, eVTOL



Surveillance

- Other surveillance sources available or required
- Spectrum limits on active surveillance



Adaptability

- Heuristic threat logic too difficult to update
- Cannot accommodate new surveillance or different vehicle dynamics

```
if (…)
   …
elseif (…)
   …
else
   …
```

ACAS X_a

Active and 1090 ADS-B

TCAS II, ACAS X_a,
ACAS X_u

Active Surveillance

Mode S or Mode C

No Protection

Non Transponding

Alerting and Vertical Guidance

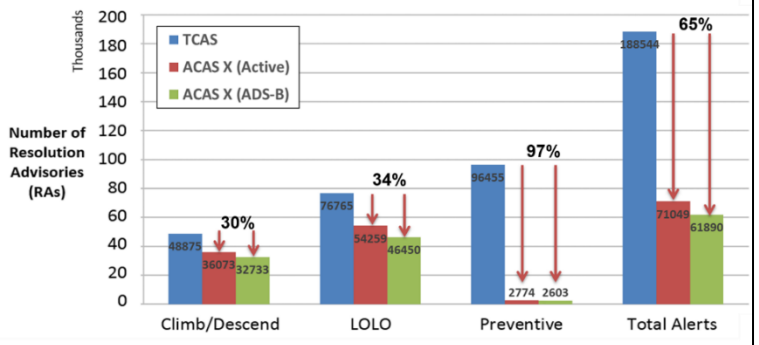
Traffic Alerts - Support Visual Acquisition

Resolution Advisories – Collision Avoidance



ACAS Xa Benefits

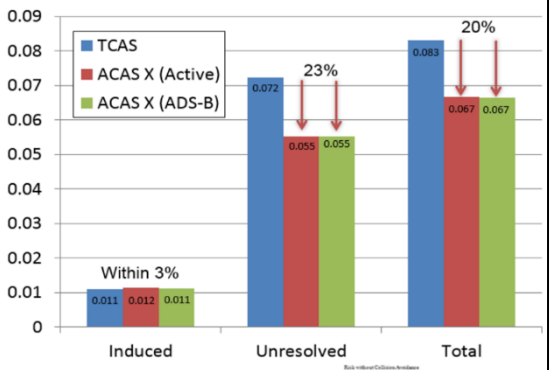
Xa Operational Benefit: Reduction in RAs



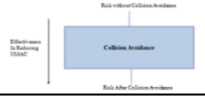
- Alerting comparison between ACASX V1R0 (RTCA DO-385) and TCAS II v7.1 on TRAMS encounter set (~250,000 Observed Encounters between October 2008 and July 2016)

Xa Safety Benefit: Reduction in Collision Risk

- Risk ratio comparison between ACAS X V1R0 (RTCA DO-385) and TCAS II v7.1 on Lincoln Laboratory Correlated Encounter Model
- Notes
  - Induced risk difference due to the prevention of crossing RAs
  - Unresolved risk reduction 23%
  - Total risk reduction of 20% across airspace



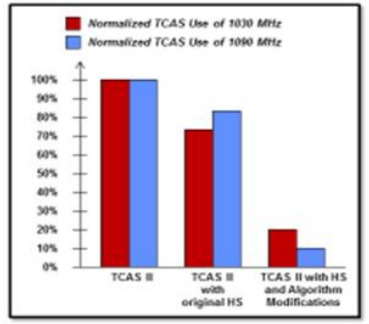
$$\text{Risk Ratio} = \frac{\text{P(NMAC with CA)}}{\text{P(NMAC without CA)}}$$



Reduced Spectrum Congestion via Hybrid Surveillance

- ACAS X implements congestion mitigation improvements resulting in a decrease in transponder use of 1090 MHz frequency in an ADS-B dense terminal environment.
- ACAS X thus maintains safety and reliability of collision avoidance systems with projected growth in operations in the NAS.

- Original DO-300 Hybrid Surveillance achieves modest reduction
  - Less than expected by community
  - Highest fidelity evaluation to date



- New DO-300A and DO-185B Change 2 yield much more significant reduction
  - 89% reduction in 1090 MHz
  - 81% reduction in 1030 MHz

ACAS X_O


Global ACAS Xa Protection
1. CSPO – 3000: ACAS Xo Modified RA
Protection Criteria – Designated Intruder
2. DNA – No RA, No TA
Designated Intruder
IMC Parallel Approach
Operations
Visual Procedures
Procedure-Specific Alerting
1. DNA (Do Not Alert) – Visual Separation Procedures
2. CSPO 3000 – IMC Parallel Approach Operations
Global ACAS Xa protection against all other traffic

ACAS X_u for Larger UAS



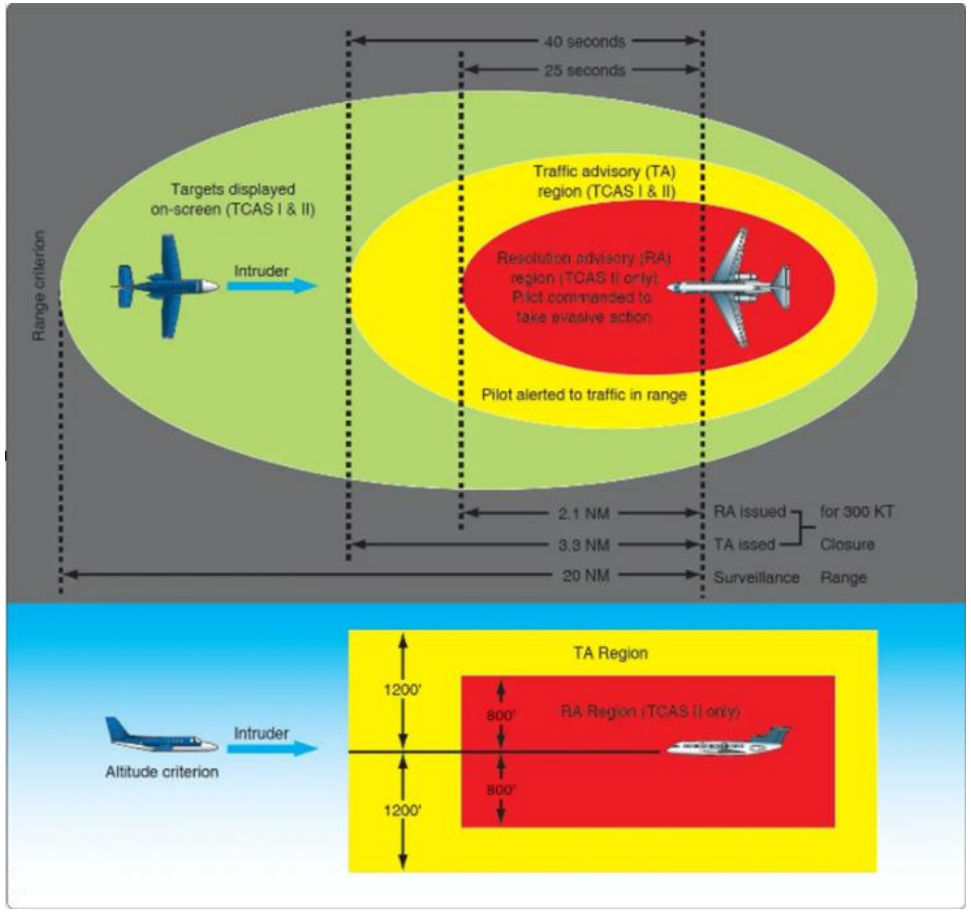
Definitions

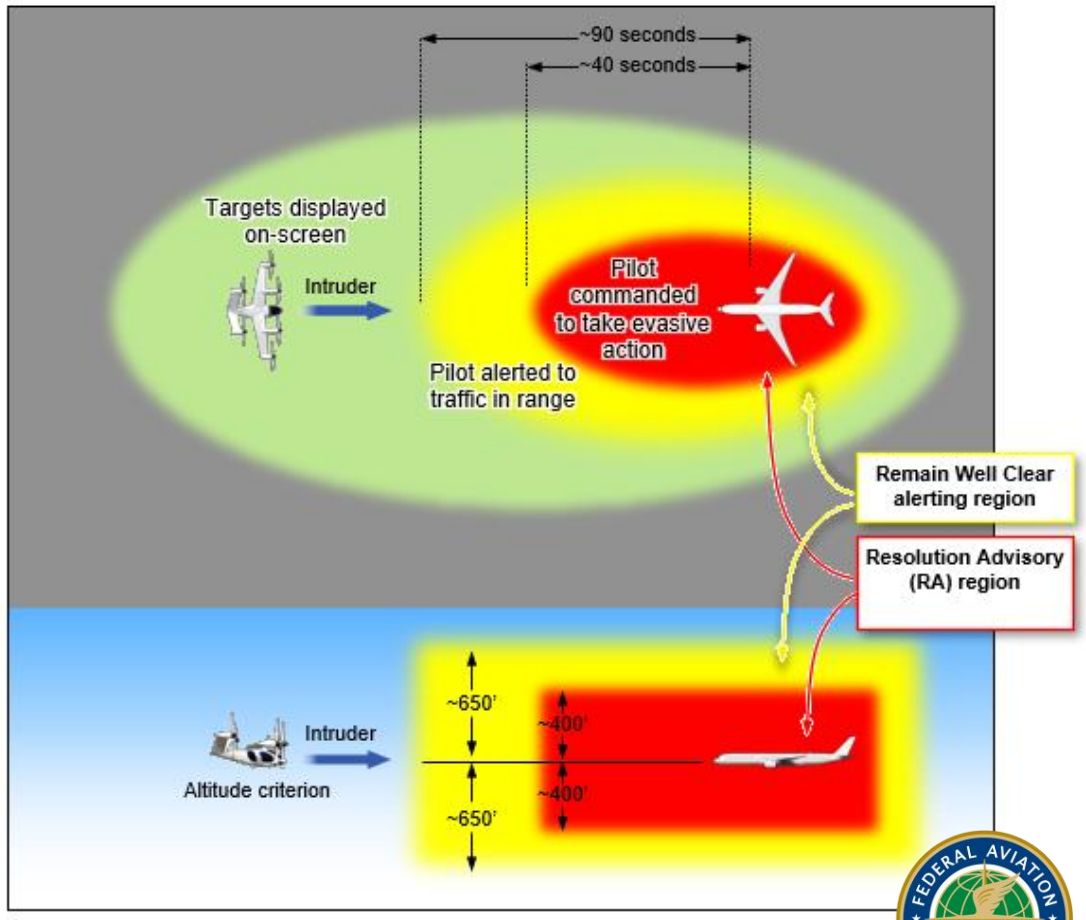
Detect and Avoid (DAA). The capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action.

DAA Well Clear (DWC). A temporal and/or spatial boundary around the aircraft intended to be used in a DAA system as an electronic means of avoiding conflicting traffic.

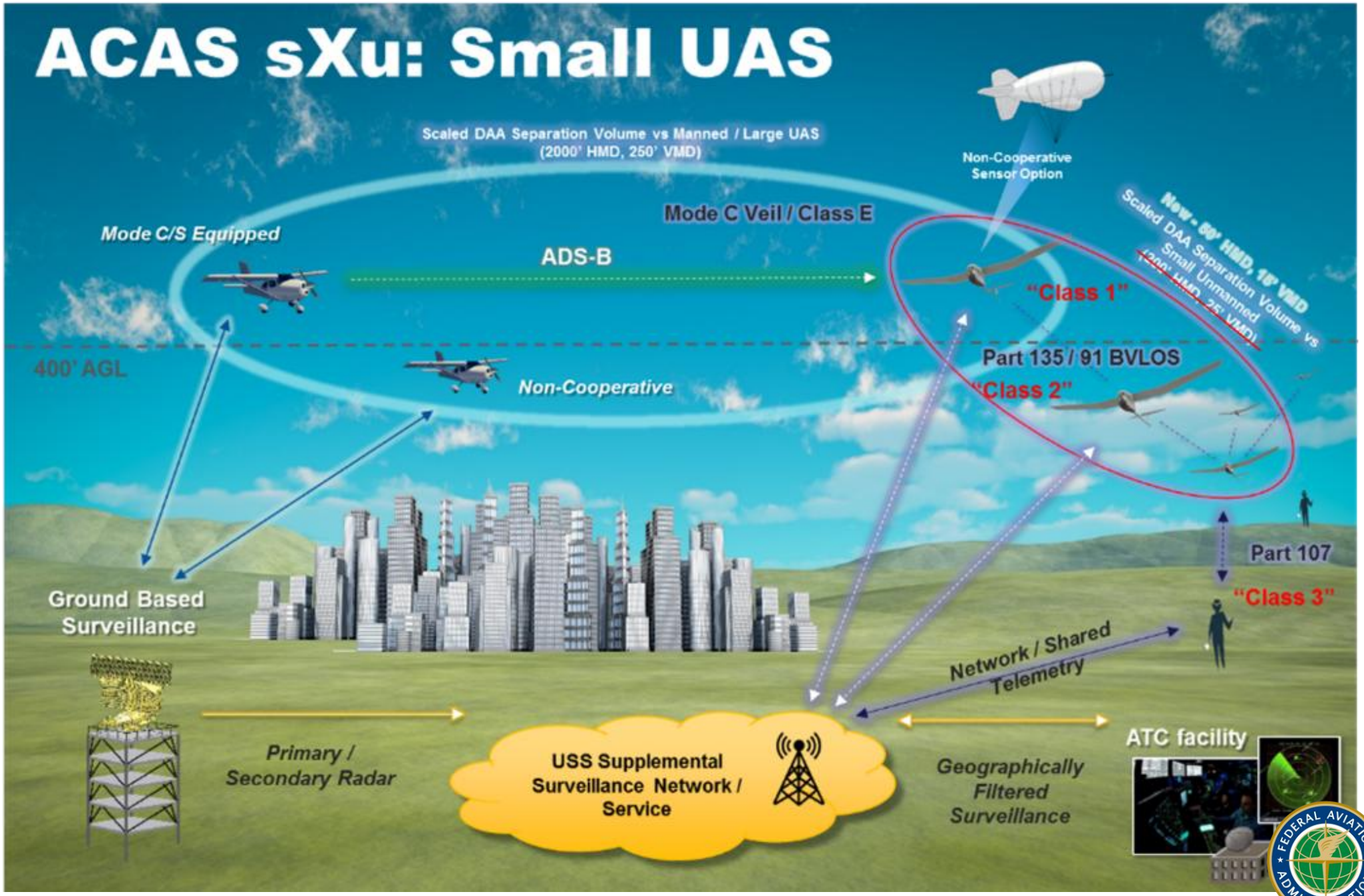
Remain-Well-Clear (RWC) function. A function used to alert the pilot of the need to take action, as approved by ATC if receiving separation services, by generating one or more recommended manoeuvres to mitigate a Potential Threat by passing DAA Well Clear.

TCAS II vs ACAS Xu Alerting





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ACAS sXu: Small UAS
Scaled DAA Separation Volume vs Manned / Large UAS
(2000' HMD, 250' VMD)
Non-Cooperative
Sensor Option
Mode C Veil / Class E
Mode C/S Equipped
ADS-B
"Class 1"
Part 135 / 91 BVLOS
"Class 2"
400' AGL
Non-Cooperative
Ground Based
Surveillance
Part 107
"Class 3"
Network / Shared
Telemetry
Primary /
Secondary Radar
USS Supplemental
Surveillance Network /
Service
Geographically
Filtered
Surveillance
ATC facility

ACAS X_r for Rotorcraft

Note: A given rotorcraft may only be equipped with a subset of listed equipment

ACAS Xr-equipped aircraft
(Traditional Rotorcraft, Unmanned Air Taxi, etc.)





Logic suitable/adaptable for:

Vertical Take-off and Landing
Hover operations
Specific missions (Xo mode)
Tailored to intruder type

Alerting with Horizontal and Vertical guidance

Caution Alerts – Traffic Advisory or Remain Well Clear
Warning Alerts – Collision Avoidance

Active Surveillance and/or 1090 ADS-B, UAT

Airborne non-cooperative sensor

Active Surveillance and/or 1090 ADS-B, UAT

Future Cooperative Surveillance (A2X)

Cooperative and Non-Cooperative Surveillance via ground link





Cooperative



Non-Transponding





Rotorcraft



Low Altitude UAS
(Small UAS,
Air Taxi, etc.)

ACAS X Variants Overview

	User Group	Surveillance Technology	Advisories	RTCA / EUROCAE	ICAO
 **ACAS X_A** (Active Surveillance)	Large Crewed Aircraft	Active supplemented with ADS-B	Vertical	DO-385A ED-256A	Incorporated into Annex 10 and Doc 9863
 **ACAS X_O** (Operation Specific)	Users of specific operations (e.g., closely-spaced parallel operations)	Active supplemented with ADS-B	Procedure-specific alerts for selected aircraft		
 **ACAS X_U** (Unmanned Aircraft System)	Larger Uncrewed Aircraft	Active, ADS-B, & Non-Cooperative	Vertical and/or Horizontal	DO-386 ED-275	Proposed for Annex 10 and Doc 9863
 **ACAS $_SX_U$** (Small UAS)	Smaller Uncrewed Aircraft	ADS-B supplemented with other sensors	Vertical and/or Horizontal	DO-396	N/A
 **ACAS X_R** (Rotorcraft)	Crewed and Uncrewed Rotorcraft and Lower Performing Aircraft	Active, ADS-B, & Non-Cooperative Omnidirectional Antenna Only Available	Vertical and/or Horizontal	DO-411 / 412 ED-354 / 355	Future Work

Thank You



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