UK Civil Aviation Authority

Detect and Avoid Policy Concept v2

CAP 3015

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Civil Aviation Authority
Aviation House
Beehive Ring Road
Crawley
West Sussex
RH6 0YR

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Enquiries regarding the content of this publication should be addressed to:
airspacemodernisationdelivery@caa.co.uk

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Revision history

This updated version of the DAA Policy Concept builds upon the original consultation document published in 2024 and reflects feedback received through the consultation process, ongoing engagement with industry, lessons identified from DAA development activities, and alignment with the UK SORA framework and emerging international standards.

The principal changes introduced in V2 are as follows:

- **Additional DAA System examples.** Additional detail on example DAA systems, considering types of alerting & guidance, functional design implementation and levels of automation
- **Transition from consultation concept to operational policy concept**. V2 establishes the DAA Policy Concept as a live policy framework that may be used to support operational authorisations during the policy concept test phase, supported by a defined regulatory pathway and structured review process
- **Expansion of DAA system descriptions and implementation approaches**. Additional detail has been provided on representative DAA system architectures, including categories of alerting and guidance, functional implementations of the Detect-Decide-Command-Execute-Feedback (DDCEF) functions, and levels of automation. This material is intended to improve consistency of applications and support compliance discussions between applicants and the CAA.
- **Consideration of Unmanned Aircraft to Unmanned Aircraft (UA-UA) encounters**. This version introduces an initial policy position for encounters between unmanned aircraft, including consideration of small UA operations and recommended approaches for protected volumes and tactical conflict management.
- **Enhanced DAA assurance requirements**. The previous high-level requirement set has been expanded into a structured framework comprising performance, system integration, reliability, data integrity, operational suitability, oversight and human factors requirements. The requirements are organised as individual DAA requirements (DAA01 to DAA20) to support the development of consistent compliance bases.

- **An indication of future Acceptable Means of Compliance (AMC) and Guidance Material (GM)**. This version includes indicative AMC and GM for each requirement, providing applicants with greater clarity regarding evidence expectations, performance assessment methods, system design considerations and operational oversight requirements. This is supported by an example set of performance qualification tests which is intended to provide clarity on test and evidence data requirements to both industry and the CAA.
- **Development of a DAA qualification framework**. A comprehensive set of qualification tests has been introduced to support assessment of DAA capabilities, including surveillance validation field tests, real-time simulations, live-virtual constructive simulations, fast-time Monte Carlo simulations, full-system operational trials and soak testing. This framework is intended to standardise evidence generation and facilitate comparison of different DAA solutions.
- **Increased emphasis on operational suitability and human performance**. Additional requirements and guidance have been introduced addressing Human Factors, Remote Pilot interaction with DAA systems, alerting philosophies, operational procedures, training requirements and Human Machine Interface design.
- **Alignment with emerging national and international standards**. This version reflects developments in UK SORA implementation, ASTM and EUROCAE standards, ICAO DAA activities, and lessons learned from ongoing DAA-related projects and regulatory engagement.

The intent of these changes is to provide a more complete, operationally focused and evidence-based framework for the assurance of DAA capabilities, thereby supporting the safe and scalable integration of Beyond Visual Line of Sight (BVLOS) unmanned aircraft operations into UK airspace.

Chapter 1
Introduction

Background

1.1 There is currently a strong industry demand for Beyond Visual Line of Sight (BVLOS) operation of Unmanned Aircraft (UA) within the UK, and while forecast estimates vary, they consistently show a large increase in the sector over the next 10+ years. Perhaps the most significant barrier to the growth of this sector is the mid-air collision risk associated with Beyond Visual Line of Sight (BVLOS) operations.

Aviation Conflict Management and BVLOS Scalability

1.2 Conflict management within the existing global aviation system is premised on cockpit-based pilot see-and-avoid supporting elements of both layer two and three of the following three-layer system [1]:

- **Layer 1: Strategic conflict management** – Airspace design, demand & capacity balancing, traffic synchronisation. Strategic is used here to mean 'in advance of tactical'. The objective of this layer is to minimise the need to apply the second layer.
- **Layer 2: Separation provision** – This is the tactical (in-flight) process of keeping aircraft away from hazards by at least the appropriate separation minima. A pre-determined separator is required, which is typically the airspace user via cockpit based see-and-avoid, unless an ATM separation provision service is required.
- **Layer 3: Collision avoidance** – Required when the separation mode has been compromised. This layer is predominately based on cockpit view pilot 'see-and-avoid', although for some categories of aircraft this may be augmented by systems such as Traffic Collision Avoidance System (ACAS).

1.3 For UA operations that are BVLOS of the Remote Pilot and outside of segregated airspace a DAA capability is therefore required to replace the pilot see-and-avoid responsibilities. DAA is defined by ICAO [3] as providing "*the capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action*". The DAA system therefore enables the Remote Pilot (RP) to exercise their responsibilities regarding other aircraft, as required within the standardised rules of the air [8].

1.4 Within their Remotely Piloted Air Systems (RPAS) CONOP for International IFR [9], ICAO also define the following:

- **Accommodation** – Where RPAS can operate along with some level of adaptation or support that compensates for its inability to comply within existing operational constructs.
- **Integration** – Where RPAS enter airspace system routinely without requiring special provisions.

1.5 DAA, as defined above, is therefore a critical enabler for BVLOS operation of UA and their safe *integration* into the wider airspace environment. Where the DAA system cannot fully replicate the pilot cockpit see-and-avoid capability then *accommodation* is still possible, with the required ruleset and procedures dependent on the capability of the DAA system.

1.6 The *scalability* of the BVLOS solution can then be defined by the restrictions imposed on other air users for the accommodation of such operations. Example restrictions may include:

- Loss of airspace access, e.g., segregation of UA from all other air users.
- Mandatory equipment carriage, e.g., Electronic Conspicuity (EC) or enhanced visual or radar conspicuity.
- Traffic control procedures, e.g., a separation or deconfliction service to structure traffic within the airspace.
- Traffic density restrictions, e.g., to enable large separation distances.
- Traffic speed / size restrictions, e.g., low speed light aircraft only.

1.7 The requirement for such restrictions, and hence the scalability of the BVLOS solution, is determined largely by the assured performance capability of the DAA system.

Objective

1.8 The CAA's vision for BVLOS UA operation within the UK is set out in the Airspace Modernisation Strategy (AMS) [10], which describes a transition from the use of segregated airspace to integrated operations, supported using Transponder Mandatory Zones (TMZs). In support of this vision, and the above discussion of BVLOS scalability, the objective of this paper is to set out V2 of the CAA's policy concept for the assurance of DAA systems. This policy concept is intended to be used by an applicant for the purpose of determining a bespoke compliance basis during the policy concept test phase. The process for this and the regulatory pathway is both defined in Chapter 4 of this document.

Structure of this Paper

1.9 The remainder of this paper is structured as follows:

- Chapter 2 defines the scope and assumptions that underpin the DAA Policy Concept.
- Chapter 3 provides definitions.
- Chapter 4 defines the regulatory pathway and process through which this policy concept will be used.
- Chapter 5 defines the DAA intended function, with additional information on example DAA systems and interaction with standardised rules of the air.
- Chapter 6 discusses DAA requirements for Unmanned Aircraft / Unmanned Aircraft (UA-UA) encounters.
- Chapter 7 provides the DAA Policy Concept requirements for UA encounters with manned aircraft.
- Chapter 8 provides AMC and GM for the DAA requirements in Chapter 7.
- Chapter 9 provides a set of DAA performance qualification tests in support of the policy concept requirements, AMC and GM.
- Finally, next steps, nomenclature, definitions, point of contact and references are provided in Chapters 10 to 13 respectively.

Chapter 2
Scope

2.1 This policy concept applies to all classes of airspace and categories of UA, with crewed and other UA as the only hazards considered. Other airborne hazards such as birds, weather and other obstacles will be considered in a later version of the policy.

2.2 No distinction is made between the use of onboard and offboard equipment within the DAA system. For example, a DAA capability may exploit ground-based surveillance rather than onboard sensors if available and preferred.

2.3 Two distinct types of flight operations are considered:

- **Type-1:** Operations primarily conducted under self-separation and see-and-avoid (primarily uncontrolled airspace).
- **Type-2:** Operations that occur with separation provided by an Air Navigation Service Provider (primarily controlled airspace).

2.4 Encounters between UA and both type-1 and type-2 traffic are considered, where an encounter is defined as an event associated with the presence of an intruder aircraft. An Encounter is simply a measure of when the proximity of two aircraft becomes relevant, or where a simulation or timeline may start. An encounter must be ‘big enough to include all things which may influence the tactical mitigations of the aircraft, but not so big that the actions of aircraft 300 miles away are also counted’ [11].

2.5 The UK SORA air risk model [15] provides a structured process for determining the Air Risk Class (ARC) of an UA BVLOS operation, which is then used to determine a proportionate level of capability and oversight. Broad descriptions of each of the four ARCs are as follows:

- **Residual ARC-a:** Encounter rate with other crewed air traffic demonstrated to be negligible, therefore DAA based tactical mitigation of the air risk is not required.
- **Residual ARC-b:** Encounter rate with other crewed air traffic demonstrated to be low and exclusively Type-1, but not negligible. DAA based tactical mitigation is therefore required but must be supported by one or more additional mitigation layers.

- **Residual ARC-c:** Predominately Type-1 traffic and negligible commercial air transport aircraft, with either an encounter rate that cannot be demonstrated to be low enough for ARC-b, or additional supporting strategic mitigations are not available. DAA based tactical mitigation is therefore required and expected to be used routinely rather than occasionally.
- **Residual ARC-d:** Predominately Type-2 traffic, therefore subject to the highest level of tactical mitigation due to highest severity consequence (e.g., risk to life) and highest safety standard airspace. Specific category operations likely to be exceptions (e.g., via certified DAA system) rather than the normal for this ARC.

2.6 This DAA Policy Concept defines the proportionate requirement for tactical DAA based mitigation for ARC-b, ARC-c and ARC-d. The derivation of each ARC is provided in the UK SORA Air Risk Model [15].

Chapter 3

Definitions

3.1 Commonly used terminology for discussing and evaluating DAA systems is as follows:

- **Ownship** (or own aircraft) – The aircraft on which the ACAS or DAA system referred to is installed / functions [21].
- **Intruder** – An aircraft external to ownship within or projected to be in the ownship's vicinity in the near future [21].
- **Cooperative aircraft** – Aircraft that transmit surveillance data that can be received by ownship [4].
- **Non-cooperative aircraft** – Aircraft that do not transmit surveillance data that can be received by ownship [4].
- **Encounter** – An event associated with the presence of an intruder aircraft. An Encounter is simply a measure of when the proximity of two aircraft becomes relevant, or where a simulation may start. An encounter must be 'big enough to include all things which may influence the tactical mitigations of the aircraft, but not so big that the actions of aircraft 300 miles away are also counted' [11].
- **Encounter set** – The complete set of encounters that are used to assess the performance of a DAA system.
- **Encounter Models** – Statistical models of encounters that are representative of what occurs in the required air environment. Can be used to sample individual encounter sets to be used to evaluate DAA system performance, e.g., in Monte Carlo simulation.
- **Near mid-air collision (NMAC)** – Two aircraft simultaneously coming within 100 ft vertically and 500 ft horizontally [4].
- **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 [4].
- **Caution level alert** – An alert that requires immediate pilot awareness and subsequent response [4]. Also see [24] for guidance on implementation.
- **Warning level alert** – An alert that requires immediate pilot awareness and immediate pilot response [4]. Also see [24] for guidance on implementation.

- **Suggestive guidance** – A range of potential manoeuvres provided to avoid a hazard with manual execution. An algorithm provides a Remote Pilot with a range of advantageous or disadvantageous manoeuvres [16].
- **Directive guidance** – A specific recommended resolution to avoid a hazard with manual or automated execution. An algorithm informs the pilot when and how to perform a recommended manoeuvre [16].
- **Explicit coordination** – Coordination in which each aircraft in an encounter uses real-time exchange of information to ensure compatible RAs [7].
- **Implicit coordination** – Coordination in which each aircraft in an encounter uses a shared set of rules without real-time exchange of information to ensure compatible manoeuvre guidance [7].
- **Surveillance volume** – The volume of airspace where the DAA sensors can detect and track intruders. The surveillance volume may be different for each sensor [7].

Chapter 4

Regulatory Pathway

4.1 UAS operational authorisations are provided by the CAA under UK Regulation (EU) 2019/947. DAA relevant extracts from this regulation are as follows:

Art. 11 Rules for conducting an operational risk assessment

- 5. (h) … identification of possible mitigation measures necessary to meet the proposed target level of safety … design features and performance of the UAS in particular (i.) … means to mitigate collisions
- 6. The robustness of the proposed mitigating measures shall be assessed to determine whether they are commensurate with the safety objectives and risks of the intended operation, particularly to make sure that every stage of the operation is safe.

4.2 **AMC1 to Article 11** is the UK SORA, which came into force on 23rd April 2025.

4.3 **UAS.SPEC.060 Responsibilities of the Remote Pilot**

- (3) During the flight, the Remote Pilot shall… (b) avoid any risk of collision with any manned aircraft and discontinue a flight when continuing it may pose a risk to other aircraft, people, animals, environment or property.

4.4 AMC1 UAS.SPEC.060(3)(b) Responsibilities of the Remote Pilot

- AVOID RISK OF COLLISION WITH ANY MANNED AIRCRAFT - WHEN BEYOND VISUAL LINE OF SIGHT: When operating BVLOS, the risk of collision with a manned aircraft must be mitigated sufficiently. Guidance can be found in AMC to Article 11 (UK SORA) and its appendices.

4.5 **Annex D to Article 11**

- TM2 - Detect and Avoid (DAA) capability – A UK CAA Policy Concept for the assurance of DAA capabilities is available in CAP3015. Any applicant wishing to use a DAA capability as a tactical air risk mitigation should contact the CAA via uksora@caa.co.uk to obtain further guidance on the review and approval process.

4.6 The DAA Policy Concept as referred to in Annex D to Article 11 (as updated to V2 by this document) is an operational, or ‘live’, policy meaning that it may be used in support of a UAS operational authorisation under the above regulation. The ‘concept’ status signifies that its use will be limited to a test phase, to ensure completeness and suitability of the requirements ahead of scaled ‘Business As Usual’ (BAU) applications. The test phase allows a limited number of DAA

dependent applications to be given additional scrutiny by CAA Subject Matter Experts (SMEs), helping to validate the application process and further develop the AMC and GM ahead of a transition to BAU.

4.7 Due to the significant reliance on equipment, the review of a proposed DAA capability against the DAA Policy Concept follows a typical 'Design and Certification' process, using a panel of SMEs (the DAA Panel) to agree a bespoke Means of Compliance with each applicant, including associated conditions and limitations to the authorising UAS inspector. A structured review process has been defined, based on the following three phases:

- Phase-1: Familiarisation
- Phase-2: Compliance strategy
- Phase-3: Compliance Evidence

4.8 Typically, the review process will be split into pre-application (phase 1 & phase 2) and application (phase 3), with these stages bridged by sign-off of the appropriate compliance strategy by a Regulatory Pathway Authority, ensuring that cross policy team agreement is reached. During any pre-application activities the DAA Panel may conduct some limited compliance evidence review to help ensure understanding and suitability of the compliance strategy, but full compliance evidence review will be conducted by the UAS inspection team post application. As per the usual application review process the inspector will be able to consult appropriate policy specialists (including the DAA Panel) during evidence review if there are any questions or issues related to the suitability of the provided data. It is expected that during initial applications significant support will be provided to the inspector by the DAA panel.

4.9 In line with CAP2533 initial BVLOS UAS operation integrated with 3rd party crewed aircraft may be limited to a TRA, where a bespoke ruleset may be defined and an ANSP is able to provide an additional safety layer. Dependent on the DAA capability and the operating environment, the requirement for an ANSP will be examined as part of the transition from a TRA towards a Transponder Mandatory Zone (TMZ) in line with the AMS.

4.10 Any DAA authorisations during the test phase will also be subject to an enhanced oversight phase to gather further evidence of safe operation and monitor for any unexpected consequences. Example data that may be requested as a condition of an authorisation is provided in DAA18.GM1 (Chapter 8). Specific reporting requirements will be defined by the UAS inspector, including recommendations from the DAA Panel.

Chapter 5

DAA Intended Function & Example Systems

Intended Function

5.1 The fundamental objective of a DAA system is to enable the RP[1] to exercise their ICAO Annex 2 'Avoidance of Collisions' responsibilities regarding both crewed and uncrewed aircraft, as implemented by the NAA, e.g., Standardised European Rules of the Air (SERA) (Regulation (EU) No 923/2012).

5.2 The top-level generic functions of a DAA system are defined within the JARUS SORA [15] as:

- **Detect**: DAA systems use sensors and surveillance technologies (e.g., radar, ADS-B, EO/IR) to conduct traffic surveillance and track other aircraft and potential intruders.
- **Decide**: DAA systems analyse the detected conflicts and provide information, recommendations or directive decisions on the best course of action to solve the conflict.
- **Command**: DAA systems or pilot issue commands (based on the Decide function) to the aircraft's control systems to execute the required manoeuvres.
- **Execute**: The aircraft's flight control system performs the commanded manoeuvres.
- **Feedback**: DAA system or the pilot monitors the situation after the manoeuvre is executed, providing feedback on the effectiveness of the action taken and ensuring ongoing safety.

5.3 DAA systems support both Remain Well Clear (RWC) and Collision Avoidance responsibilities. Collision avoidance is an essential function of the DAA system and can be assumed to be independent of other residual risk (tactical) mitigations. Remain Well Clear may be implemented as an additional function, taking care of the necessary integration with any other form of separation provision (e.g. via ANSP or UTMSP), as per the specific system and planned operation.

[1] Issues related to ownership of liability between the remote pilot and the operator are discussed in a Law Commission study on Autonomy in Aviation (Aviation autonomy: final report – Law Commission)

Example DAA Systems

5.4 In this section we provide example descriptions of possible DAA implementations. The functional groupings are intended to capture both common designs found in industry and those addressed by different technical standards. These are by no means prescriptive but are included as they are expected to significantly influence performance test and evidence expectations within the authorisation process. The following design groupings are discussed further below:

- Categories of alerting and guidance
- Functional design implementation of the generic residual risk (tactical) mitigation functions
- Level of automation

5.5 The following distinct options of alerting and guidance schemes are discussed within several different DAA technical standards [16,17,18,20,21]:

- **Traffic display & alerting** – In this case the Remote Pilot is provided with enough information to allow him/her to perform self-separation with an intruder (e.g., call sign, range, location, heading, bearing, relative and absolute altitude, vertical trend, and ground speed). While manoeuvre guidance is not provided, it is expected that an alerting scheme would be required, and that this category of system would only be suitable for low complexity operations, e.g., ARC-b.
- **Suggestive guidance** – In this case, the Remote Pilot is provided with the same kind of information as in the previous case, but he/she is also provided with guidance in the form of a range recommended (positive guidance) or not recommended (negative guidance) manoeuvres with regards to the solution of the current potential conflict. Nevertheless, it is under the pilot's responsibility to choose the appropriate course of actions. An example of 'not recommended' (negative guidance) manoeuvres are those expected to worsen the conflict.
- **Directive guidance** – In this case, the DAA system provides a single recommended avoidance manoeuvre and relies on either the Remote Pilot or automated systems to execute it.

5.6 Two levels of alerts are discussed by the various DAA standards [16,17,18,20,21]:

- **Caution alerts** – Those which require immediate Remote Pilot awareness and potential subsequent response.

- **Warning alerts** – Those that require immediate Remote Pilot awareness and immediate Remote Pilot response.

5.7 Alerting thresholds are typically defined to ensure that separation/avoidance manoeuvres can be conducted in time to prevent a loss of DAA Well Clear (DWC) or NMAC, as required by the RR performance targets. However, consideration of nuisance alerts is also required to meet operational suitability metrics. Specific examples of alerting levels and scenarios are provided in the technical standards [16,17,18,20,21]. For example, the ASTM DAA standard [21] requires the following:

- Use of a caution alert if an intruder is not currently predicted to breach the DWC volume but may do so if either the ownship or intruder manoeuvres abruptly.
- Use of a warning alert if an intruder is predicted to breach either the DWC or NMAC volumes.

5.8 Another example of an alerting scheme is ACAS Xu [16] which uses the following:

- **Preventive DAA alert (yellow)** – No action required. Generating peripheral guidance bands. Monitor for potential increase in severity. Aural alert *"Traffic, Monitor".*
- **Corrective DAA Alert (yellow)** – Action required to remain 'DAA Well Clear'. Coordinate with ATC prior to manoeuvring. Aural alert "*Traffic, Avoid".*
- **Resolution Advisory (red)** – Immediate action required to comply. Must comply with initial RA within 5 sec & with subsequent RA within 2.5 sec. Notify ATC after manoeuvre. Aural Alert "*Climb/Descend*" x2 or "*Turn Left/Right"* x2".

5.9 Different categories of manoeuvre guidance are possible, including the following (in order of complexity):

- **Generic manoeuvre, open loop** – pre-determined behaviour such as returns home, descending to an atypical region (such as below the height of nearest trees, builds or infrastructure) or landing somewhere safe[2]. Such guidance is triggered by the DETECT function, any discrete options evaluated by the DECIDE function, with COMMAND and EXECUTION dependent on the chosen level of automation. Such generic response behaviour may be implemented in an open-loop manner with no closed-loop coupling (FEEDBACK) between the intruder and ownship behaviour. However, it is still considered as DAA for integrated operations and must demonstrate appropriate performance according to the ARC.
- **Generic manoeuvre, closed loop** – pre-determined behaviour selected from a fixed or limited set of manoeuvre options, but executed with closed-loop (FEEDBACK) guidance during manoeuvre tracking or adjustment. While the tactical response itself remains generic rather than encounter-optimised, feedback may be used to improve execution robustness or maintain the intended separation objective under changing ownship or intruder conditions.
- **Optimised manoeuvre, open loop** – Manoeuvre evaluation and selection through optimisation of candidate trajectories or actions based on the detected encounter geometry, followed by execution of the selected manoeuvre in an open-loop manner without continuous feedback adaptation to intruder behaviour.
- **Optimised manoeuvre, closed loop** – Manoeuvre evaluation and selection with closed loop (FEEDBACK) guidance to maintain accepted ‘well clear’ separation from other traffic. Such behaviour enables integrated operations within busier areas and must demonstrate appropriate performance according to the ARC.

5.10 The generic tactical mitigation ‘DDCEF’ functions can be implemented within a DAA capability in many ways, with examples provided within various technical standards [16,17,18,20,21], covering both performance level requirements and architecture and algorithm design. Within these options there are some minor differences in terminology and functionality regarding different classes of UAS and classes of airspace. However, the core intended DAA functionality within these standards is typically comprised of the following:

- **Traffic surveillance** – The traffic surveillance function's purpose is to detect airborne traffic, using cooperative and non-cooperative sensors as required by the proposed operation. The traffic surveillance function can be implemented airborne and/or on the ground.

[2] Note that such a ‘land-away’ or very low flight decision should consider the trade-off between air and newly introduced ground risk.

- **Track processing** – The track processing function can be hosted on the ground or airborne (or a combination of both) and is responsible for acquiring data from the traffic surveillance function, creating tracks from detections, and managing tracks so they can be used by the alerting and guidance algorithms. Track management includes associating tracks from different sensors that belong to a single intruder to provide consolidated (fused) tracks, track prioritization, transforming frames to have tracks in a single reference frame for association purposes, and providing a unique interface to the alert and guidance algorithms (remain Well Clear and collision avoidance).
- **Traffic awareness and guidance display** – This function provides the Remote Pilot with situational awareness information related to all UA he/she oversees, the environment and possible hazards surrounding the UA, within a sufficient predicted time to allow him/her to understand the situation and take the correct decision regarding the evasive manoeuvre. This function, supported by the previous ones oversees:

- Display of single consolidated track for each detected airborne intruder, relative to the ownship, and display of ownship.
- Display of alerts from Collision Avoidance (CA) and Remain Well Clear (RWC)
- Display of CA and RWC guidance
  - **Remain Well Clear (RWC)** – Providing alerting and guidance to maintain any intruder aircraft outside of a pre-defined DAA Well Clear (DWC) volume., i.e., remain a sufficient distance from other aircraft such as not be considered a collision hazard.
  - **Collision Avoidance (CA)** – Providing alerting and guidance to maintain any intruder aircraft outside of a pre-defined Near Mid Air Collision (NMAC) volume.

5.11 Aside from the primary DAA functions the secondary functions of DAA are:

- **Monitoring its health** – Health management is supported both by on-board and ground-based surveillance equipment. Health Management function goal is to manage functions provided by the DAA system in operational, standby, failure or other modes deemed required by applicant.
- **Managing its modes** – This involves overseeing the different operational modes of the DAA system to ensure it functions correctly under various conditions and scenarios.

- In operational mode, the DAA system is fully active and functioning as intended. It continuously monitors the airspace, detects potential conflicts with other aircraft, and provides alerts and guidance to avoid collisions. The functions are provided depending on the phase of flight and are managed through controls, or automated behaviour.
- In standby mode, the DAA system is powered on but not actively monitoring or processing data. It is ready to switch to operational mode when needed.
- In failure mode, the DAA system has encountered a malfunction or error that prevents it from performing its intended functions. This mode requires immediate attention to diagnose and rectify the issue, potentially triggering abnormal or contingency behaviours.

- **Logging information and events for further processing** – The DAA system logs critical information and events, which can be used for further analysis and processing as well as maturation of the system. This logging function is essential for maintaining a record of the system's performance, diagnosing issues, and improving future operations. The logged data can include details about system health, operational modes, and any anomalies or incidents that occur during flight. This information is invaluable for providing evidence of system performance, continuous improvement and ensuring the reliability and safety of the DAA system.

5.12 Finally, it should be noted that the various functions discussed above may each be implemented at different levels of automation. Although various automation frameworks exist, the JARUS preference is shown below [11] which defines automation on a function-by-function basis, focussing on the division of authority / responsibility between human and machine elements of the overall system[3].

- **Level 0** – Manual Operation: The human is fully responsible for function execution, with no machine support.
- **Level 1** – Assisted Operation: The machine operates in an out-of-the-loop supporting role to the human in executing the function, e.g., provision of relevant information.
- **Level 2** – Task Reduction: The machine operates in an in-the-loop management role in reducing human workload to accomplish the task, e.g., conflict alert and resolution advisory based on predicted flight paths.

[3] Issues related to ownership of liability between the remote pilot and the operator are discussed in a Law Commission study on Autonomy in Aviation (Aviation autonomy: final report – Law Commission)

- **Level 3** – Supervised Automation: The machine executes the function under the supervision of the human who is expected to monitor and intervene as required, e.g., an automatic traffic collision and avoidance (TCAS) system tied to an autopilot which can automatically perform a manoeuvre when a Resolution Advisory is alerted.
- **Level 4** – Manage by Exception: The machine executes the function alerting the human in the event of an issue. The human is not required to monitor the function in real time and is able to intervene at any time after being alerted by the machine to an issue.
- **Level 5** – Full Automation: The machine is fully responsible for function execution. The human is unable to intervene in real-time either due to practical limitations or deliberate exclusion within the ODD.

5.13 For example, it is possible to utilise directive guidance from the DAA capability at the following levels of automation:

- **Level 2** – Directive guidance provided to the Remote Pilot, who is then responsible for command and execution.
- **Level 3** – Directive guidance is automatically commanded and executed, with the Remote Pilot responsible for supervising appropriate behaviour and execution.
- **Level 4** – Directive guidance is automatically commanded and executed, with the Remote Pilot only required to supervise or intervene in the event of an error or other abnormal behaviour.
- **Level 5** – Directive guidance is automatically commanded and executed, without any Remote Pilot oversight or intervention.

Interaction with Standardised European Rules of the Air (SERA)

5.14 Focussing only on the collision hazard with other aircraft, the relevant rules from SERA [8] are:

a) SERA.3201, which states that nothing within SERA relieves the pilot-in-command of an aircraft from the responsibility to take collision avoidance action. The GM also requires "… vigilance [on-board an aircraft] for the purpose of detecting potential collisions…".

b) SERA 3205, which requires to not operate an aircraft in such proximity to other aircraft as to create a collision hazard.

c) SERA 3210, which defines the right-of-way rules between certain types of aircraft, and manoeuvres that must be taken to avoid collisions.

5.15 The DAA system enables the RP[4] to exercise their responsibilities about the above rules and hence other aircraft. The specifics of the required DAA capability can expect to be dependent on the equipage requirements of the air environment.

5.16 The ICAO DAA Manual [6] states that DAA Remain Well Clear manoeuvres are intended to respect the right-of-way rules of SERA. However, DAA Collision Avoidance manoeuvres allow the RP to 'take any action necessary to best avoid a collision', which is 'similar to Airborne Collision Avoidance System (ACAS)'. Also required by [6] is that when operating under a separation service, then RWC alerting must provide sufficient time to coordinate a required manoeuvre with ATC. Collision Avoidance manoeuvres do not require coordination with ATC.

5.17 The UK CAA has recently conducted a review of the SERA conflict management rules and concluded that UA should not be identified as a new category of aircraft. The review concluded that large UA are likely to be treated as manned aircraft (due to difficulty determining if manned or not), and that creating a sub-category of UA to be treated differently risks misidentification and confusion over right-of-way responsibilities.

5.18 However, it is recognised that visual detection of 'smaller' UA from the cockpit of manned aircraft may be limited, and EC-in detection of the UA by the manned is not currently expected to be mandated, hence UA are to resolve any conflicts at range.

5.19 Where UA are expected to operate BVLOS and integrate with manned aviation the mitigations provided by see and avoid may limit the pilots' ability to detect small UA. However, it is recognised that other situational awareness capabilities are available, e.g.:

a) Air Traffic Services

b) In the future FIS-B and/or TIS-B

c) EC-in

d) NOTAMS (as part of Flight Planning)

[4] Issues related to ownership of liability between the remote pilot and the operator are discussed in a Law Commission study on Autonomy in Aviation (Aviation autonomy: final report – Law Commission)

Chapter 6

UA-UA Encounters

Introduction

6.1 The objective of this section is to clarify initial expectations of DAA performance for encounters between unmanned aircraft. Encounters between unmanned aircraft and manned aircraft are discussed in chapters 7, 8 & 9 of this policy concept.

6.2 Two distinct categories of Unmanned Aircraft (UA) are considered within DAA related technical standards:

- **Small UA** – <55lbs [18], and wingspan <25ft [21]
- **UA** – Unmanned aircraft not meeting the criteria above.

6.3 This results in the following three types of UA-UA encounters being possible:

- UA / UA
- Small UA / UA
- Small UA / small UA

6.4 DAA performance requirements for UAS encountering manned aircraft are defined in Chapter 7 (DAA02), with the primary safety metrics defined via Logic Risk Ratio (RR) for two distinct protected volumes, Near Mid Air Collision (NMAC) and DAA Remain Well Clear (DWC). The remainder of this Chapter discusses the required protected volumes and RR performance for the above types of encounters.

UA / UA & small UA / UA Encounters

6.5 Regarding any encounter with a ‘larger’ UA, e.g., UA / UA or small UA / UA, the RR performance and protected volumes required for manned aircraft shall be used. These are defined according to ARC, see Chapter 7 DAA02 for further detail.

Small UA / small UA Encounters

6.6 Within the DAA technical standards some consensus has been reached regarding a smaller NMAC volume for small UA / small UA encounters:

- sNMAC = ‘hockey puck’ 50ft horizontal radius, +/- 15ft vertical

6.7 This reduced NMAC volume was originally proposed by [34], and has since been adopted by ASTM [21] and RTCA [18]. The volume was derived from Monte Carlo simulation studies based on advertised small UA and General Aviation dimensions and typical flight profiles. The proposed value was chosen to maintain the conditional probability of MAC given sNMAC = 10% but explicitly does NOT account for navigation or surveillance uncertainty.

6.8 Both ASTM and RTCA adopted this reduced protected volume while maintaining the associated NMAC RR of 0.18 for cooperative intruders (in the absence of explicit regulatory guidance). No competing definitions have been identified in the literature.

6.9 Regarding the DWC volume, no consensus was found in the literature. A single published study [35] was identified where a small Well Clear (sWC) volume was proposed in support of either Bluetooth or Wi-Fi Remote ID surveillance. The proposal was a hockey puck volume of 113ft radius +/- 34ft vertical. Additionally, RTCA [18] explicitly state that they do not believe that the DWC concept is applicable to small UA / small UA encounters.

6.10 Discussion of the above options within the CAA's DAA Technical Working Group identified the following concerns:

1. Different protected volumes for different classes of encounters introduce additional complexity, where different intruder aircraft require different protected volumes (how does an air user know what volume to use?).
2. Would airspace restrictions be necessary? (e.g., small UA only volumes), noting that this is not in line with the current AMS.
3. Is sNMAC volume (50ft horizontal, +/- 15ft vertical) too small to be practical given expected navigation and surveillance uncertainty?
4. Dropping the DWC volume removes a safety layer of 'Well Clear' protection and reporting which is a leading indicator for NMAC events. Do we really want to enable a higher risk of small UA – small UA MAC compared to other aircraft?

6.11 However, it is also recognised that maintaining the manned aircraft protected volumes (NMAC and DWC) for small UA / small UA encounters is likely to be prohibitively conservative, resulting in a higher safety standard being applied to small UA / small UA (due to the reduced conditional probability of MAC given NMAC). This approach may also result in unnecessarily low-capacity limits for certain environments, e.g., Multiple Simultaneous Operations (MSO).

6.12 The following options were proposed:

a) Maintain common protected volumes, testing to understand the impact on MSO environment, e.g., via simulation studies with different integration concepts.

b) Trial dedicated high density small UA MSO zones with reduced protected volumes (sNMAC and possibly sDWC), ensuring any required access by manned aircraft (e.g., Helicopter Emergency Medical Service) is deconflicted separately.

c) Remove the DWC layer but maintain the protected NMAC volume that is common to manned aircraft. This should ease capacity limits for MSO environments and ensures that any unexpected encounters with manned aircraft are protected by the normal NMAC volume.

6.13 From the above options, (c) was recommended by the DAA TWG as an incremental and conservative step during the remainder of this policy concept test phase. In parallel to this, testing can be conducted to understand the impact of the different options on MSO capacity limits.

Chapter 7
Requirements

7.1 The regulatory context within which this policy sits is UK SORA [15], where an increasing level of tactical mitigation and robustness is required for each Air Risk Class (ARC). The DAA requirements support this by establishing the three distinct categories of DAA capabilities shown in Table 1, differentiated primarily by the required level of system robustness and assurance. DAA based tactical mitigation of air risk is not required in ARC-a, since the residual risk in this case is deemed acceptable. For ARC-d existing technical standards are available and ICAO DAA SARPS are in progress, therefore the focus of the DAA requirements for V2 of this policy concept is the ARC-b and ARC-c environments.

ARC	Robustness
ARC-a	n/a (DAA mitigation is not required)
ARC-b	Build to a lesser standard, reduced cost capability for low-risk environments, e.g., elements of ASTM F3442-25 (low risk) & Eurocae (Draft[5]) ED-330 (ARC-b).
ARC-c	Corresponding robustness to existing aviation systems, e.g., CS-23, elements of ASTM F3442-25 (medium risk), DO-396 & Eurocae (Draft) ED-330 (ARC-c).
ARC-d	Highest safety standard environment, e.g., ICAO DAA SARPS (Draft), EUROCAE ED-275/RTCA DO-386 (ACAS Xu), EUROCAE ED-264/RTCA DO-38 (MASP for ACAS interoperability), RTCA DO-365, ED-329 (Draft): MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR DETECT AND AVOID [TRAFFIC] IN CLASS A-G AIRSPACES UNDER IFR.

Table 1 – Increasing Robustness per UK SORA Air Risk Class

7.2 The proposed set of DAA requirements for both ARC-b and ARC-c environments are provided in Table 2.

DAA01	ARC-b & ARC-c

[5] Draft documents are referenced here to highlight ongoing developments and expected future standards.

	The applicant shall document and submit with the application the proposed DAA system design with sufficient detail to allow assessment of the proposed compliance strategy.
DAA02	ARC-b & ARC-c The nominal DAA capability shall meet the following Logic RR performance requirements: Cooperative with coordinating manoeuvre: NMAC RR ≤ 0.04, LWC RR ≤ 0.4 Cooperative: NMAC RR ≤ 0.18, LWC RR ≤ 0.4 Non-cooperative: NMAC RR ≤ 0.3, LWC RR ≤ 0.5 The NMAC volume is defined as 500 ft horizontally and +/-100 ft vertically around the ownship, and Well Clear Volume is defined as 2000 ft horizontally and +/-250 ft vertically around the ownship. *Note-1, Application of the above performance requirements (e.g., cooperative or non-cooperative) is dependent on the expected traffic in the operating environment, as may be understood by either airspace characterisation or NAA equipage requirements.* *Note-2, ASTM F3442–25 refers to a MAC proxy rather than NMAC, basing the definition on a 10% conditional probability of MAC given an MAC proxy event. The ASTM standard volume for MAC proxy is as used here, with an option for alternative volumes if 'deemed appropriate'.* *Note-3, current definitions of NMAC and WCV (Well Clear Volume) apply to UAS vs. manned intruder aircraft or large UAS vs. large UAS. However, small UAS vs. small UAS may have different volume definitions.*
DAA03	ARC-b & ARC-c In addition to the primary RR safety metrics, the applicant should also consider the use of secondary safety and operational suitability metrics (discussed in DAA03.GM2) providing suitable justification if they are not used in the DAA system performance assessment. Performance assessment metrics must include the following:

	• Induced LWC or NMAC • Severity of LWC • Reversal rate (for systems which provide guidance) • Operational suitability via the rate of unnecessary manoeuvres, missed alerts, false alerts and late alerts.
DAA04	ARC-b & ARC-c A Human Factors evaluation is required to demonstrate that the DAA Human Machine Interface (HMI) and Remote Pilot operating procedures are appropriate and timely for the intended use of the DAA function. The Remote Pilot will interact with the HMI in the control station to follow the DAA functions.
DAA05	ARC-b & ARC-c During evaluation of the performance of the DAA capability any individual encounters that result in a LWC, NMAC, induced LWC or induced NMAC must be investigated to understand the causation of the issue(s). Errors in the logic must be corrected, and deficiencies or limitations explicitly identified in system operating limitations and procedures.
DAA06	ARC-b & ARC-c In addition to the nominal system performance requirement (DAA02) a sensitivity analysis shall also be conducted to ensure that the designer, operator and authority all understand the variability of system performance to key design parameters.
DAA07	ARC-b & ARC-c Simulation assessment of the RR performance of the DAA capability must be based on an encounter set that accurately represents the proposed operating environment.
DAA08	ARC-b & ARC-c The accuracy / fidelity (suitability) of all simulation models used for performance assessment must be evidenced.
DAA09	ARC-b & ARC-c The DAA capability shall be capable of simultaneously processing, tracking and prioritising an appropriate number of intruder aircraft

	based on the expected traffic density in the operating environment and the manoeuvrability of the ownship.
DAA10	ARC-b Allowable loss of function shall be less than 1x10-2 per flight hour. ARC-c Allowable loss of function shall be derived from a '1309 like' approach, based on the agreed loss of DAA function severity and the applicable probability of a conflict with another aircraft.
DAA11	ARC-b Hazardously misleading information shall occur less than $1x10^{-3}$ per flight hour. ARC-c Allowable hazardously misleading information shall be derived from a '1309 like' approach, based on the agreed loss of DAA function severity and the applicable probability of a conflict with another aircraft. *Note, hazardously misleading information is introduced by undetected software or hardware faults.*
DAA12	ARC-b & ARC-c DAA systems that are dependent on the C2 link (e.g., those utilising non-automated guidance or ground based surveillance or processing) must have suitable contingency mitigation for MAC in the event of lost C2 link, unless the C2 link can be demonstrated to be suitably reliable.
DAA13	ARC-b & ARC-c The Remote Pilot (RP) must be alerted within an appropriate timeframe of any in-flight degraded or lost function that impacts DAA performance or requires contingency actions.
DAA14	ARC-b & ARC-c DAA system failures where degraded performance cannot be detected in-flight must be identified in advance.
DAA15	ARC-b & ARC-c

	A maintenance plan is required for the DAA system, including the ability to detect pre-flight failures.
DAA16	ARC-b Independent validation of EC tracks is not required unless GNSS jamming, spoofing, and / or intruder track spoofing is identified as a specific risk for the operating area. ARC-c Independent validation of EC tracks is required, and the DAA system (and ownship position, navigation and timing) must be resilient to GNSS jamming and spoofing by design, unless the operating environment is such that this risk is agreed as acceptable by the NAA.
DAA17	ARC-b & ARC-c The expected accuracy / uncertainty of any other required data (e.g., terrain elevation, feature location or weather) must be defined and used by the DAA system performance assessment. The applicant shall provide evidence to support the defined values.
DAA18	ARC-b & ARC-c The DAA capability shall include an Incident log, and if requested by the authority the operator shall supply routine operational performance reports to enable oversight & performance monitoring.
DAA19	ARC-b & ARC-c DAA specific updates to Remote Pilot training and standard operating procedures shall be identified.
DAA20	ARC-b & ARC-c Environmental limitations on the DAA equipment when installed in the operational system must be identified.

Table 2 – DAA Performance Based Requirements

Chapter 8

Indicative Means of Compliance and Guidance material

8.1 The table below contains material for each proposed requirement that could lead to AMC / GM at the end of the policy concept test phase. This material may be considered by the applicant during determination of the compliance basis, following the process defined in Chapter 4.

DAA01.MOC1	The applicant shall define the DAA system using the definitions and terminology defined within Chapter 5 of this policy concept. Any technical standards used for the design and development of the system should be explicitly referenced. The list of DAA capabilities to be documented as a minimum are: • Functional and physical system architecture diagrams, defining airborne and ground- based elements of the system, interfaces with the wider UAS and any dependencies on the C2 link. • Alerting scheme, including timeline and trigger conditions. • Type & complexity of guidance. • Levels of automation for the key DAA capability functions, using the JARUS framework defined in [12]. At a minimum this should address the 'DDCEF' functions. • Right of way expectations (Functional or manual). • Ownship performance. • Declaration Volume, and any dependencies on intruder types. • Sensor Field of View (FOV)/Field of Regard (FOR). • Surveillance equipment, accuracy, and any dependencies on intruder types. • Environmental operating conditions (OSO#23). • Data integrity.

	• Latencies, including system processing, C2 link and Remote Pilot response time. Note that justifications on the selected parameters and algorithms required by the applicant via simulation and / or flight test. A timeline analysis is also required to demonstrate the suitability of the selected parameters and algorithms for the operations. An example timeline analysis is provided in ASTM F3442–25.
DAA02.MOC1	Refer to the DAA qualification tests defined in Chapter 9. The full test of ARC-b / ARC-c qualification tests must be conducted, with the logic RR performance requirements demonstrated primarily via the fast-time simulations. If necessary, the applicant may adapt the example analysis for each test mode to suit the proposed DAA capability, justifying any proposed deviation. However, to allow performance comparison between different systems standardisation of both the protected volumes and the encounter set is necessary. Any deviations from the qualification tests should therefore be Justified by argument / evidence.
DAA02.GM1	The primary internationally accepted DAA safety metric, in common with that used for Airborne Collision Avoidance System (ACAS) / Traffic Collision Avoidance System (TCAS), is a risk ratio defined as follows: $$Risk\ Ratio\ (RR) = \frac{\text{Probability of an event occurring WITH the mitigation in place}}{\text{Probability of the same event occurring WITHOUT the mitigation in place}}$$ Equation. 1 A RR is a dimensionless quantity that captures as a percentage the relative benefit of a mitigation. It is a metric that assesses the performance of a DAA system, aiming to satisfy the target level of safety of the airspace ARC. A smaller value denotes improved performance, e.g., a RR of 0.1 indicates that 90% of events have successfully been mitigated. Two types of RRs are typically quoted: • Logic RR, which is the net benefit of the mitigation assuming nominal performance (incl. sensors, comms,

	human, manoeuvring, etc.) against expected encounter rates and encounter geometries. Logic RRs are quoted by ICAO for TCAS performance [4], ASTM F3442–25 and are also planned for ICAO DAA performance. • System RR, which includes failure conditions (e.g., hardware, software, human), unusual or unexpected encounter rates or geometries, and operations in adverse environments. System RRs are quoted within JARUS SORA V2.5 (Annex D). Based on the DAA intended functions of Remain Well Clear (RWC), and Collision Avoidance (CA) described in Chapter 5, DAA system performance can then be measured by two distinct RRs: $RR\ (LWC\|Enc) = \frac{P_{Mitigated}(LWC\|Encounter)}{P_{Unmitigated}(LWC\|Encounter)}$ Equation. 2 $RR\ (NMAC\|Enc) = \frac{P_{Mitigated}(NMAC\|Encounter)}{P_{Unmitigated}(NMAC\|Encounter)}$ Equation. 3 Where: • P(X|Y) is the conditional probability of event X given that event Y has occurred. • CA = Collision Avoidance • LWC = Loss of Well Clear • NMAC = Near Mid- Air Collision The use in the RR definition of conditional probabilities rather than unconditional probabilities ensures that performance is comparable regardless of the encounter rate. Additionally, the use of a ratio ensures that the result is not dependent on the definition of an encounter.
DAA02.GM2	Evaluation of avoidance functionality may be based on a combination of different testing approaches, including: • *Fast-time simulations* - involves running many scenarios in a compressed timeframe using computer models, which allows for rapid assessment of system

	performance across a wide range of scenarios, while identifying potential issues and optimizing system parameters before moving to more resource-intensive tests. • *Real-time simulations* - involves testing the DAA system in a simulated environment that mimics real-world conditions in real-time. This includes human-in-the-loop (HITL), hardware-in-the-loop (HIL) and Software-in-the-loop (SITL) simulations where human interaction and actual system components are tested within the simulation. This kind of simulation provides a realistic assessment of system performance under real-time conditions, ensuring that all system components work together seamlessly, and can help identify and resolve issues that could arise during actual operations. • *Live-virtual constructive (or "hybrid simulations")* - combines live (real-world), virtual (simulated), and constructive (computer-generated) elements to create a comprehensive test environment. This allows for the interaction of live ownship and DAA system with virtual and constructive elements (e.g., simulated intruder). This kind of testing evaluates DAA system performance in complex, multi-faceted scenarios that are difficult or impossible to replicate in the real world (e.g., simulating collisions between aircraft). It could also provide realistic training environments for UAS operators, improving their readiness and response. • *Bench test* - involves testing individual components or subsystems of the DAA system in a controlled laboratory environment. This can include testing sensors, processors, and other hardware components to ensure that each component meets its specifications and performs as expected. This test helps to detect and resolve issues at the component level before full system integration. • *Field tests* - involves testing the DAA system or its components in real-world conditions, typically in designated test area. This includes testing the system's/components' performance in actual flight scenarios to confirm that they perform as expected in real-world conditions. This test also helps to assesses

	the impact of environmental variables such as weather and terrain, on the system/component performance and ensure that they can handle the complexities of real-world operations. • '*As-built' full system trials* - involve testing the fully integrated DAA system as it will be used in actual operations. This includes end-to-end testing of the entire system in real-world conditions to provide the final confirmation that the system meets all operational requirements and is ready for deployment. The scope and rigour of tests may be adapted to the complexity of the DAA capability, its automation level, manoeuvre options and the risk of the intended operation, provided that the resulting analysis maintains equivalent demonstration power for the relevant performance requirements.
DAA02.GM3	Within several parts of the DAA performance qualification tests referenced above there is a requirement for an 'instrumented' intruder aircraft. This note provides guidance regarding suitable equipment. For intruder aircraft position and track (in lieu of heading) an aviation grade GPS receiver (TSO-C129, or C145, or C146) with data logging would suffice. If these are not available then a standard C/A code GPS receiver (e.g. such as those built into tablets and smartphones) is acceptable, albeit potentially slightly less accurate. If orientation is needed as well, then an attitude reference source from the aircraft is needed. If the aircraft has integrated avionics (e.g. Garmin 1000 or newer), then it might be possible to record AHRS, air data and position from the avionics directly.
DAA03.MOC1	Performance results from the chosen secondary safety and operational suitability metrics should be extracted from all ARC-b / ARC-c DAA qualification tests defined in Chapter 9.
DAA03.GM1	Secondary safety and operational suitability metrics are an important way to understand the performance and behaviour of the DAA capability beyond the high-level RR requirements.

	Alert rate & nuisance alerts are influenced by surveillance performance, in particular intermittent or false detections. Alert rate & nuisance alerts can also be influenced by the conservativeness of the algorithm, giving additional space to manned aircraft and providing more time to act. Such behaviour tuning is sensitive to the operational environment, in particular the expected density and behaviour of other traffic.
DAA03.GM2	Secondary safety metrics that are commonly used include: • Probability (or number of) induced NMACs or Loss of Well Clear (LWC) – An induced NMAC or LWC is one that happened only in the mitigated scenario where the DAA system was active. • Probability (or number of) unresolved NMACs / LWC – It is important to note that achieving a RR performance does NOT mean that NMAC or LWC will not occur. The RR is simply a comparative measure of the improvement in safety when the DAA system is added. Therefore, the CAA may also want to review the probability or number of NMACs or LWCs that occurred during acceptance testing. • Probability (or number of) of unnecessary manoeuvres. • Severity of LWC – This can be reported as a percentage of penetration into the WC volume, and potentially also the time spent by the intruder within the DWC volume. • Horizontal & vertical miss distances – To avoid having to consider different aircraft shapes, penetration into the NMAC volume can be considered as a collision and therefore miss distance is measured from the NMAC volume boundary. This is also often referred to as the Closest Point of Approach (CPA). Operational suitability metrics that are commonly used include: • Alert rate / frequency – The percentage of encounters where an alert was issued. • False alert rate – The percentage (or number) of encounters where alerts were issued unnecessarily, e.g.,

	when other traffic is appropriately separated under a separation service (ATC / UTM). • Missed alert rate – The percentage of encounters where the system failed to detect conflict or notify about NMAC or DWC volume penetration • Reversal rate – The percentage of encounters where direction reversing guidance is provided. • Split rate – The percentage of encounters where a second alert is issued after notifying clear of conflict. • Flight path deviations – Noting that it may be desirable to minimise the deviation from a planned flight path in response to DAA guidance, which may prevent induced NMACs or Loss of Well Clear. • Alert timings – Where sufficient time may be required to react to the situation, coordinate with ATC (when relevant) and execute the manoeuvre. • Number of false tracks by the DAA sensor(s) - Refers to the count of instances where the DAA sensor incorrectly identified intruder aircraft, or the object did not actually exist. • Number of split tracks by the DAA sensor(s) - The number of occurrences where a single intruder aircraft was represented by multiple tracks by the DAA sensor. • Number of missed detections/tracks by the DAA sensor(s) - Indicates the count of times the DAA sensor failed to detect or track an intruder aircraft. Additional detail on multiple open and closed loop DAA metrics is available in RTCA DO-365c Appendix L and the FAA Operational Validation report for sXu [23]
DAA04.GM1	This requirement is linked to OSO#20; therefore, it should be applied according to the level of integrity and assurance required for the intended SAIL of the operation. The SAIL is currently determined in Step 7 of the SORA process and considers both the air risk class and the ground risk class.
DAA04.GM2	An assessment of the HMI design principles against relevant aviation standards (e.g., ACAS-II, others, TBC) shall be conducted.

	This assessment should take into consideration the human response to each of the DDCEF functions and the ability to perform them in terms of accuracy and time. Consideration should also be given to operational context (e.g., extended periods without alerts) and operational suitability metrics defined in DAA03.GM02. All relevant information should be presented to the Remote Pilot in the control station intuitively and without causing saturation. The display of information should achieve a balance between situational awareness and available information. The HMI in the control station shall include, as a minimum: • Display of Traffic information relative to ownship, including declaration range and Field of View. • Timely alerts to remain Well Clear (DWC as defined per standard). • Timely alerts if needed to coordinate with other traffic (under IFR operations for certified equipment in ARC-c) • Support for the execution of remain Well Clear manoeuvre before the collision avoidance (CA) alert occurs. • Support for the execution of collision avoidance manoeuvre (dependant on the level of automation selected and the teaming of human operator with the automation?) • Guidance and time to command the manoeuvre (if provided, and dependant on the level of automation). This should consider if the command is suggested, directive or informative [Ref within this document]. Some consideration regarding the installation of the DAA equipment as a separated component of the UAS system: • Controls and displays of the DAA HMI should be accessible from the Remote Pilot's position in the control station. • HW and SW compatible with the HMI of the control station.

	• Operation of the equipment should not affect the aircraft manoeuvres or control under normal operation (i.e. not with the RWC or CA alerts on). • Timeliness of data transmission and latency.
DAA04.GM3	General applicable standards and guidance that could be relevant to DAA displays are covered under Human Factors for Aircraft Design: • Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Controls_V2 • CS/AC 25.1302-1 - Installed Systems and Equipment for Use by the Flight crew • AC_25.1322-1.pdf which provides guidance for regulations at eCFR :: 14 CFR 25.1322 -- Flight crew alerting. (CS/FAR 25.1322) • Human Systems Integration (HSI) Guidebook (US DoD May 2022) • MIL-STD-1472 / Def Stan 00-251 - Display of critical information to consider human capabilities and limitations. Additionally, the following reference provides an example HF evaluation on ACAS Xu: *C. L. Smith, R. C. Rorie, K. J. Monk, J. N. Keeler, and G. Sadler, UAS pilot assessments of display and alerting for the Airborne Collision Avoidance System Xu. Human Factors and Ergonomics Society 64th International Annual Meeting, Chicago, IL, 2020.*
DAA05.GM1	It is essential to investigate LWC / NMAC events to help identify any deficiencies in the capability and ensure that they are not hidden by the probabilistic nature of the RR assessment. Although it is recognised that during fast time simulation the number of encounters assessed may prohibit individual investigation of each discrete event, it is expected that common themes may emerge and be grouped. This applies to all ARC-b / ARC-c DAA qualification tests defined in Section 6.

DAA06.MOC1	Refer to the DAA qualification tests defined in Chapter 9, where an example sensitivity analysis is defined for ARC-b and ARC-c fast time simulation. If necessary, the applicant may adapt the example analysis to suit the proposed DAA capability, justifying any proposed deviation. However, to simplify comparison across different capabilities any deviations from the qualification tests should be minimised wherever possible.
DAA06.GM1	Note that ICAO SARPS for DAA systems are not expected to specify off-nominal performance, stating rather that the reduced performance should be proportionate to the degradation. Note also that the NATO SAA standard [25] does provide example off-nominal performance, based on subject matter expertise of both authorities and applicants.
DAA07.GM1	Assessment of system performance metrics is based on an agreed *encounter set*, which define the complete set of air-to-air conflict encounters to be considered. DAA system metrics provide a relative measure of performance against a specific encounter set, and specific NMAC and DWC volumes. Therefore, it is critical that these are standardised to allow comparison of different system performances. NATO Sense and Avoid Standard [25] recommends that encounter sets shall have the following properties: • *Relevance* – To expected intruder types, equipment carriage and operating rules. Note that this must also consider military traffic that may be present within the operating volume. • *Realism* – Approach geometries should be physically possible and distributed / weighted by likelihood. • *Range* – Spanning the defined variables of interest, including timeline (early and late detection), approach geometries (including variance in horizontal and vertical miss distances), sensor performance, intruder types, pilot response, ownship manoeuvrability, environmental conditions, etc.

	• *Resolution* – Proportionately discretising the range of the encounter set variables to ensure that the results are statistically significant. Standard encounter sets exist for ACAS evaluation in different air environments, and there is a need to identify suitable encounter sets for the types of UAS operations addressed by the SORA. These encounter sets may also vary per country depending on national specificities. It is therefore essential that authority agreement is obtained on the encounter set ahead of final performance evaluation. Selection of an operationally representative encounter set also helps identify any potential issues regarding compatibility of the DAA capability avoidance manoeuvres with expected traffic. If local airspace characterisation data is available, then this may be used to tailor the encounter set characteristics to the specific operating region. If no such data is available, then Chapter 9 provides examples of standard encounter sets that may be used.
DAA08.GM1	Simulation model validation is usually defined to mean "substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model" [33]. For the simulated DAA capability to represent real-world performance (e.g., fast time simulation for generation of logic RR performance) it is essential to ensure that the modelled performance *conservatively* represents the real-world performance. Key system parameters to be modelled include the following: • Surveillance performance, including, declaration volume, accuracy and latency, false / missed tracks (as dependent on intruder type, orientation, encounter geometry and EC equipment) • Ownship navigation performance, e.g., inherent inaccuracies in sensed position, altitude, speed, heading • Ownship manoeuvre performance, e.g., climb rate, descent rate, turn rate, acceleration, deceleration, which may also include UA autopilot control.

	• C2 link latency • DAA processing latency (algorithm development) • Remote Pilot response time • Terrain elevation or other data used by the system The ASTM DAA test methods standard [22] discusses methods through which the realism of a simulation model may be demonstrated, including the Bhattacharya coefficient which can be used to show similarity between two probability distributions. Additionally, as another example of modelling accuracy, the NATO Sense and Avoid Standard [25] requires that single parameter simulation elements (e.g., C2 link delay, pilot response, sensor tracking range) no less than the 95-percentile value is used for performance assessment. [25] also allows simulation elements to be modelled as probability distributions if more representative. It is important to note that Standard error models (e.g., bearing error from ACAS) may be valid for certified platforms, but not for small UAS. Installation affects sensor performance, especially on small UAS. The applicability of such models shall be shown by the applicant for the platform in question. Finally, as a supplement to DO-178 & DO-254, DO-330 / ED-215 addresses software tool qualification.
DAA08.MOC1	Refer to the DAA qualification tests defined in Chapter 9, where an example field test validation of surveillance sensors is defined. Such a test may be used to justify the sensor performance model used in the DAA performance assessment. If necessary, the applicant may adapt the example analysis to suit the proposed DAA capability, justifying any proposed deviation. However, to simplify comparison across different capabilities any deviations from the qualification tests should be minimised wherever possible.
DAA09.GM1	Refer to appropriate technical standards for examples of intruder track capacity, e.g., [16,17,18,20,21].

	In addition to ensuring tracking of a minimum number of intruders, care must be taken to ensure that the maximum number of tracks that may be detected does not result in processing time budgets being exceeded. Note also that the maximum track count may need to consider false tracks, as dependent on the characterised surveillance performance.
DAA10.GM1 & DAA11.GM1	Refer to OSO#4 (SAIL-IV upwards) and OSO#5 (SAIL-III upwards) of the SORA methodology, where the SAIL dependent probability of loss of operational control rates, and expected level of integrity and assurance are defined. The DAA capability may be considered a novel and possibly complex component. DAA specific elements for these OSOs should therefore be identified and a Functional Hazard Assessment conducted. The failure of DAA equipment should not degrade the operation of other systems connected to it. Likewise, the failure of other components which are connected to the DAA equipment should not affect its operation. If a '1309-like' analysis is required then it may refer to the assumed loss of control rates for the SAIL, as well as any layered mitigations that reduce the severity of an outcome.
DAA10.GM2 & DAA11.GM2	The 'Soak Test' defined in DAA Performance Qualification tests (Chapter 9) acts in support of these requirements. Software and hardware implementation rigour is provided by suitable development assurance and testing, e.g., DO-178 / ED-12 and DO-254 / ED-80 which provides guidance to produce software and hardware with a level of confidence appropriate for associated failure condition severity. Such implementation rigor is expensive and time consuming to provide, and less guidance currently available for specific category UAS systems. Examples include ASTM F3201-16 and ASTM F3153-22. Additionally, EUROCAE have a working group (WG-127 / Lower Risk Aviation Applications) to create a software development standard for EASA Specific Category UAS operations.

	The applicant is free to propose a different software development and testing process if these standards are considered as not proportionate for the application.
DAA10.GM3 & DAA11.GM3	The availability of these systems may be demonstrated by ASTM F3442-25: (1) Showing redundancy in the equipment providing that function. An analysis of a redundant system in the UA is complete if it can demonstrate isolation between redundant system channels and reliability for each channel; or (2) In the case where a single failure leads to a failure condition, by demonstrating that the system is simple, uses conventional architecture, is appropriately qualified for the installed environment and the individual failure rates of its components are below the objective indicated in DAA10 and DAA11.
DAA12.GM1	The applicant should identify any additional MAC barriers that are available, for example: • The ability to warn other air users, e.g., via available ANSP / UTMSP services, VHF radio broadcast, transponder squawk code, etc. • The ability for other air users to detect and avoid the UA, e.g., via visual conspicuity or electronic conspicuity supporting situation awareness or ACAS equipment NAAs may be willing to consider an ‘exposure to risk’ argument, as influenced by: • The likelihood & duration of a C2 link loss (dependent on OSO#6) • The volume & type of traffic in the operating area (dependent on ARC). • The UA behaviour during a C2 link loss (dependent on OSO#8). • The availability and effectiveness of identified MAC barriers.
DAA12.GM2	Any impact on Remote Pilot operating procedures must be identified and will be reviewed in OSO#8.

DAA13.GM1	The DAA system shall incorporate a failure functionality so that it is possible to know if the DAA is operative while airborne. To assess the performance of the DAA and be able to detect function failures, the following data quality parameters managed by the DAA system should be defined: • Accuracy • Resolution • Integrity • Uncertainty and error • Timeliness (update rate) and latency. Any probable failure of the data equipment or interface should not degrade the normal operation of the equipment or systems connected to it. When a DAA function depends on proper data quality of other systems, this should be considered in the system level safety assessment. An FHA and installation appraisal shall be considered. Mitigations to lower the probability of failures include health status, detection and redundancy. Note: DAA function might be affected by failures on the UA or in the control station. It should be considered that the CA manoeuvres automatically in case of failure of any of the systems (i.e. lost link).
DAA13.GM2	For ownship navigation that is dependent on GNSS there are several metrics from the receivers that may be monitored in real-time, including: • Horizontal Figure of Merit (HFOM) • Vertical Figure of Merit (VFOM) • Position Dilution of Precision (PDOP) • Number of satellites available For ADS-B surveillance several data quality metrics are available, including: • Navigation Integrity Category (NIC) • Navigation Accuracy Category – position (NACp) • Navigation Accuracy Category – velocity (NACv)

	In case of airborne DAA, relying on the C3 link to send and receive data from the control station, the Remote Pilot needs to have real time information of the C3/C2 datalink performance status during the operation. This datalink performance is linked to the air risk (ARC) of the airspace via OSO#6. Such metrics may be monitored in real-time for status outside of the nominal performance expectations, enabling contingency behaviour to be triggered if required. Remote Pilot operating procedures associated with DAA degraded performance will be reviewed in OSO#8.
DAA13.GM3	Examples from technical standards supporting this requirement include: • The NATO SAA standard [25] addresses this status monitoring by requiring individual SAA functions to report status as: on/off/degraded/failed. • ASTM F3442-25. The DAA system shall detect and notify the RP of any degradation or loss of function that requires the RP action or take a contingency/emergency measure to mitigate the risk in a timeframe adequate for the alerting condition. A degradation of function includes: any partial loss for functionality or a degradation of performance. Failures without means to be detected should be identified during system design and comply with the availability requirements. If the notification is required, it may be a specific message on HMI, an invalid value in the field of the loss of functionality or a specific code. • ED-76B, Standards for Processing Aeronautical Data - The DAA system status should be known to the Remote Pilot with a health status indicator. It can have three states: Normal, Degraded (where some of the functions are degraded, but the DAA system is operative) and Failed (DAA system inoperative). Examples are provided in DO-365B. • STANAG 4586 is Standard Interfaces of Unmanned Aircraft (UA) Control System (UCS) for NATO UA Interoperability. This standard considers Health and Status Messaging and Data link reliability.

DAA14.GM1	Health monitoring limitations should be explicitly identified in system limitations and potentially operating procedures (OSO#8). Additional ALARP barriers should be considered where practicable.
DAA15.GM1	This requirement is linked to OSO#3 and OSO#7; therefore, it should be applied according to the level of integrity and assurance required for the intended SAIL of the operation. The SAIL is currently determined in Step 7 of the SORA process and considers both the air risk class and the ground risk class. DAA specific maintenance activity & pre-flight check procedures (including objectives & limitations) must be identified for inclusion in the maintenance plan, e.g., • Maintenance plan and schedule. • Definition of maintenance processes and instructions. • Ensure/ certify that the maintenance plan has been completed according to instructions.
DAA15.GM2	ASTM F3442-25 Section 5.6 provides additional supporting information to address this requirement, including: • A methodology for anticipating and detecting failures and achieving adequate maintenance actions should be identified and implemented for the DAA system and its major subsystems and components. • Maintenance plan and schedule in accordance with the maintenance instructions provided by the DAA system manufacturer. The instructions shall provide direction as to verify proper installation and calibration of the system to ensure its proper function. • DAA system shall have a test function for detecting foreseeable system failures like degradations in the condition of the system that prevent its correct operations (i.e. memory faults, device failure, wearing out.). These failures are different from those due to unforeseen events during operation. Test function requirements should be based on system safety principles considering rate, exposure and criticality of latent failure.

DAA16.GM1	A requirement for independent validation of cooperative surveillance is expected to be influenced by: • The threat environment for GNSS jamming and spoofing within the operating volume. • The threat environment for spoofing of ADS-B tracks within the operating volume. • The integrity and assurance of the navigation source used by the cooperative surveillance sensor. The risk / consequence of manoeuvring against a spoofed intruder track may also be weighed against the risk of not manoeuvring against a track that has either not yet been validated or has failed validation.
DAA17.GM	*Reserved for future updates.*
DAA18.GM1	In addition to the usual Mandatory Occurrence Reporting (MOR) the competent authority will conduct an enhanced monitoring programme on any approved DAA enabled operations. This will ensure that the build-up of operational experience is monitored, and any unexpected consequences are identified. During the policy concept trial phase, it is expected that authorisation approvals will require monthly reporting[6] of the following: • BVLOS flight-time accumulated, delineated by segregated and non-segregated flights. • Encounter[7] rate against intruder aircraft. • Rate of intruder aircraft within the operating area that did not meet the encounter criteria, e.g., due to UA not being airborne, or at a sufficiently large distance. • Triggering of DWC or NMAC alerting or guidance.

[6] To be delivered to the CAA no later than the 11th day of the following month.

[7] For initial integrated BVLOS oversight operations an encounter can be approximately defined as an intruder aircraft within 6,000ft horizontally and +/- 750ft vertically of the ownship (~3x the DWV volume).

	• Retrospective analysis of operational airspace in comparison to any airspace characterisation conducted during application[8]. • Closest point of approach for any encounters where alerting or guidance is triggered. • Loss of DWC or NMAC, or other degradation of the agreed DAA performance and operational suitability metrics. • Technical or operational issues, e.g., surveillance performance worse than expected (late or intermittent detections), intermittent or lost C2 link, increased C2 Link latency, or other DAA function in-flight, implementation of abnormal or emergency procedures. • Any remote pilot intervention or override of DAA guidance. • Any remote pilot conflict management manoeuvre separate to DAA alerting and guidance. • Any encounter that resulted in a 'land-away' or flight termination. • For systems that are dependent on the C2 link for generation and execution of alerting and guidance additional C2 link performance data may be requested, including frequency and duration of dropouts and variation in link latency. The applicant shall log appropriate information to enable the above and is referred to ASTM F3442-25 and NATO standards [21,25] for further requirements on the DAA system incident log function, including sufficient data recording, timestamping, incident ID and data recovery.
DAA19.GM1	This requirement is linked to OSO#8, OSO#9 and OSO#16; therefore, it should be applied according to the level of integrity and assurance required for the intended SAIL of the operation. The SAIL is currently determined in Step 7 of the

[8] For example this may be a simple comparison of operational encounters against the expected encounter or alerting rate from prior airspace characterisation.

	SORA process and considers both the air risk class and the ground risk class.
DAA19.GM2	The RP training programme & SOPs shall include the following: • Simulation training, rather than just a briefing • DAA specific pre-flight checks • DAA specific health monitoring • DAA specific limitations • Any updates / reaction to the outputs of the HF assessment • Limitations of any presented data identified in DAA17
DAA20.GM1	This requirement is linked to OSO#23, and OSO#24; therefore, it should be applied according to the level of integrity and assurance required for the intended SAIL of the operation. The SAIL is currently determined in Step 7 of the SORA process and considers both the air risk class and the ground risk class. Note that environmental factors may significantly impact surveillance performance, which should be considered under DAA08. This is not just limited to non-cooperative surveillance. For instance, a function may be required to detect environmental conditions, especially if operating under VMC. OSO#24 refers to available tests for environmental conditions [RTCA DO-160/EUROCAE ED-14G]. These standards allow demonstration of the required performance under the environmental test conditions and test procedures appropriate for airborne equipment. The DAA manufacturer can choose the environmental conditions which are most severe for the certification of the DAA system. ASTM F3442-25 provides additional supporting information, including: • The DAA system shall satisfy performance requirements (DAA02) across the range of environmental conditions as defined by the manufacturer and communicated to the UAS operator.

	• The DAA system integrator (if different from the manufacturer) shall identify all environmental limitations of the system where it does not meet the performance requirements (DAA02) and document them in the operator's manual and technical specifications.

Table 3 – indicative Means of Compliance and Guidance Material

Chapter 9

Performance Qualification Tests for ARC-b and ARC-c

Introduction

9.1 The following DAA performance assessment methods also referred to as ‘qualification tests’, are designed to demonstrate regulatory compliance and should not be confused with development tests, which are conducted by the companies internally during the design and development phases.

9.2 These tests provide an example pathway and evidence base for applicants to demonstrate suitable performance of a DAA system for the proposed operation. While existing standards such as RTCA DO-396, EUROCAE ED-330, ASTM F3442-25, and RTCA DO-365 provide important verification of DAA system performance, their primary focus is on demonstrating compliance with minimum equipment performance requirements. These standards evaluate the technical behaviour of DAA components and interfaces, typically through requirement-based verification, laboratory testing, and controlled simulation environments. However, compliance with equipment standards alone does not necessarily demonstrate that a DAA capability performs safely within a specific operational concept, as operational performance may depend on factors such as system integration, operational procedures, the characteristics of the operating environment, and the interaction between surveillance, avoidance logic, and human or automated responses.

9.3 The DAA qualification framework addresses this gap by focusing on the operational suitability of the DAA capability in the context of a particular operation. Rather than defining additional design requirements, it provides a structured assurance methodology that progressively builds operational evidence through a combination of field testing, real-time simulations, hybrid simulations, fast-time simulations, and integrated system trials. These activities enable the evaluation of the complete DAA capability as implemented on the aircraft and operated according to the intended Concept of Operations (ConOps), including the performance of the surveillance elements, the behaviour of the avoidance function, and the response of the Remote Pilot or automated system.

9.4 Evidence derived from compliance with recognised technical standards may be used as supporting input to this qualification process, as it can provide confidence in the technical performance of individual system components. In some cases, such evidence may reduce the scope of additional testing required within the qualification framework, provided that sufficient evidence remains to demonstrate that the integrated DAA capability achieves the intended level of safety in the operational environment. This approach allows the qualification

framework to leverage existing standards where applicable, while ensuring that the operational safety of the DAA capability is validated in the context in which it will be used.

9.5 This approach supports the key question faced by operators and regulators under the SORA framework: whether sufficient evidence exists to demonstrate that the DAA capability, as integrated and operated, can maintain the intended level of safety in the specific operational environment. In this sense, the framework complements existing equipment standards by bridging the gap between technical system verification and operational safety validation.

9.6 The following categories of qualification tests are recommended. Each category builds upon the results of the previous one, with later tests using the outcomes of earlier tests to further validate system performance. In this way, the testing approach progressively increases the level of confidence in the performance results obtained in earlier stages. The objective and additional details for each test category are provided in the following sections:

1. Surveillance validation field tests.
2. Real-time simulations for human response time and HMI validation for operational suitability.
3. Live-virtual constructive (LVC, or hybrid) simulations for avoidance validation.
4. Fast-time simulations for validation of DAA performance requirements.
5. ‘As-built’ full system trials to demonstrate the system’s performance in operational environment, and
6. Soak test for endurance checks.

9.7 The selection, combination, and rigour of the qualification tests should reflect not only the risk of the intended operation within the Air Risk Class, but also the functional complexity and implementation characteristics of the DAA capability under assessment.

9.8 Relevant factors include the level of automation, the type of guidance provided (See Chapter 5 – Example Systems), the DAA system architecture, and the scope of DAA functions implemented. The qualification test framework may be tailored by reducing the number and scope of certain tests, provided that the overall demonstration power and risk coverage remain equivalent to that achieved by the full qualification test framework for an operation of comparable risk.

9.9 Any such tailoring is expected to be supported by quantitative justification and objective evidence showing that the proposed test set is sufficient to characterise

the expected performance of the DAA capability for the intended operational environment. Any proposed tailoring may be subject to review by the competent authority based on this justification and supporting evidence.

9.10 If the DAA system is modified, the extent of re-testing will depend on the nature of the change. Not all tests may need to be repeated. For example, if the surveillance sensor is replaced, it is not necessary to repeat the LVC testing. Another example is when avoidance changes, it is not necessary to repeat the surveillance testing. An applicant can also refer to the sensitivity analysis, where appropriate (please, refer to Table 11 and Table 17), to understand the impact of change variable on the test results. Finally, CAP722L provides guidance on UAS modifications in the specific category.

9.11 The assumption in each assessment method is that the UAS is regarded as the ownship while the manned aircraft is viewed as the intruder. However, from a philosophical standpoint, the pilot of the manned aircraft may perceive the UAS as the intruder. While we acknowledge the hazard that traditional aviation can potentially cause by seeing and avoiding unmanned aircraft, this is not currently considered in this DAA testing and evaluation framework. Further, the Well Clear Volume has been selected appropriately within DAA requirements, such that traditional aviation is not expected to see and avoid unmanned aircraft.

Surveillance Validation Field Tests

Objectives

9.12 This is a statistical qualification test, designed to validate DAA sensor detection/tracking performance independently, without validation of avoidance performance. Objectives are as follows:

1. Demonstrate that the DAA sensor reliably detects and tracks relevant intruder aircraft within its declaration range under realistic operational conditions and to provide evidence of the performance to the regulator.
2. Verify false alarm rates (e.g., false tracks), split tracks, missed tracks, and overall tracking reliability.
3. Establish sensor performance to be used in the fast time simulation, real-time simulation and live-virtual qualification tests.

9.13 The series of tests will be set up in such a way that intruder aircraft will intermittently enter and exit the sensor's field of view from various azimuth angles and at different altitudes and speeds. Sensor data will be recorded and then analysed.

9.14 The results of the surveillance validation field tests should be used to inform and calibrate the surveillance and tracking models applied in the fast-time, real-time

and hybrid simulation-based qualification tests defined in the corresponding sections.

9.15 **Note**: Where available, evidence derived from recognised technical standards, certification activities, or manufacturer / designer flight test campaigns may be used to support or partially satisfy the objectives of the surveillance validation field tests. Such evidence may include documented sensor detection and tracking performance, false alarm characteristics, and tracking reliability obtained under representative operational conditions. The regulator may accept this evidence in lieu of additional testing, provided that the data is sufficiently representative of the intended operational environment, system configuration, and integration with the UAS platform. Additional surveillance validation testing should only be required where existing evidence is insufficient to demonstrate the performance assumptions used in the qualification process or where the available data is not representative of the intended Concept of Operations.

ARC-b

9.16 Test principles are as follows:

1. To validate the performance of a DAA system under test, both UAS and intruder aircraft must be instrumented (see DAA02.GM3). The “true” position and orientation (pose) of each aircraft must be recorded with precise timestamps. This data should be synchronized with all DAA sensor outputs, also timestamped, to enable thorough post-flight analysis.
2. Demonstrate reliable detection of representative intruders – minimum 10 flight hours. Although the test duration is set for 10 hours, it does not require continuous operation.
3. Intruder must be in the sensor declaration volume 90% of the time during the testing.
4. If the sensor is intended for airborne operation, testing must primarily be conducted with the sensor installed on an aircraft rather than in ground-based setups.
5. Must test for intruders both on a collision course, and not on a collision course.
6. Intruder manoeuvre categories include constant speed, straight-and-level flight, turns, acceleration, deceleration, climbs, descents, and hovering helicopter case as relevant for the environment of operation.
7. The field tests must include corner cases of the sensor performance (e.g., tangential targets for the radar, radial targets for camera).

9.17 Expected test outcomes are as follows:

1. Repeatable results are required; total test hours alone are insufficient.
2. Field tests must confirm that environmental interference, (e.g., ground clutter, noise, etc. as relevant), is detected and successfully filtered by the surveillance system.
3. Flight tests must demonstrate that ownship movement does not lead to excessive false alarms or significant uncertainty in the estimated position of intruders, and that motion compensation, if used, is effective.

9.18 An example test matrix is provided in Table 4 for a DAA system with the following parameters:

- 240 degrees horizontal field of view (FOV)
- 30 degrees vertical FOV
- 2 km declaration range
- 2 types of expected intruders (helicopter and FW)

9.19 The example test matrix is provided as an illustrative example of how the above principles may be implemented. For a surveillance sensor with different parameters a different test matrix may be proposed, but the updated test design should follow the same principles, and enough coverage of relevant geometries, manoeuvres and sensor performance corner cases must be demonstrated.

9.20 **Note**: calculation of the test time assumes approximately 5 mins for 1 intercept (setup time+ flight time + return to the next position)

Test ID	**Intruder Azimuth / Elevation**	**Manoeuvre**	**Intruder Position**	**Intercepts per Intruder**	**Total Intercepts (assuming 2 intruder types)**	**Expected Outcome**
1	0° / 0°	Straight & Level	Radial	10	20	NMAC
2	±60° / 0°	Straight & Level	Radial	5	10	NMAC
3	±90° / 0°	Turning	Mid-FOV	5	10	Loss of WC
4	±120° / 0°	Turning	Edge of FOV	5	10	Loss of WC
5	±90° / +15°	Climb	Top edge	5	10	Loss of WC

6	±90° / -15°	Descent	Bottom edge	5	10	NMAC
7	±60° / ±10°	Accel/Decel	Mid-FOV	5	10	Loss of WC
8	±120° / ±15°	Climb + Turn	Corner of FOV	5	10	NMAC
9	±90° / 0°, (Offset 1 km from ownship)	Straight & Level	Tangential	5	10	Not on collision course
10	±90° / 0°, (Offset 2 km from ownship)	Straight & Level	Tangential	5	10	Not on collision course
11	0° / 0°	Hovering helicopter		10	10	NMAC
Total time: 600 minutes = 10 hours						

Table 4 – ARC-b Surveillance Field Test Example Matrix

ARC-c

9.21 As with ARC-b, with the following differences:

1. Demonstrate reliable detection of representative intruders – minimum 40 hours.
2. Intruder manoeuvre categories include straight-and-level flight, turns, acceleration, deceleration, climbs, descents, hovering helicopter case, and multiple intruder aircraft (including close-proximity scenarios to verify sensor resolution as well as tracking performance), as relevant for the operational environment.
3. Multiple intruder test could be conducted with DAA sensor being installed on the ground.

9.22 An example test matrix is provided in Table 5 for a DAA capability with the same parameters as the ARC-b example (above). As stated for ARC-b, alternative test matrices may be proposed to reflect the specifics of the surveillance system and its coverage.

Test ID	Azimuth / Vertical Angle	Manoeuvre	Intruder Position	Intercepts per Intruder	Total Intercepts (assuming 2 intruder types)	Expected Outcome
1	0° / 0°	Straight & Level	Radial	25	50	NMAC
2	±60° / 0°	Straight & Level	Radial	25	50	NMAC
3	±90° / 0°	Turning	Mid-FOV	25	50	Loss of WC
4	±120° / 0°	Turning	Edge of FOV	25	50	Loss of WC
5	±90° / +15°	Climb	Top edge	25	50	Loss of WC
6	±90° / -15°	Descent	Bottom edge	25	50	NMAC
7	±60° / ±10°	Accel/Decel	Mid-FOV	20	40	Loss of WC
8	±120° / ±15°	Climb + Turn	Corner of FOV	20	40	NMAC
9	±90° / 0°, (Offset 1 km from ownship)	Straight & Level	Tangential	20	40	Not on collision course
10	±90° / 0°, (Offset 2 km from ownship)	Straight & Level	Tangential	20	40	Not on collision course
11		Multiple intruders	Mid-FOV and Centre of FOV	10	10	1 CA, 1 Not on collision course

12	0° / 0°	Hovering helicopter	Radial	10	10	CA
Total time: 2400 minutes= 40 hours						

Table 5 - ARC-c Surveillance Field Test Example Test Matrix

Real-Time Simulations

Objectives

9.23 This category of test assesses alerting and avoidance logic performance in real time with a simulated ownship, intruder(s) and surveillance. Note, real-time simulations are not intended to provide statistically significant performance metrics, but to evaluate operational suitability of HMI, human response and integrated system behaviour under representative time-critical scenarios. Objectives are as follows:

1. Establish human factor delays being used in the fast-time simulation. Note that the CAA does not currently mandate the presence of a human in the operational loop. However, if human involvement is part of the concept of operations, associated performance and latency should be assessed accordingly.
2. Confirm that the human-machine interface (HMI) is suitable for the intended operations.
3. Verify reliable real-time operation of hardware components involved in performing alerting and avoidance functions, as applicable, with the simulated ownship, intruder and surveillance.
4. Simulate avoidance of commercial aircraft (since this will not be tested in either field test or as-built system trials), if relevant for the operational environment.
5. Test with multiple pilots for ARC-c, which is a less expensive option than Live-Virtual Constructive.

9.24 Two types of real-time simulations may be employed:

- **Software-in-the-Loop (SITL)** – The set-up runs in real time, but the aircraft, sensor, environment, alerting and avoidance logic are simulated in software.
- **Hardware-in-the-Loop (HITL)** – Real DAA hardware (e.g., processors) is integrated into a real-time simulation environment. For example, ownship and intruder are simulated but alerting/avoidance logic is executed on real hardware.

9.25 While SITL is a required step for development timeline, it could be skipped during the qualification tests for efficiency.

9.26 **Note**: The scope and rigour of real-time simulation may be adapted to the complexity of the DAA capability and the level of human involvement in conflict resolution, provided that sufficient confidence is achieved in the suitability of the human–system interaction for the intended operation.

9.27 The applicant shall define acceptance criteria for the real-time simulation results, including those related to alerting, guidance interpretation, response time and operational suitability, consistent with the intended concept of operations and the level of automation of the DAA capability

ARC-b

9.28 Test principles are as follows:

1. HITL simulations: >70 encounters for human-in-the-loop DAA systems, and >20 encounters for human-on-the-loop DAA systems.
2. Encounters must result in approximately one third split between NMAC, LWC and no conflict.
3. Applicant must demonstrate 100% successful collision avoidance and 95% RWC for conflict scenarios, which are expected to be mitigated, and zero induced NMACs/LWC. Any failure to meet these requirements must be investigated and explained.
4. The simulation and ownship trajectory must be representative of the missions, while the details of the simulation setup are to be suggested by the applicant.
5. Multiple encounters may be included in a single mission simulation, with variation in encounter times and pilot workload.
6. Testing with a single pilot is acceptable, provided the pilot represents an average skill level and typical operational behaviour.
7. Pilot must be isolated from the simulation and encounter set design[9].
8. Must demonstrate equally successful conflict resolution with representative intruder types relevant to the environment of operation.
9. Must consider statistically representative intruder trajectories on various azimuth angles relative to ownship, such that intruder remains in the FOV of the sensor.
10. Intruder manoeuvre categories are straight/level, turn, speeding up, slowing down, climbing, descending, as relevant for the operational environment.

[9] This is essential to ensure that the pilot is not aware of upcoming encounters.

11. Single intruder encounters are sufficient for ARC-b.
12. Testing scenarios involving a hovering helicopter are not required, as such conflicts are considered easily resolvable under typical operational conditions.
13. Must include stress cases like:
    a) Reversals of guidance examples must be included in the tests, where initially recommended by the DAA RWC/CA manoeuvres are updated with different guidance recommendation.
    b) Intermittent intruder detection.

9.29 An example test design for a hypothetical human-in-the-loop DAA system is provided in Table 6.

Parameter	**Values / Description**
Ownship Speed	1 fixed value, e.g., 50 knots
Ownship Altitude	1 fixed value – e.g., 400 ft AGL
Intruder Types	2 types: GA, Helicopter
Conflict Types	3 types: NMAC, LWC, No Conflict
Azimuth Bins	4 bins (head-on, intruder approaching from the right, intruder approaching from the left, approach from behind)
Variable statistically representative trajectories for intruder	4 types: Straight and Level, Turning, Climbing/Descending (½ split), Accelerating/Decelerating (½ split). **Note:** 50%-50% splits across all the simulations are used to avoid a very large number of encounters to account for every combination.
Additional cases	Reversals, 1 per intruder type = 2
Total encounters	98 (1 ownship speed × 1 ownship altitude × 2 intruder types × 3 conflict types × 4 azimuths x 4 intruder trajectory types + 2 additional cases)
Notes	Intruder speed profiles should be realistically distributed in the statistically representative trajectories. See Figure 3 for examples of statistically representative intruder trajectories.

	5x45min simulations per day, with 4 encounters per simulation allows 100 encounters in a 5-day simulation test campaign.

Table 6 - ARC-b Real time simulation encounter set parameters

9.30 If there is no human in the loop for DAA manoeuvre execution, the encounter set may be reduced as follows to focus on evaluation of HMI alone:

1 ownship speed × 1 ownship altitude × 2 intruder types × 3 conflict types × 1 azimuths x 4 intruder trajectory types=24 encounters

ARC-c

9.31 As with ARC-b, with the following differences:

1. HITL simulations: >150 encounters for human-in-the-loop DAA systems, and >50 encounters for human-on-the-loop DAA systems.
2. Must test vs multiple pilots (at least 2).
3. Must test at least once against large commercial aircraft, if relevant to the environment of operation.
4. At least one multiple intruder avoidance must be demonstrated.
5. Must include stress cases including:
   a) Reversals of guidance
   b) Intermittent detection
   c) Late intruder detection

9.32 An example test design for a hypothetical human-in-the-loop DAA system based is provided in Table 7.

Parameter	**Values / Description**
Ownship Speed	1 fixed value, e.g., 50 knots
Ownship Altitude	1 fixed value – e.g., 400 ft AGL
Intruder Types	2 types: GA, Helicopter
Conflict Types	3 types: NMAC, LWC, No Conflict
Azimuth Bins	4 bins (head-on, intruder approaching from the right, intruder approaching from the left, approach from behind)

Variable statistically representative trajectories for intruder	4 types: Straight and Level, Turning, Climbing/Descending (½ split), Accelerating/Decelerating (½ split). Note: 50%-50% splits across all the simulations are used to avoid a very large number of encounters to account for every combination.
Additional cases	Reversals, 1 per intruder type + 2 multi-intruder + 2 commercial aircraft
Total encounters	102 per pilot (1 ownship speed × 1 ownship altitude × 2 intruder types × 3 conflict types × 4 azimuths x 4 intruder trajectory types + 6 additional cases) 2x pilots, each using the same encounter set provides a total of 204 encounters.
Notes	Intruder speed profiles should be realistically distributed in the statistically representative trajectories. See Figure 3 for examples of statistically representative intruder trajectories. 5x45min simulations per day, with 4 encounters per simulation allows ~200 encounters in a 10-day simulation test campaign.

Table 7 – ARC-c Real time simulation encounter set parameters

9.33 If there is no human in the loop for DAA manoeuvre execution, the encounter set may be reduced as follows:

1 ownship speed × 1 ownship altitude × 2 intruder types × 3 conflict types × 1 azimuth x 4 intruder trajectory types=24 simulations x 2 pilots =48 simulations + 4 reversals (1 for each intruder type, 2 pilots) +2 multiple intruder (1 per each pilot) +2 large commercial aircraft (1 per each pilot) = ***56***

Live Virtual Constructive

Objectives

9.34 These tests involve the use of a simulated intruder while a live UAS performs real avoidance manoeuvres. These tests are intended to first evaluate the UAS avoidance performance, including C2 delay, time to transition from mission to avoidance, and time/speed to establish safe distance. Further, they act as a

stepping-stone between real-time simulation and the ‘as-built’ full system live trials, validating readiness of the DAA capability to progress to live intruder encounters. Objectives are as follows:

1. Experimentally demonstrate that live avoidance manoeuvres are consistent with simulation results in real-time simulations.
2. Collect data and document the avoidance performance for further use in fast time simulations, e.g. manoeuvre time, time to transition, and time to establish safe distance.
3. Establish C2 link delays to be used in fast-time simulations.
4. Validation of live DAA capability and all associated operating procedures in a representative operating environment, without evaluating detection capabilities.
5. Validation of HMI assessment in a live environment

9.35 **Note**: The scope and rigour of Live-Virtual Constructive (LVC) testing may be adapted to the manoeuvre nomenclature and the risk of the intended operation within ARC, provided that the resulting test campaign maintains equivalent demonstration power for the objectives and the relevant performance requirements. Any such adaptation shall be justified and documented, including any resulting operational limitations.

ARC-b

9.36 Test principles are as follows:

1. UAS and intruder “ground truth” and DAA events must be recorded during the flight test with a timestamp and centralized synchronization during the flight test for further analysis.
2. Approx. 45 encounters with simulated intruders.
3. Must test for loss of WC and CA alerts, (e.g., half of the test cases should involve each type). For the best use of time no alert cases do not need to be tested, since the objective of the test is to validate avoidance performance.
4. Applicant must demonstrate 100% successful collision avoidance and 95% RWC for conflict scenarios, which are proven to be mitigated in real-time simulations.
5. Pilot must be isolated from the flight test encounter set design, with the operational scenario representative of the actual mission.
6. Must demonstrate equally successful conflict resolution with representative intruder types relevant to the operational environment.

7. Must consider statistically representative simulated intruder trajectories on multiple azimuths.
8. Intruder manoeuvre categories are turn, speeding up/slowing down, climbing/descending, constant speed straight and level, as relevant to the operational environment.
9. Testing scenarios involving a hovering helicopter are not required, as such encounters are considered easily avoidable under typical operational conditions.
10. Single intruder encounters are sufficient.

9.37 An example test design is provided in Table 8 for a hypothetical DAA system under test that happens to respond with 4 generic responses e.g. turn left/right, descend/climb depending on the azimuth

9.38 **Note** that this example includes four manoeuvre options. If the DAA system provides only one manoeuvre option, the number of cases could be reduced by a factor of four while choosing the azimuth that represents the worst case.

Parameter	**Values / Description**
Ownship Speed	1 fixed value, e.g., 50 knots
Ownship Altitude	1 fixed value – e.g., 400 ft AGL
Intruder Types	2 types: GA, Helicopter
Conflict Types	2 types: NMAC, LWC
Azimuth Bins/Avoidance manoeuvre options	4 bins (head-on - descend, intruder approaching from the front right – turn right, intruder approaching from the from the rear right - turn left, approach from behind - climb)
Variable statistically representative trajectories for intruder	3 bins (Straight and Level / Turning (½ split), Climbing/Descending (½ split), Accelerating/Decelerating (½ split)
Total encounters	48 = (1 ownship speed x 1 ownship altitude x 2 conflict types x 2 intruder types x 4 azimuth bins x 3 intruder trajectory types)

Table 8 – ARC-b LVC encounter set parameters

ARC-c

9.39 As with ARC-b, with the following differences:

1. Approx. 80 encounters with simulated intruders.

9.40 An example test design is provided in Table 9 for a hypothetical DAA system under test that happens to respond with 4 generic responses e.g. turn left/right, descend/climb depending on the azimuth.

9.41 **Note** that this example includes four manoeuvre options. If the DAA system provides only one manoeuvre option, the number of cases could be reduced by a factor of four while choosing the azimuth that represents the worst case.

Parameter	**Values / Description**
Ownship Speed	1 fixed value, e.g., 50 knots
Ownship Altitude	1 fixed value – e.g., 400 ft AGL
Intruder Types	2 types: GA, Helicopter
Conflict Types	2 types: NMAC, LWC
Azimuth Bins/Avoidance manoeuvre options	4 bins (head-on - descend, intruder approaching from the front right – turn right, intruder approaching from the from the rear right - turn left, approach from behind - climb)
Variable statistically representative trajectories for intruder	5 bins (Straight and Level, Turning, Climbing, Descending, Accelerating/Decelerating (½ split)).
Total encounters	80 = (1 ownship speed x 1 ownship altitude x 2 conflict types x 2 intruder types x 4 azimuth bins x 5 intruder trajectory types)

Table 9 – LVC ARC-c encounter set parameters

Fast-Time Simulation

Objectives

9.42 The primary objective of fast-time simulations is to execute numerous test cases to gather statistical performance data, identify corner cases, validate the DAA system's Risk Ratio (RR) and Loss of Well Clear Ratio (LWCR) metrics, and conduct sensitivity analyses. This collected statistical data will then be provided to the regulator as evidence of expected performance.

9.43 Fast-time simulations primarily assess the conflict prediction detection, decision and guidance logic of the DAA capability using modelled surveillance

performance, and does not replace the physical validation of surveillance sensors performed under 6.2

9.44 **Note**: The scope and rigour of fast-time simulation may be adapted to the complexity of the DAA capability, its automation level, manoeuvre options and the risk of the intended operation, provided that the resulting analysis maintains equivalent demonstration power for the relevant performance requirements

9.45 For both ARC-b and ARC-c assessment principles and modelling guidance is provided for each of the following:

1. Encounter generation
2. Sensor and tracker modelling
3. Conflict prediction and resolution (DAA capability under test)
4. Sensitivity analysis

ARC-b

9.46 Encounter generation principles are as follows:

1. On the order of 10,000–200,000 encounter-geometry simulations should be conducted.
2. Encounters must result in a split between NMAC, LWC (to support Risk Ratio and LWCR calculations) and no conflict (to validate false alert/unnecessary manoeuvre rate performance) with % of each split to be suggested by the applicant as per Principle 3 below.

   Note: For no-conflict cases used to assess false alert or unnecessary manoeuvre performance, particular care should be taken to ensure that the intruder remains within the sensor field of view for a representative portion of the encounters, such that the absence of alerting reflects correct system behaviour rather than lack of detectability. Accordingly, the number of such observable no-conflict cases should be sufficiently large relative to the total no-conflict population to support statistically meaningful assessment of false alert/unnecessary manoeuvre performance.
3. The total number of simulations, as well as the percentage allocated to each split, should be determined by convergence of the Risk Ratio, Loss of Well Clear ratio, and unnecessary manoeuvre rate (including induced NMACs/LWC) to within 5% of a stable value (see Figure 1).
4. A deterministic simulation framework may be used, providing quick results without requiring extensive computational resources. However, Monte-Carlo methods (as required for ARC-c) could be used if preferred by the applicant.

Note: Deterministic frameworks use fixed inputs and repeat the same outcome every time. This contrasts with Monte Carlo methods which use random sampling to represent real-world input condition uncertainty.

5. The simulation may support only constant trajectories for the intruder. Constant trajectories include idealized or simplified paths where key flight parameters remain unchanged. Examples are straight and level path and constant speed climb or descend. Constant intruder trajectories from kinematic models follow idealized and “perfect” paths, and they help to check the baseline performance. Variable trajectories from the statistical models are not required for ARC-b but could be used by the applicant if preferred.

6. Encounter geometries primarily consist of linear converging scenarios across all azimuth angles from 0-360°, with fixed horizontal and vertical offsets between intruder and ownship.

   Note: A convergence-at-fix encounter is a conflict scenario in which two aircraft are on converging flight paths that intersect at a common fix, where fix is a predefined geographical point.

7. A subset of the above-described convergence cases must include horizontal-plane collision scenarios in which both the intruder and ownship maintain constant velocity in straight, level, and non-accelerating flight.

8. A subset of the above-described convergence cases must include vertical-plane collision scenarios, where the ownship is level and the intruder climbs or descends. Intruder vertical rates must be selected to reflect realistic climb and descent profiles.

9. Appropriate UA flight characteristics must be selected to reflect operational realities. These include aircraft type (e.g., multirotor, fixed wing), operational speed ranges, altitude envelopes, and manoeuvrability profiles.

10. Both the intruder and ownship may be modelled using simplified kinematic models with limited dynamics to reduce implementation complexity.

11. Take-off and landing of both intruder and ownship do not need to be modelled, unless the DAA capability is intended to be used on this flight phase.

12. To ensure full coverage of encounter geometries:

    a) Ownship speeds must be varied with a maximum resolution of 5 knots.

    b) Intruder speeds must be varied with a maximum resolution of 10 knots.

    c) Intruder headings must be uniformly distributed over 360°, with maximum 10° resolution.

d) Intruder elevations must be uniformly distributed over 60°, with maximum 10° resolution.

9.47 An example encounter set based on the above principles is provided in Table 10. Further information on this category of DAA assessment is available in [26,27,28].

Parameter	**Values / Description**
Ownship Speeds	5 values (For example 30–50 knots in 5-knot increments)
Ownship Altitude	1 fixed value – e.g., 400 ft AGL
Intruder Types	3 types: For example, GA, Gyrocopter, Helicopter Note: Distinct intruder types may be differentiated by both flight profiles and surveillance performance models.
Conflict Types	3 types: NMAC, LWC, No Conflict
Azimuth Bins	36 bins (straight and level)
Elevation Bins	9 bins (climb/descend)
Intruder speeds	15 bins (e.g., 00-150 knots)
Offset samples per conflict type	10 (see notes for possible offset cases)
Total encounters	Horizontal Combinations = 5 ownship speeds × 1 ownship altitude × 3 intruder types × 36 azimuth bins x 15 intruder speed bins x 10 offsets = 81,000 Vertical Combinations = 5 ownship speeds × 1 ownship altitude × 3 intruder types × 9 elevations x 15 intruder speeds x 10 offsets = 20,250 Total=81,000 + 20,250 = 101,250 Note, conflict types are implicitly represented through the modelling of encounter offsets, where different horizontal and vertical offset configurations correspond to scenarios such as NMAC, Well Clear violations, and no-conflict encounters.

Possible offsets	Possible offset variation cases are as follows: 1. 0 offset for direct collisions (MAC) 2. Horizontal offset within NMAC volume, vertical clear (no conflict) 3. Horizontal offset within NMAC volume, vertical within WCV (WC violation) 4. Both horizontal and vertical offsets are within NMAC volume (NMAC) 5. Vertical offset within NMAC volume, horizontal clear (no conflict) 6. Vertical offset within NMAC, horizontal within WCV (Well Clear violation) 7. Horizontal offset within WCV, vertical clear (no conflict) 8. Vertical offset within WCV, horizontal clear (no conflict) 9. Both horizontal and vertical offsets are within WCV (WC violation) 10. Both horizontal and vertical beyond Well Clear Volume (no conflict)

Table 10 – Example ARC-b fast time simulation encounter set

9.48 **Note**: The required number of encounters is intended to provide statistical significance of the results; alternative sample sizes may be proposed depending on the algorithmic complexity of DAA system, its automation level and manoeuvre options. In those cases, equivalent confidence in the estimated performance metrics must be demonstrated through sensitivity analysis. This sensitivity analysis of Risk Ratio vs number of tests is recommended prior the final test.

9.49 **Note**: the number of tests above (101,250) is recommended for a highly complex DAA system, assuming multitude of possible manoeuvres to choose from automatically by the DAA system. If their DAA system is not complex, having implemented a singular manoeuvre for example, a reduced number of tests may be sufficient to demonstrate the same performance result. Figure below shows example sensitivity graph of how the Risk Ratio depends on the number of tracks for a simple DAA system with 240 degrees horizontal FOV, 30 degrees vertical, 2 km range, automatic avoidance with a single open-loop DAA manoeuvre –

descend to the safe altitude. It is evident from this graph that the Risk Ratio stabilises at about 18,000 tracks. To be more prudent, a slightly higher than minimum number is recommended for the final experiment. Similarly, the number of tests to establish Loss of Well Clear ratio could be determined.

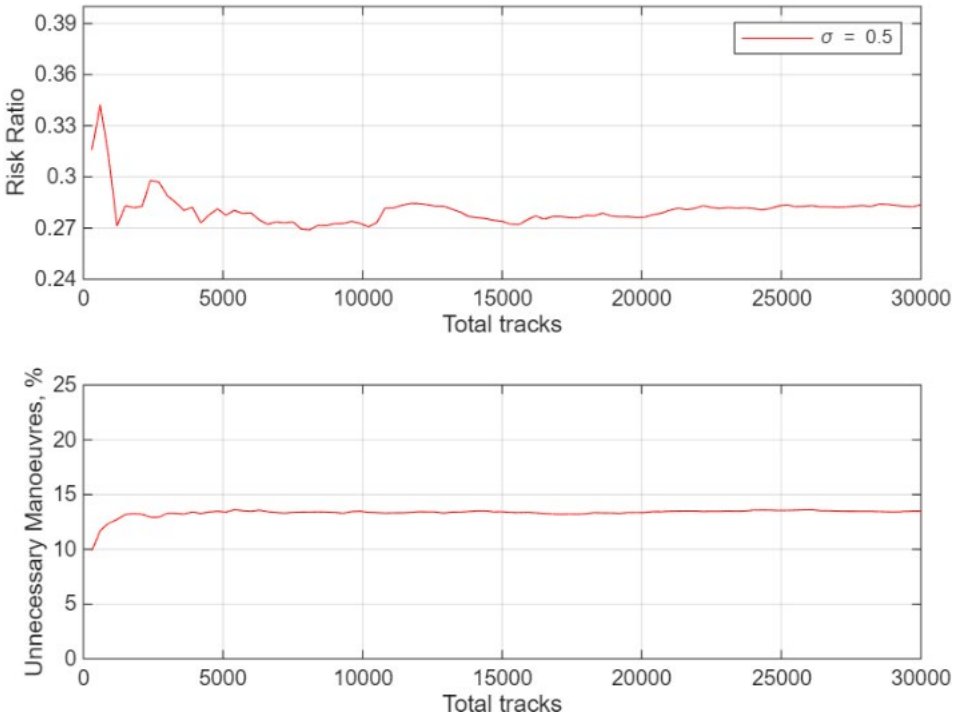

Figure 1 – Example of RR and Unnecessary manoeuvre settling with the number of total tracks

9.50 Sensor & tracker modelling principles are as follows:

1. Minimum Required Track Fields by Sensor Type need not be modelled.
2. Sensor uncertainties must be modelled for both intruder and township.
3. Modelling of split or false tracks is not required.
4. The simulation must incorporate missed tracks in probabilistic manner
5. Intruder trajectory filtering/tracking may be modelled in a simplified manner. However, the real tracker may be implemented if preferred.

9.51 A low-fidelity sensor model may be used to reduce computational complexity. Sensor limitations, such as range and field of view, can be applied to intruder trajectories to simulate detection constraints. The probability of detection can be approximated by probabilistically removing a proportion of intruder tracks, thereby emulating sensor performance degradation. Sensor uncertainty could be modelled by adding sensor noise to the “true” intruder positions and then filtered by the simplified tracker model.

9.52 Conflict prediction and resolution modelling principles are as follows:

1. The simulation must implement conflict prediction, alerting and guidance as implemented in the DAA system under test.
2. Wind effects on avoidance performance must be modelled.
3. All relevant worst-case nominal delays must be modelled and accounted for, including command and control (C2), human factors (HF), track formation, and other system latencies.

Sensitivity analysis:

9.53 The above principles and encounter set can also be used to conduct a sensitivity analysis, evaluating how variation in key DAA capability parameters impacts performance.

9.54 The key DAA parameters may be altered to suit the DAA system under test, but the order of magnitude of testing should not be reduced without justification.

9.55 An example analysis is provided in Table 11.

Parameter	**Values / Description**
Surveillance range	0.01-0.2M encounters for declaration range reduced by 5% 0.01-0.2M encounters for declaration range reduced by 10% 0.01-0.2M encounters for declaration range reduced by 15%
Sensor FoF	0.01-0.2M encounters for hog and or vFOV reduced by 5% 0.01-0.2M encounters for hot and or vFOV reduced by 10% 0.01-0.2M encounters for how and or vFOV reduced by 15%
Owns hip Navigation accuracy	0.01-0.2M encounters for position and velocity errors increased by 15% 0.01-0.2M encounters for position and velocity errors increased by 25% 0.01-0.2M encounters for position and velocity errors increased by 50%
Intruder surveillance & tracking accuracy	0.01-0.2M encounters for position and velocity errors increased by 15%

	0.01-0.2M encounters for position and velocity errors increased by 25% 0.01-0.2M encounters for position and velocity errors increased by 50%
System delays	0.01-0.2M encounters for system delays increased by 5% 0.01-0.2M encounters for system delays increased by 10% 0.01-0.2M encounters for system delays increased by 20%
Ownship manoeuvre response	0.01-0.2M encounters for manoeuvre time increased by 15% 0.01-0.2M encounters for manoeuvre time increased by 25% 0.01-0.2M encounters for manoeuvre time increased by 50%
Environmental (wind only)	0.01-0.2M encounters with moderate wind (±5 kt crosswind) 0.01-0.2M encounters with strong wind (±10 kt crosswind) 0.01-0.2M encounters with randomized wind vectors (0-10 kt)
Total encounters	7 parameters x 3 variations x (0.01M-0.2M) = 0.21M-4.2M
Notes	The same core encounter set from the nominal performance analysis may be used for each simulation run.

Table 11 – Example ARC-b Sensitivity Analysis

ARC-c

9.56 Encounter generation principles are as follows:

1. On the order of 10,000–500,000 Monte-Carlo simulations should be conducted. Note: Monte-Carlo methods use randomized inputs (e.g., initial positions, flight parameters etc. of intruder and ownship), and the outputs are probabilistic, giving distributions rather than a single outcome. They are computationally intensive but capture uncertainty and variability.

2. Encounters must be randomized, with a split between NMAC, LWC (to support Risk Ratio and LWCR calculations) and no conflict (to validate false alert/unnecessary manoeuvre rate performance) with % of each split to be suggested by the applicant as per principle 3 below.

3. The total number of simulations, as well as the percentage allocated to each split, should be determined by convergence of the Risk Ratio, Loss of Well Clear ratio, and unnecessary manoeuvre rate (including induced NMACs/LWC) to within 5% of a stable value (see Figure 1).

   Note: Figure 1 shows example sensitivity graph of how the Risk Ratio depends on the number of tracks for a simple DAA system with 240 degrees horizontal FOV, 30 degrees vertical, 2 km range, automatic avoidance with a single open-loop DAA manoeuvre – descend to the safe altitude. It is evident from this graph that the Risk Ratio stabilise at about 18,000 tracks. To be more prudent, a slightly higher than minimum number is recommended for the final experiment. Similarly, the number of tests to establish Loss of Well Clear ratio could be determined.

   Note: for no-conflict cases used to assess false alert or unnecessary manoeuvre performance, particular care should be taken to ensure that the intruder remains within the sensor field of view for a representative portion of the encounters, such that the absence of alerting reflects correct system behaviour rather than lack of detectability. Accordingly, the number of such observable no-conflict cases should be sufficiently large relative to the total no-conflict population to support statistically meaningful assessment of false alert performance.

4. Ownship trajectory generation:

   a) The ownship trajectory may be generated using kinematic models.

   b) The simulation must support both constant and variable trajectories for the ownship.

   Note: Constant trajectories include idealized or simplified paths where key flight parameters remain unchanged. Examples are straight and level path, constant speed climb or descend, circular holding pattern (Figure 2).

   Note: Variable trajectories involve changes in one or more flight parameters over time. They reflect more realistic or dynamic flight conditions, like rapid changes in speed, altitude, heading, etc. (Figure 3)

5. Appropriate UAS flight characteristics must be selected to reflect operational realities. These include aircraft type (e.g., multirotor, fixed wing), operational speed ranges, altitude envelopes, and manoeuvrability profiles.

6. Intruder Trajectory Modelling:

   a) The simulated intruder trajectory must include both constant (from kinematic models) and variable (from the statistical models) trajectories across a full range of azimuth angles (0-360°) relative to the ownship. Monte-Carlo simulations with both types of trajectories help cover a wider range of scenarios. Constant intruder trajectories from kinematic models follow idealized and “perfect” paths, and they help to check the baseline performance. On the other hand, the variable trajectories from the statistical models add realism by including the kind of variations we see in real-world trajectories, so they help check how robust the DAA system really is.

   b) Ownship and intruders' take-off and landing doesn’t need to be modelled, unless DAA is used during those phases.

   c) Constant Intruder trajectory test cases include convergence-at-fix cases located within NMAC volume, WCV and outside of WCV, with direct collisions being simulated as a subset of NMAC breaches with zero offset.

      Note: A convergence-at-fix encounter is a conflict scenario in which two or more aircraft are on converging flight paths that intersect at a common fix, where fix is a predefined geographical point.

   d) Constant Intruder trajectory test cases should simulate representative intruders for the airspace of the operation (e.g., helicopters, airliners, general aviation (GA), etc.). While ideally weighted by actual traffic distributions in the airspace of operation, practical implementation may use equal sampling of traffic types.

   e) Variable intruder trajectories should statistically represent behaviours of expected intruders (e.g., general aviation (GA), airliners, helicopters etc.). While ideally weighted by actual traffic distributions in the airspace of operation, practical implementation may use equal sampling of traffic types.

   f) Variable intruder trajectory test cases include both near-straight-and-level intruder trajectories (representing minimal manoeuvring) and dynamic intruders executing complex manoeuvres such as turns, acceleration, deceleration, climbs, descents, hovering (for helicopters), and multi-intruder encounters.

9.57 An example encounter set based on the above principles is provided in Table 12. Note, the number of tests above is recommended for a highly complex DAA system, assuming multitude of possible manoeuvres to choose from automatically by the DAA system. If their DAA system is not complex, having

implemented a singular manoeuvre for example, a reduced number of tests may be sufficient to demonstrate the same performance result.

Parameter	**Values / Description**
Intruder constant trajectories	101,250 encounters (same set as for ARC-b)
Intruder variable trajectories	Intruder variable trajectory types include turns, acceleration, 97,200 (5 ownship speeds × 1 ownship altitude × 3 intruder types × 6 variable trajectory types × 3 conflict types × 360 azimuths) Note, in constant-trajectory encounters the encounter geometry is explicitly controlled because of linearities, which allows specific configurations, such as detailed horizontal and vertical offsets, to be deliberately constructed to test boundary conditions. In contrast, encounters with variable intruder trajectories based on statistical encounter models. In this approach, encounter geometry is sampled from probability distributions and therefore cannot be controlled with the same level of precision as in deterministic cases. As a result, defining many specific offset configurations becomes impractical. Instead, encounters are categorized by three outcome types—NMAC, WCV, and no conflict—which provides sufficient representation of the relevant safety conditions for the stochastic simulations.
Extra cases	Hovering helicopter combinations: 5,400 (5 ownship speeds × 1 ownship altitude × 3 conflict types × 360 azimuths) Note, in the hovering-helicopter scenarios, the intruder is assumed to remain near-stationary while the ownship continues along its trajectory; therefore, the conflict outcome (NMAC, WCV, or no conflict) is determined by the minimum separation between the moving ownship path and the nearly fixed helicopter position. Multiple intruder combinations: 58,320 (5 ownship speeds x 1 ownship altitude x 3 conflict types with intruder one x 3 conflict types with intruder two x 6 azimuths for intruder one x 6 azimuth for intruder two x 6 trajectory types for intruder one x 6 trajectory types for intruder two)

Total encounters	Constant trajectories	101,250
	Variable trajectories	97,200
	Hovering helicopter	5,400
	Multiple intruders	58,320
	Total	262,170

Table 12 – Example ARC-c fast time simulation encounter set

9.58 To generate the ownship tracks, a point-mass kinematic model could be implemented. Simulation of a planned mission could be implemented, or randomization of common UAS BVLOS mission profiles could be considered if a planned mission is varying e.g., straight flight path, ground feature following, circular flight path, and survey flight path (Figure 2). Every flight could have an appropriate duration (e.g., 500 seconds) or simulate the duration of the UAS missions and must contain the three major phases of flight: Take-off, Cruise/Loiter, and Landing, if the DAA system is used during those phases.

9.59 Each mission type could use Equation 1 to determine the position of the ownship with each mission profile changing how the velocity during the cruise portion of flight is determined (described in detail in [29]). The initial horizontal position of the ownship ($P_{x,y}(0)$) could be randomized within an initial bounding box (e.g., 50,000 ft × 50,000 ft) centred at (0,0) for all simulations. For the initial vertical position ($P_z(0)$) the RPA is assumed to start on the ground so it must be set to 0 ft AGL.

9.60 During the generation of the flight scenarios, different variables must be randomized, depending on the type of flight, as to generate a large variance in flight paths to simulate an appropriate ownship type - multi-rotors or fixed-wing.

9.61 $$P(t) = P(t-1) + v(t-1) * \Delta t \quad (1)$$

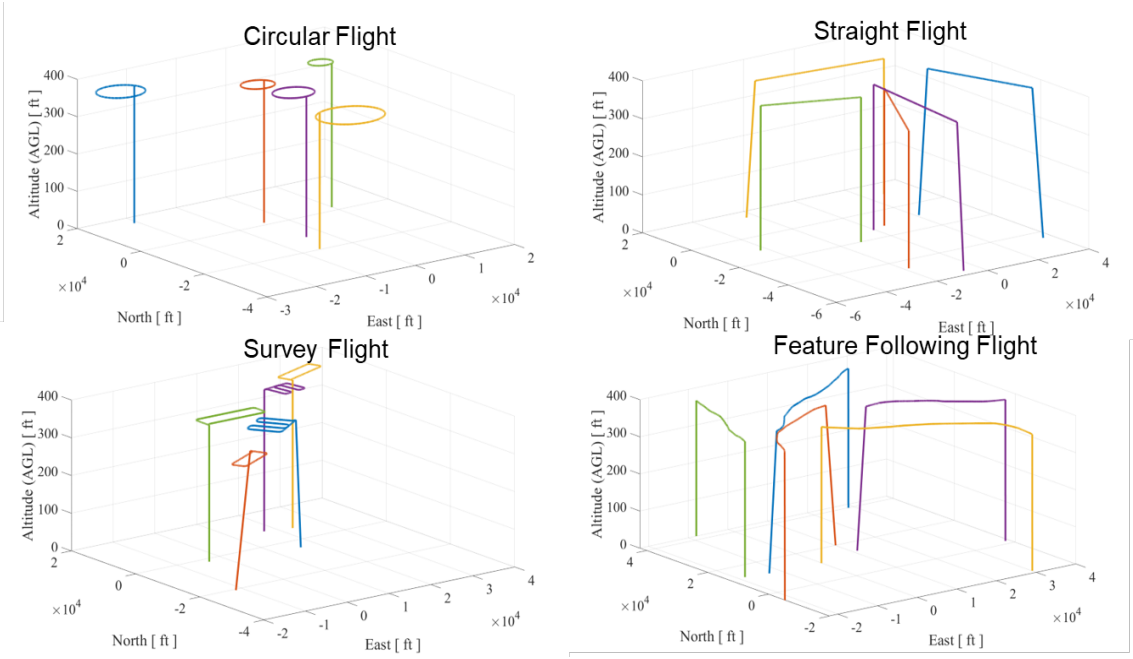

Figure 2 – Example Ownship trajectories

Horizontal speed	30-70kts
Vertical speed	5-16ft/s
Take-off and landing slopes	6-90 degrees
Track angle	0-359 degrees

Table 13 – Example ownship simulation parameters

9.62 To generate intruder tracks, available statistical models should be used. Examples include the following:

1. Canadian (Figure 3) - GitHub - nrc-cnrc/Canadian-Airspace-Models: Canadian airspace models — Modèles de l'espace aérien canadien
   a) Light WTC (typical GA)
   b) Medium WTC (typical airliner)
   c) Heavy (cargo)
   d) Helicopter
   e) Gyrocopter
   f) Ultralight
2. MIT Lincoln Laboratory - GitHub - Airspace-Encounter-Models/em-overview: Overview of the aircraft encounter models that support safety analysis and development of aircraft avoidance systems.

a) Rotorcraft

b) FW single engine

c) FW multi engine etc.

9.63 Over time more countries will develop their own statistical airspace models, derived from their unique data and representative of their specific airspaces. These models will consider the aircraft operating within those airspaces, acknowledging that aircraft models vary from country to country, leading to differences in turn rates, speeds, and other performance metrics. Further, using airspace models of the operational airspace could make risk assessment more robust and accurate.

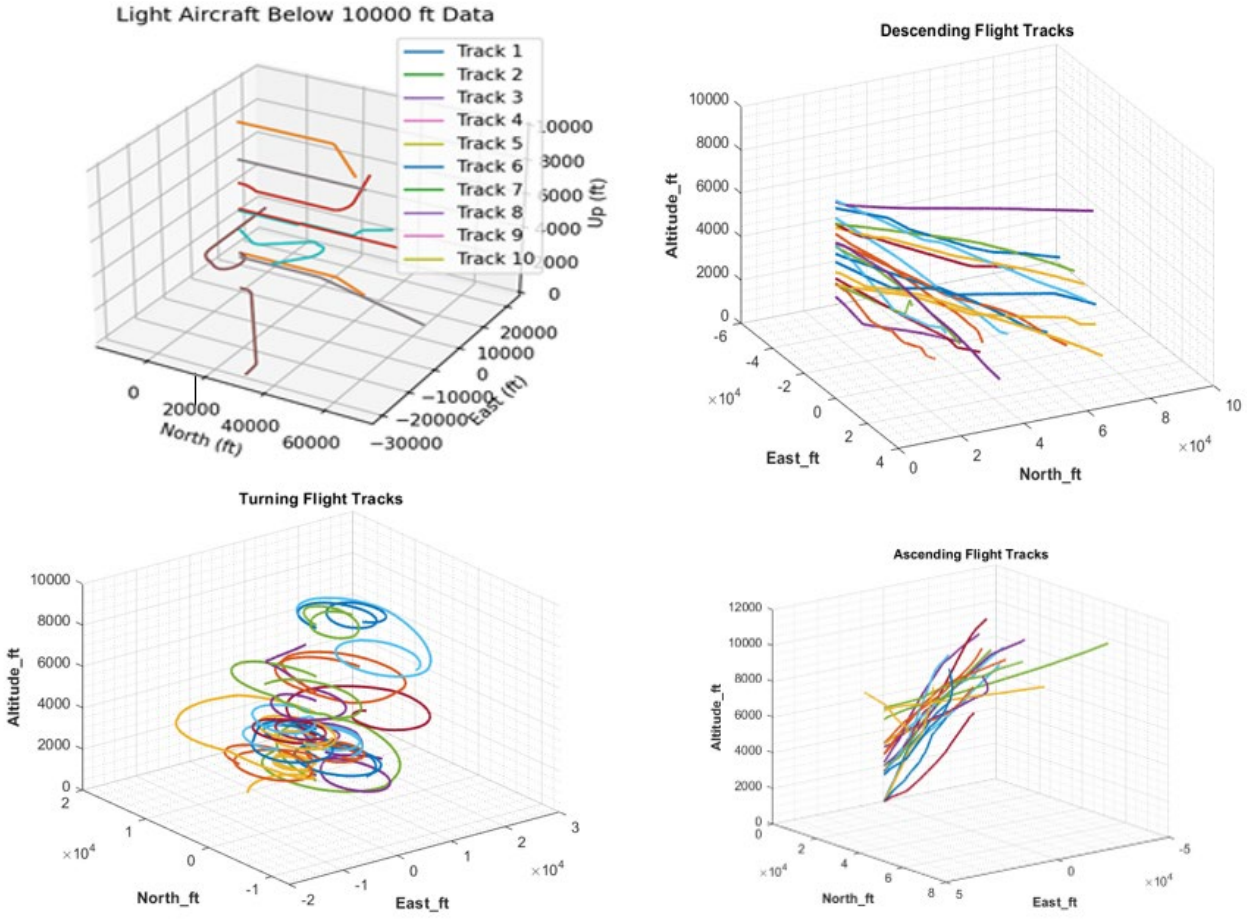

Figure 3 – Example Canadian airspace statistically representative intruder trajectories

9.64 Sensor & tracker modelling principles are as follows:

1. Fixed Nominal sensor performance must be modelled:

   a) It is important that sensor models ensure realism, including modelling for the target cross section.

   b) Sensor update rate must match live test of the surveillance equipment.

c) Sensor FOV and declaration range must match live test of the surveillance equipment

d) Sensor uncertainties must be modelled for both the ownship and intruder tracks. Examples include:

i. *Ownship*: GPS position uncertainty, pose uncertainty, and pose rate uncertainty

ii. *Intruder*: Position and velocity uncertainties from cooperative and non-cooperative sensors under the test.

2. Intruder Tracking:

a) Intruder trajectory filtering and tracking must be implemented as in the DAA system.

3. Sensor Track Anomalies Modelling:

a) The simulation must model missed tracks, false tracks, and split tracks to reflect real-world sensor behaviour.

b) The simulation must model intermittent detections to validate tracker's ability to sustain tracking continuity under such conditions.

9.65 To accurately model ownship trajectory, ownship position error must be modelled. An example is provided in Table 14, where the values were adopted from [32]. The applicant must implement the uncertainties as defined by the sensor onboard the ownship.

Position	≤ 8m 95% Horizontal Error, ≤ 13m 95% Vertical Error
Velocity	≤ 0.2 m/s 95% Velocity Error, any axis

Table 14 – Example Ownship Global Average Uncertainties

9.66 An example of cooperative intruder surveillance uncertainty modelling is provided below for ADS-B, where noise may be introduced to the intruder's 'true' trajectory. Specifically, an ADS-B sensor could be modelled using parameters such as NACp, NACv, and GVA. The ADS-B noise characteristics could be derived in accordance with the guidelines outlined in RTCA DO-282C, and the example parameters are provided in Table 15. ADS-B could be modelled as omni-directional sensor with a limitation on range.

9.67 **Note**: In Table 15 NACp (Navigation Accuracy Category Position) represents the accuracy of the position information transmitted by the ADS-B system. NACv (Navigation Accuracy Category Velocity) represents the accuracy of the velocity information transmitted by the ADS-B system. GVA (Geometric Vertical Accuracy) is vertical position accuracy of the ADS-B system. ADS-B latency

refers to the delay between the change in the aircraft's state and time of its transmission via ADS-B. Resolution refers to the smallest change in a parameter such as speed, vertical rate, altitude etc. that can be detected and reported by the ADS-B system.

9.68 It's important to highlight that the simulated ADS-B signal typically undergo filtering to appropriately condition the signal for the display, alerting & guidance functions. Some guidance of tracker design and implementation could be found in [31].

Parameter name	**Value**
NACp=9 uncertainty	30 m
NACv=2 uncertainty	3 m/s
GVA=2 uncertainty	45 m
Altitude Resolution	25 ft
Speed Resolution	1 kt
Max Latency	1.5 sec
Vertical Rate Resolution	64 ft/min

Table 15 – Example ADS-B Model Parameters

9.69 Non-cooperative sensors must be modelled with parameters appropriate for the selected sensor technology. The model must be configured to the performance of the DAA system, e.g., sensor range and field of view limitation must be implemented, uncertainties modelled, and tracking must be incorporated. Example parameters are provided in Table 16 for an EO sensor.

Parameter name	**Baseline setting**
Range	2000 m
Horizontal FOV	240 degrees
Vertical FOV	30 degrees
Coasting time	2 s
Bearing Sigma (standard deviation)	0.002 rad
Elevation Sigma (standard deviation)	0.002 rad

Bearing Rate Sigma (standard deviation)	0.002 rad/s
Elevation Rate Sigma (standard deviation)	0.002 rad/s
Range Table	[0.5 0.85 1]
Range Sigmas (standard deviations)	[0.12 0.12 0.2]
Range Rate Sigmas (standard deviations)	[0.2 0.2 0.2]

Table 16 – Example Non-cooperative Sensor Model Parameter (EO sensor)

9.70 Examples of implementing uncertainty within an encounter trajectory pair is provided in Figure 4 for ADS-B surveillance and Figure 5 for EO surveillance.

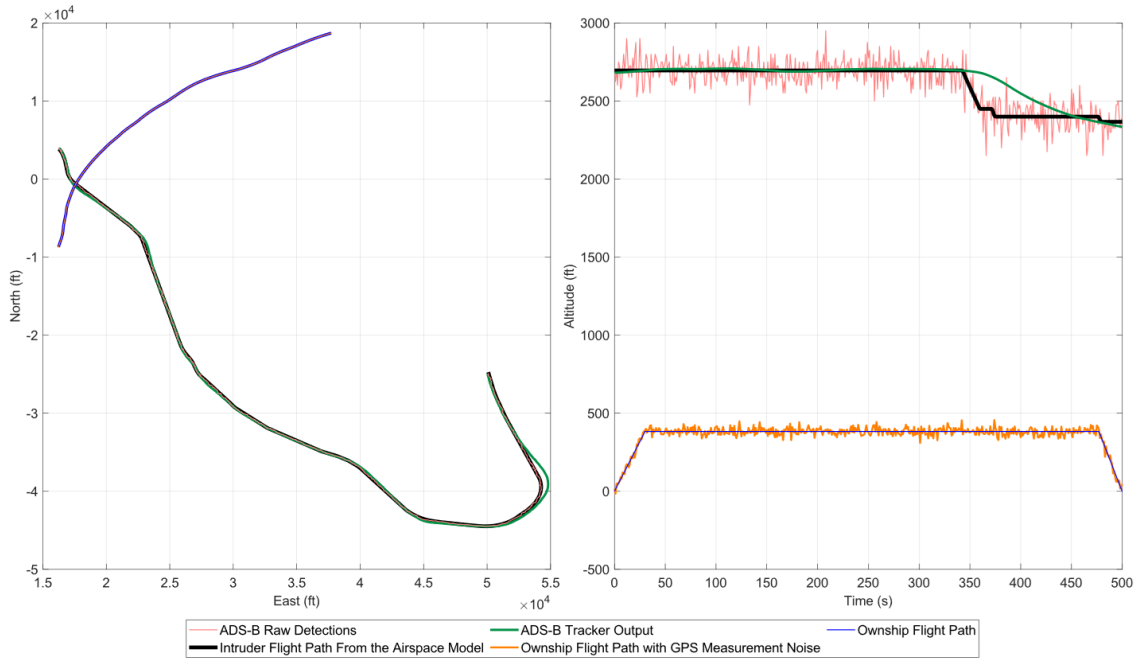

Figure 4 - Simulated ownship / intruder trajectories & ADS-B sensor output

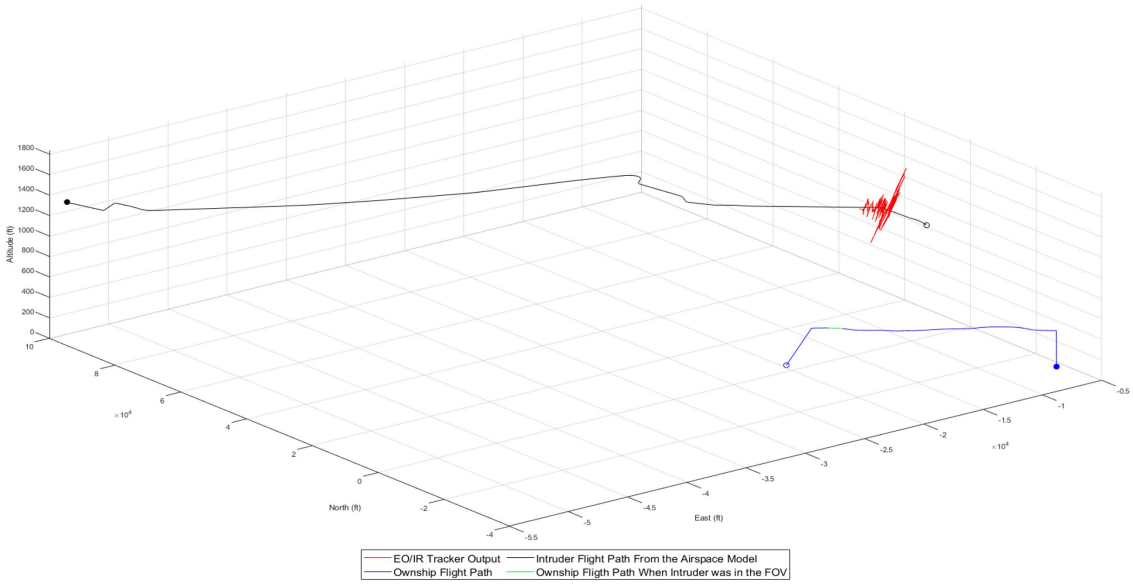

Figure 5 - Simulated ownship / intruder trajectories & EO sensor output when intruder is in FOV

9.71 Conflict prediction and resolution modelling principles are as follows:

1. The simulation must implement conflict prediction, alerting and guidance as defined by the DAA system.
2. Wind effects on avoidance performance must be modelled.
3. All relevant worst-case nominal delays must be modelled and accounted for, including command and control (C2), human factors (HF), track formation, and other system latencies.

9.72 Sensitivity analysis:

1. The above principles and encounter set can also be used to conduct a sensitivity analysis, evaluating how variation in key DAA capability parameters impacts performance.
2. The key DAA parameters may be altered to suit the DAA system under test, but the order of magnitude of testing should not be reduced without justification.
3. An example analysis is provided in Table 17.
4. The applicant should also consider a sensitivity analysis for couplings of the parameters in Table 17, if it is believed to be important.

Parameter	**Values / Description**
Surveillance range	0.01-0.5M encounters for declaration range reduced by 5%

	0.01-0.5M encounters for declaration range reduced by 10% 0.01-0.5M encounters for declaration range reduced by 15%
Sensor FoV	0.01-0.5M encounters for hFOV and or vFOV reduced to 5% 0.01-0.5M encounters for hFOV and or vFOV reduced by 10% 0.01-0.5M encounters for hFOV and or vFOV reduced by 15%
Ownship Navigation accuracy	0.01-0.5M encounters for position and velocity errors increased by 15% 0.01-0.5M encounters for position and velocity errors increased by 25% 0.01-0.5M encounters for position and velocity errors increased by 50%
Intruder surveillance & tracking accuracy	0.01-0.5M encounters for position and velocity errors increased by 15% 0.01-0.5M encounters for position and velocity errors increased by 25% 0.01-0.5M encounters for position and velocity errors increased by 50%
System delays	0.01-0.5M encounters for system delays increased by 5% 0.01-0.5M encounters for system delays increased by 10% 0.01-0.5M encounters for system delays increased by 20%
Ownship manoeuvre response	0.01-0.5M encounters for manoeuvre time increased by 15% 0.01-0.5M encounters for manoeuvre time increased by 25% 0.01-0.5M encounters for s manoeuvre time increased by 50%

Environmental (lighting for EO/IR)	0.01-0.5M encounters under low-light conditions (e.g., evening) 0.01-0.5M encounters under glare or high dynamic range (sun in field of view) 0.01-0.5M encounters under variable lighting (e.g., cloud cover, shadows)
Environmental (wind only)	0.01-0.5M encounters with moderate wind (±5 kt crosswind/gusts) 0.01-0.5M encounters with strong wind (±10 kt gusts or shear) 0.01-0.5M encounters with turbulent conditions (randomized wind vectors, vertical gusts)
Total encounters	9 parameters x 3 variations x 0.5M = 0.27M-13.5M
Notes	The same core encounter set from the nominal performance analysis may be used for each simulation run.

Table 17 - Example ARC-c Sensitivity Analysis

‘As-Built’ Full System Live Trials

Objectives

9.73 Final test of the end-to-end operation of the system, including surveillance, tracking, alerting, guidance and successful avoidance of conflict in the realistic operational environment. Spot point validation of elements from all previous tests. Note, flight tests operate at extremely low sample sizes. They are conducted in controlled, scripted conditions. Flight testing is intended to continue validating the assumptions, parameters, and system function behaviour used in fast-time simulation. It is not intended to demonstrate probabilistic safety performance (e.g. Risk ratio or Loss of Well Clear ratio), nor does it permit intentional loss of Well Clear or missed avoidance events. Quantitative metrics such as Risk Ratio must therefore be established through only large-scale simulation, not flight test.

9.74 The as-built system trials provide an additional opportunity to flight test and spot-validate the sensor model derived from field sensor tests, as well as other DAA parameters such as C2 link performance and manoeuvre execution time obtained from LVC simulations. This validation is not the primary objective of the as-built system trials; the primary objective is to demonstrate successful operation of the integrated system in the operational environment. However, it is beneficial to take advantage of these flight test opportunities to confirm the

assumptions and models used in earlier analyses. If the performance of the as-built system does not match the models or assumptions used in the fast-time simulations, the discrepancy should be investigated and resolved.

9.75 **Note**: The scope and rigour of 'As-Built' full system live trials may be adapted to the complexity of the DAA capability, its automation level, manoeuvre options, sensor suite and integration constraints, as well as the operational environment and the risk of the intended operation, provided that the resulting flight test campaign maintains equivalent demonstration power for the end-to-end objectives and the relevant performance requirements. Any such adaptation shall be justified and documented, including any resulting operational limitations.

ARC-b

9.76 Test principles are as follows:

1. Sensor detections, tracks, UAS and intruder "ground truth" and DAA events must be recorded during the flight test with a timestamp and centralized synchronization during the flight test for further analysis.
2. Approx. 50 representative encounters.
3. Must test for LWC, NMAC, and caution level alerts.
4. Applicant must demonstrate 100% successful NMAC avoidance and 95% RWC for conflict scenarios, which are proven to be mitigated in earlier tests.
5. Flight tests should be conducted against representative intruders for the operational airspace.
6. Flight tests should be conducted for typical operational speeds of ownship aircraft, including hovering, if applicable.
7. Flight tests should be conducted for typical speeds of intruder aircraft.
8. Flight tests may be conducted with ownship flying at single altitude.
9. Flight tests should be representative of a mission, especially its duration and profile.
10. Flight tests should be conducted for intruder flying both above and below horizon.
11. Intercepts should be flown for slowing down/speeding up, climbing/descending, turning and constant speed straight/level intruder flight profiles, including hovering helicopter case if applicable.

9.77 Expected test outcomes:

9.78 Flight tests must confirm that environmental interference, (e.g., ground clutter, noise etc.) as relevant to the surveillance sensor, is detected and successfully filtered/rejected by the system.

9.79 An example test design is provided in Table 18.

Parameter	Values / Description
Ownship Speed	1 fixed value, e.g., 50 knots
Ownship Altitude	1 fixed value – e.g., 400 ft AGL
Intruder altitudes	300 ft AGL and 500 ft AGL (below and above horizon)
Intruder Types	2 types: GA, Helicopter
Conflict Types	3 types: NMAC, LWC, No Conflict
Azimuth Bins	1 bin (near head-on collision)
Variable nonlinear trajectories for intruder	4 types: Straight and Level, Turning, Climbing or Descending (50%-50% splits), Accelerating or Decelerating (50%-50% splits)
Total encounters	49 (1 ownship speed × 1 ownship altitude × 2 intruder types × 3 conflict types × 1 azimuth x 4 intruder trajectory types x 2 Intruder altitudes=48 + 1 hovering helicopter case)

Table 18 – Example 'As Built' ARC-b Encounter Set

ARC-c

9.80 As with ARC-b except as follows:

1. Approx. 100 representative encounters.
2. Low altitude cases must be tested to verify that intruder gets detected in the ground clutter

9.81 An example test design is provided in Table 19.

Parameter	Values / Description
Ownship Speed	1 fixed value, e.g., 50 knots
Ownship Altitude	2 fixed values – e.g., 400 ft AGL and 2000 ft AGL

Intruder altitudes	2 (1000 ft AGL and 3000 ft AGL (below and above horizon))
Intruder Types	2 types: GA, Helicopter
Conflict Types	3 types: NMAC, LWC, No Conflict
Azimuth Bins	1 bin (near head-on collision)
Variable nonlinear trajectories for intruder	4 types: Straight and Level, Turning, Climbing or Descending (50%-50% splits), Accelerating or Decelerating (50%-50% splits)
Total encounters	97 (1 ownship speed × 2 ownship altitudes × 2 intruder types × 3 conflict types × 1 azimuth x 4 intruder trajectory types x 2 Intruder altitudes =96 + 1 hovering helicopter case)

Table 19 – Example ‘As Built’ ARC-c encounter set

Soak Test

Objectives

9.82 The soak test for endurance checks serves primarily as a software and hardware reliability assessment, with a key focus on continuous operation. The objective is to ensure that the DAA system can run for extended periods without ‘crashing’ or experiencing significant performance degradation.

9.83 This test could involve, for example, installing a DAA sensor near an airport to continuously record air traffic, or running the avoidance algorithm on a dedicated hardware non-stop within a simulation environment. Unlike other tests where only the total duration of testing is specified, due to the practical difficulty of orchestrating long-duration avoidance scenarios, soak tests explicitly require uninterrupted operation to validate system stability over time.

9.84 Primary objective of the soak tests are as follows:

1. To verify latency and computational load.
2. Sensor data handling, data parsing from the sensor, and data quality.
3. Confirm there are no memory leaks or software breakages.
4. Confirm reliable detection of errors and component failures.
5. Edge case data handling.

9.85 Types of bench tests:

1. Unit tests;

2. Regression tests; and
3. Data replay tests.

9.86 **Note**: Applicable ISOs or other relevant standards should be followed where available. In the absence of applicable standards, the principles described below may be used.

ARC-b

9.87 Must demonstrate minimum 12 hours of continuous errorless operations of all DAA hardware components.

9.88 **Note**: The MOC above is for airborne systems only. For ground-based sensors/systems that are intended to operate 24/7, soak tests should include at least 168 hours of uninterrupted operations (1 week), while simulating service-based reliability, including peak traffic scenarios.

ARC-c

9.89 Must demonstrate minimum 48 hours of continuous errorless operations of all DAA hardware components.

9.90 **Note**: The MOC above is for airborne systems only. For ground-based sensors/systems that are intended to operate 24/7, soak tests should include at least 336 hours of uninterrupted operations (2 weeks), while simulating service-based reliability, including peak traffic scenarios.

Chapter 10

Next Steps

10.1 This policy concept will be used as the baseline for DAA assurance during the remainder of the policy concept test phase (currently planned to end approximately Q4 2027, contingent on sufficient trial experience and learning). During this time, along with the additional test phase activities, preparation for BAU DAA policy adoption will continue, including:

1. Assessment of published technical standards as direct AMC to the policy.
2. Consideration of mandatory architecture requirements, e.g., onboard emergency collision avoidance for ARC-c and above, or mandatory guidance provision for ARC-c and above.
3. Continuation of applicant led DAA assessment projects.
4. Targeted industry engagement.
5. Oversight and testing activities, in support of evidence based regulatory decision making.
6. Public Consultation.
7. Training of CAA applications and oversight teams.
8. Consideration of ‘assure and re-use’ process, e.g., via TSO, SAIL mark, ARC-mark etc.
9. Consideration of additional cyber security specific requirement(s).
10. Review of requirement set for suitable proportionality between ARC-b and ARC-c, based on experience during the concept test phase.

APPENDIX A

Nomenclature

- ACAS Airborne Collision Avoidance System
- ADS-B Automatic Dependent Surveillance – Broadcast
- AFCAS Airborne Collision Avoidance System
- AGL Above Ground Level
- AHRS Attitude and Heading Reference System
- AIP Aeronautical Information Publication
- ALARP As Low As Reasonably Practicable
- AMC Acceptable Means of Compliance
- AMS Airspace Modernisation Strategy
- ANSP Air Navigation Service Provider
- ARC Air Risk Class
- ARM Air Risk Model
- ATC Air Traffic Control
- ATM Air Traffic Management
- BAU Business As Usual
- BVLOS Beyond Visual Line of Sight
- C&A Certification & Assurance (implied references)
- CA Collision Avoidance
- CAA Civil Aviation Authority
- CANP Civil Aviation Notification Procedure
- CAP Civil Aviation Publication
- C2 Command and Control
- C3 Command, Control and Communications
- CONOP Concept of Operations
- ConOps Concept of Operations

- CPA Closest Point of Approach
- DAL Development Assurance Level
- DAA Detect and Avoid
- DDCEF Detect, Decide, Command, Execute, Feedback
- DWC DAA Well Clear
- EC Electronic Conspicuity
- EO Electro-Optical
- FOR Field of Regard
- FOV Field of View
- FHA Functional Hazard Assessment
- FIS-B Flight Information Services – Broadcast
- FISO Flight Information Service Officer
- FW Fixed Wing
- GA General Aviation
- GM Guidance Material
- GNSS Global Navigation Satellite System
- GRC Ground Risk Class
- GVA Geometric Vertical Accuracy
- HDOP Horizontal Dilution of Precision
- HEMS Helicopter Emergency Medical Service
- HF Human Factors
- HFOM Horizontal Figure of Merit
- hFoV Horizontal Field of View
- HIL Hardware In the Loop
- HITL Human In the Loop
- HMI Human Machine Interface
- HSI Human Systems Integration
- ICAO International Civil Aviation Organization

- IFR Instrument Flight Rules
- JARUS Joint Authorities for Rulemaking on Unmanned Systems
- LVC Live Virtual Constructive
- LWC Loss of Well Clear
- LWCR Loss of Well Clear Ratio
- MAC Mid-Air Collision
- MASP Minimum Aviation System Performance
- MOR Mandatory Occurrence Report
- MOC Means of Compliance
- MOPS Minimum Operational Performance Standards
- MSO Multiple Simultaneous Operations
- NAA National Aviation Authority
- NACp Navigation Accuracy Category – Position
- NACv Navigation Accuracy Category – Velocity
- NIC Navigation Integrity Category
- NMAC Near Mid-Air Collision
- NOTAM Notice to Airmen / Notice to Air Missions
- ODD Operational Design Domain
- OSO Operational Safety Objective
- PDOP Position Dilution of Precision
- PNT Position, Navigation and Timing
- RA Resolution Advisory
- RP Remote Pilot
- RPA Remotely Piloted Aircraft
- RPAS Remotely Piloted Aircraft System
- RR Risk Ratio
- RTCA Radio Technical Commission for Aeronautics
- RWC Remain Well Clear

- SAA Sense and Avoid
- SAIL Specific Assurance and Integrity Level
- SARP / SARPSStandards and Recommended Practices
- SERA Standardised European Rules of the Air
- SIL Surveillance Integrity Level
- SITL Software In the Loop
- SME Subject Matter Expert
- SOP Standard Operating Procedure
- SORA Specific Operations Risk Assessment
- STANAG NATO Standardisation Agreement
- SUA Special Use Airspace
- sNMAC Small UA Near Mid-Air Collision
- sWC Small Well Clear
- sXu Small UAS Collision Avoidance System Xu
- TCAS Traffic Collision Avoidance System
- TIM Tactical Integrity Metric
- TLS Target Level of Safety
- TMZ Transponder Mandatory Zone
- TIS-B Traffic Information Service – Broadcast
- TSO Technical Standard Order
- TRA Temporary Reserved Area
- TSA Temporary Segregated Area
- TWG Technical Working Group
- UA Unmanned Aircraft
- UCS Unmanned Aircraft Control System
- UAS Unmanned Aircraft System
- UTM Unmanned Traffic Management
- UTMSP UTM Service Provider

- VFOM Vertical Figure of Merit
- vFOV Vertical Field of View
- VFR Visual Flight Rules
- VHF Very High Frequency
- VMC Visual Meteorological Conditions
- WC Well Clear
- WCV Well Clear Volume
- WTC Wake Turbulence Category

APPENDIX B

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