New issues raised on collision avoidance by the introduction of remotely piloted aircraft (RPA) in the ATM system

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Challenges of introducing RPAs in civil airspace

- Integration of unmanned aircraft into the airspace will require **detect and avoid capability** with *proven level of safety*
- "Future collision avoidance must safely support and integrate new surveillance, users, and reduced separation procedures with minimal nuisance alerts"
- *Outcome of ANCONF/12: (2012 Rec.4/6) "ICAO should as a matter of urgency, develop the necessary regulatory framework in its entirety to support the integration of remotely piloted aircraft into non-segregated airspace and at aerodromes including and clearly showing the scope of such regulation"*

Collision avoidance in ICAO operational concept (ANCONF/11 report, Dec 2003)

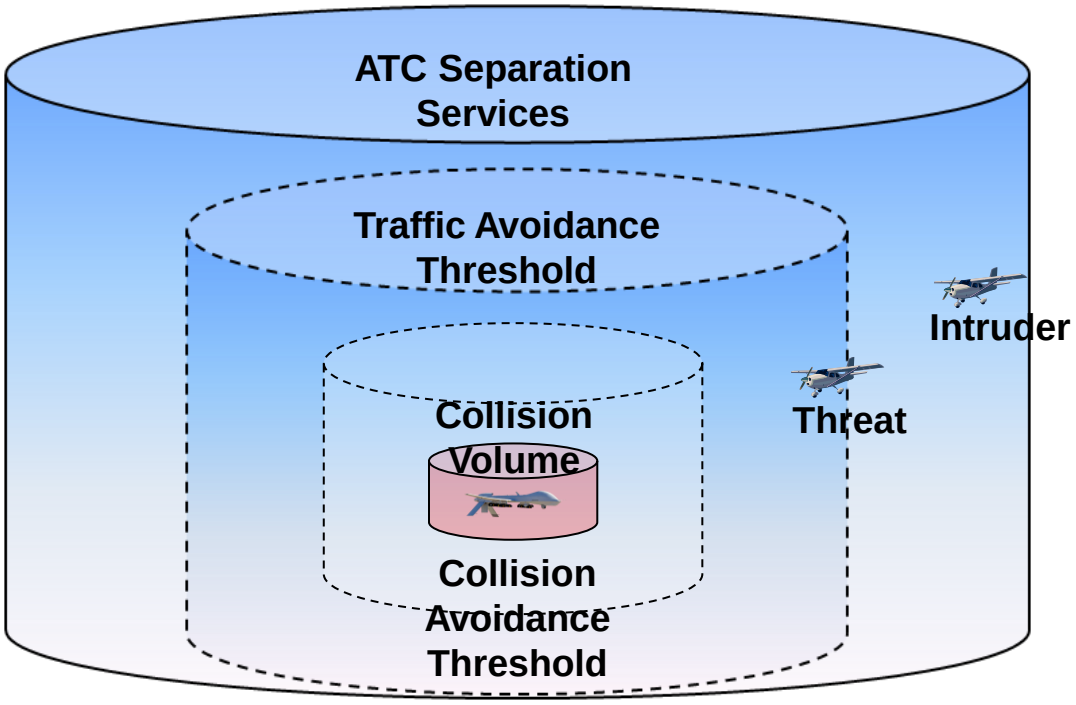
Conflict Management

- *The ATM system will minimize restrictions to user operations*
- *The role of separator may be delegated*
- *The ATM system will respect the different nature of the three layers of conflict management identified in the operational concept*
  - *strategic conflict management, (e.g. airspace design, flight plan)*
  - *tactical conflict management (e.g., ATC instruction) and*
  - *collision avoidance (visual acquisition, ACAS, detect & avoid)*
- ***Collision avoidance systems** are part of ATM system safety management, but not used in calculating safety levels*

Application to RPAs for detect & avoid (DAA)

Introduction of the traffic avoidance to support airborne separation

- Need to ensure there are no common points of failure between collision avoidance and traffic avoidance



Lessons learnt from ACAS standardisation

- ACAS design includes the Traffic Advisory (TA) to support visual acquisition and the Resolution Advisory (RA) for collision avoidance.
  ➔ For RPA where visual acquisition by the remote operator is not required, a new logic must be designed and the need for TA before RA can be revisited.
- ACAS II performance is affected by pilot behavior: automatic following of ACAS RA by connecting autopilot to ACAS showed significant safety and operational benefits
  (SESAR results reported at ICAO and ANCONF/12-IP14)
  ➔ For RPA where the latency of the C2 link can be an issue, automatic following of evasive maneuvers is recommended.
- *ACAS II is not suitable for all aircraft. Similarly, not all RPAs would be required to carry a detect and avoid function.*

Latest developments on ACAS II (a.k.a v7.1)
(source ICAO ANCONF12 IP14 and B0-101)

- ACAS v7.1 includes logic enhancements for reversal situations and level-off encounters bringing significant safety and operational benefits.
- ***ACAS v7.1 is mandatory for MTOW>5.7t from 2014 (forward fit) to 2017 (retrofit)***
- Optional features provide for connection to the autopilot which enable:

  - automatic following of resolution advisories (RAs) with significant safety benefits.
  NOTE: this is certified by EASA on AIRBUS A380 and on EUROCOPTER SC225.

  - automatic adjustment of altitude capture law in presence of intruder with significant reduction of unnecessary RAs
  NOTE: this is being certified by EASA on AIRBUS new aircraft.

Safety Requirements applicable to RPAs (source ICAO UASSG)

MAIN REQUIREMENTS DERIVED FROM CURRENT WORK:

➔ Maintaining an equivalent risk for mid-air collision or an equivalent level of safety (ELOS)

➔ Compatibility with ACAS and either coordinated responses or assurance of compatible maneuvers

- Consequences:

  ➔ Safety case must be established per class of airspace

  ➔ Safety case must be established per type of RPAs

  ➔Surveillance requirements are expressed on ADS-B (OUT and IN), on cooperative surveillance (transponder)

  ➔ Automatic following of evasive maneuvers is recommended to resolve latency issue with the remote pilot

European work on Detect & Avoid
The MIDCAS project

- MIDCAS is a European project (European Defense Agency) http://www.midcas.org/
  - Traffic situational awareness (provided to the remote pilot and/or to airborne systems)
  - TRAFFIC AVOIDANCE (~self separation capability involving the remote pilot and/or automated systems for 2 minutes horizon aiming at preventing ACAS RA)
  - Collision avoidance with automatic maneuver compatible with ACAS II (maneuver determined AFTER ACAS RA on other aircraft).

European work on Detect & Avoid
The MIDCAS project
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- These RPAs are MALE type and aim at flying in non segregated airspace (at least before reaching their cruise level). The system shall:
  - (req 26) provide information for traffic separation (deconfliction as defined in the Eurocontrol document) to remote pilot (who can take an action according to airspace rules, if needed)
  - (req 12) provide a last resort emergency manoeuvre to prevent collision between air vehicles (collision avoidance as defined in the Eurocontrol document)
  - (req 13) not rely on operator for collision avoidance
  - (req 14) provide a solution for the S&A issue for IFR enroute flights in IMC and VMC with comparable levels of safety as manned aviation
  - (req 20) be compatible with established ACAS (TCAS) manoeuvre logic
  - (req 32) be auto-compatible (MIDCAS equipped UAS vs MIDCAS equipped UAS),
    this shall be demonstrated, at least in simulations

US work on UAS D&A= ACAS Xu
(source ICAO ASP13-19 Sept. 2012)

- ACAS Xu is a variant of ACAS adapted to unmanned (remotely piloted) aircraft.
- The D&A function would rely on
  - Detection: various surveillance means (electro-optical, radar, ADS-B, etc.) to enable detection of non-cooperative traffic
  - Avoidance: vertical (and horizontal) advisories issued by dynamic programming logic (core of ACAS X)

US work on UAS D&A= ACAS Xu
(source ICAO ASP13-19 Sept. 2012)
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- Features of ACAS Xu: Plug-and-Play Surveillance - Includes dual link Automatic Dependent Surveillance - Broadcast (ADS-B) reception capabilities, and could include active surveillance. Additionally, sources such as electro-optical (EO) and radar can be input to ACAS XU to provide artificial vision for non-cooperative traffic.
- Tailored Advisories – ACAS X threat resolution logic can be tailored to accommodate vehicle performance. Several logic tables designed to accommodate different classes of UAS performance will be developed.
- Coordinated Advisories – ACAS XU will coordinate with other ACAS XU equipped UAS, and will use “responsive coordination” for TCAS II or ACAS XA threats, which automatically chooses a compatible maneuver with the threat aircraft. In this way, ACAS XU ensures interoperability with legacy systems

Conclusions and future work

ICAO: Outcome of ANCONF/12: recognition of incremental approach with ASBU (B1-90, B2-90, B3-90)

ICAO UASSG is dealing with all issues

- ICAO manual for 2014 - RPAS Symposium in October 2014
- SARPS for 2016 (all ICAO annexes are potentially affected)

Europe: MIDCAS is planning to demonstrate acceptable solutions for collision avoidance by 2015.

US: ACAS X is being designed for conventional aircraft (demo in 2013, MOPS in 2017) and ACAS Xu is specifically designed for RPA (MOPS in 2020), while ensuring compatibility with ACAS X-equipped aircraft.

Thank you – Questions?