February, 2019

International Standards

and Recommended Practices

Annex 10

to the Convention on

International Civil Aviation

Aeronautical Telecommunications

Volume IV, Part 2

Detect and Avoid Systems

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FOREWORD

The initial release of these SARPS is based on the concepts contained in the initial release of the ICAO Manual on Remotely Piloted Aircraft Systems (RPAS) (Doc 10019, First Edition, 2015), which identified five hazards to be mitigated by a Detect and Avoid (DAA) capability; conflicting traffic, terrain and obstacles, hazardous meteorological conditions, ground operations, and other airborne hazards. At the time of this initial publication, DAA for conflicting airborne traffic is the only function these SARPS address, due in part, to technology maturity. It is intended that this Annex will be updated in the future to cover other hazards, but until such time, it is expected that these other hazards will be mitigated through procedures or other systems (e.g., Terrain avoidance using TAWS) during international IFR operations of RPAS. Unless specifically addressed otherwise, the technical standards in this Part consider nominal RPAS operations, which include an operating C2 Link.

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

CHAPTER 1. DEFINITIONS

Note: A number of definitions that existed in Part 1 of Volume IV have been adapted considering the specific context of Detect and Avoid. Where the terms identified in this section are common with terms defined in other parts of Volume IV, the definitions used in this section apply. In this chapter, the adapted definitions are identified using the prefix [DAA]. The prefix however, is not added in the actual text of the SARPS.

Rationale: This chapter provides definitions for terms used in Annex 10, Volume IV, and Part2. This includes new definitions and definitions with recommended changes for DAA, identified with a "[DAA]" preceding the term.

Definitions that are not ultimately used in this Part will be removed, but all potential definitions are included here temporarily as a reminder for the drafting team.

1.1 DEFINITIONS FROM ANNEX 10 VOLUME IV PART 1, REVISED FOR DAA

The following definitions in this section are closely related to definitions in Part 1, but revised to make them applicable for DAA. When these terms are used, they include the term "DAA" to show the broader definition is intended.

[DAA] Coordination. The process by which DAA-equipped aircraft select compatible RWC and DRA manoeuvres.

Note. – The coordination process could be either implicit or explicit. It may vary between Remain Well Clear and Collision Avoidance, as well as for aircraft and intruders of different levels of equipage.

Rationale: The current definition is very ACAS-specific, so a new definition is needed for the more generic case of DAA. This definition also recognizes DAA manoeuvres can be from potential threats or threats.

"Coordination" could be a more generic term in a revised Part 1 to apply to both DAA and ACAS-equipped aircraft by adding two new definitions for "Implicit Coordination" and "Explicit Coordination". For now, this change will be proposed for Part 2.

[DAA] Intruder. An aircraft within the surveillance volume for which a track has been established.

Rationale: DAA requires a more generic definition for intruder, but there is no need to create a different term. Can work with SP to generate a more generic definition that can be used in both parts. Unlike ACAS, Part 2 cannot assume that all aircraft are SSR transponder equipped. This definition starts with Part 1 definition and modifies the definition to be more broadly generic.

"Surveillance range" has been changed to "surveillance volume" since not all sensors used for surveillance will be omnidirectional like in ACAS, but may have a limited field of regard.

[DAA] Near threat. An intruder that may become a DAA potential threat.

Rationale: No specific definition is provided in Part 1. The Part 2 definition is more generic because the position of a DAA intruder can be validated with active surveillance or other approved means. Goal is to keep the same relationship as for ACAS as the risk of potential collision increases (DAA Intruder, DAA Near threat, DAA Potential threat & finally DAA Threat). See table below for comparison between key points for ACAS and DAA.

	Near threat	***Potential threat***	***Threat***
ACAS SARPs Use	*Intruder that shall be tracked under active surveillance as determined by separate tests on the range and altitude of the aircraft with respect to own aircraft (Annex 10, V4 4.5.1.4)*	*Warning time such that a Traffic Advisory (TA) is justified. If displayed on a traffic display, then displayed in amber or yellow. (4.3.3.1.1)*	*Warning time such that a Resolution Advisory (RA) is justified. If displayed on a traffic display, then displayed in red. (4.3.5.1.1)*
Proposed [DAA] SARPs Use	*Intruder that shall be tracked under surveillance as determined by separate tests on the measurements.*	*The alerting time provided against a potential threat is sufficiently small that display of a DAA Remain Well-Clear (RWC) alert is justified, but not so small that a resolution advisory would be justified.. (4.3.3 as example SARPs to modify)*	*Warning time such that a DAA Resolution Advisory (DRA) is justified using warning-level alerting. (4.3.5 as example SARPs to modify)*

[DAA] Potential threat. An intruder deserving special attention either because of its close proximity to own aircraft or because successive range and altitude measurements indicate that it could be on a collision or near-collision course with own aircraft. The alerting time provided against a potential threat is sufficiently small that display of a DAA Remain Well-Clear (RWC) alert is justified, but not so small that a resolution advisory would be justified.

> **Rationale:** The words of this definition are similar to Annex 10 V4 Part 1, but the Part 2 definition needs to be different to show that the action is to display a DAA manoeuvre and not a traffic advisory like ACAS II. Goal is to keep the same relationship as for ACAS as the risk of potential collision increases (DAA Intruder, DAA Near threat, DAA Potential Threat & finally DAA Threat). See table with comparison between key points of these definitions for ACAS and DAA.

[DAA] Resolution Advisory (DRA) – An indication given to the flight crew recommending:

a) A vertical and/or horizontal manoeuvre intended to mitigate a collision hazard from all current threats; or

b) A vertical and/or horizontal manoeuvre restriction intended to limit the risk of collision.

> **Rationale:** The definition of "Resolution Advisory" requires a change to make it more generic for DAA with vertical and/or horizontal manoeuvres and to avoid the use of the controversial word "separation". The proposed definition uses wording from the proposed definition for collision avoidance function and the proposed definition should change for consistency if the wording for the collision avoidance function definition is changed.
>
> This definition could be placed in a revised Part 1 with modifications to indicate that resolution advisories apply to the DAA collision avoidance function or to ACAS. The definition above will be proposed for Part 2 to meet DAA needs, but if it is changed in Part 1, then the definition would not be needed here and Part 2 will just reuse the Part 1 modified definition. There is agreement with the Surveillance Panel's ACSG to revise the definition in Part 1, but until such time, the definition is kept.
>
> Note that the word "threat" is defined below.

[DAA] Threat. An intruder with a validated position requiring special attention either because of its close proximity to own aircraft or because successive measurements indicate that it is on a collision or near-collision course with the own aircraft. The warning time provided against a threat is sufficiently small that a Resolution Advisory is justified using warning-level alerting.

Rationale: The words of this definition are similar to Annex 10 V4 Part 1, but the Part 2 definition needs to be different to show that the action is to display a DAA manoeuvre and not a traffic advisory like ACAS II. Goal is to keep the same relationship as for ACAS as the risk of potential collision increases (DAA Intruder, DAA Near threat, DAA Potential Threat & finally DAA Threat). See table with comparison between key points of these definitions for ACAS and DAA.

1.2 NEW DEFINITIONS IN PART 2

Collision Avoidance Function. A function used to alert the pilot of the need to take immediate action by generating a recommended manoeuvre to limit the risk of collision with all threats.

Rationale: Reference is made to RPASP/12 WP3 and Flimsy 1.

Cooperative Aircraft. Aircraft that carry and operate equipment for the purpose of surveillance. These aircraft transmit surveillance data directly from their onboard systems.

Rationale: RTCA DO-365 definition included to show that for DAA, a cooperative aircraft is one that provides electronic identification. This information can be used by the RPAS DAA system to execute its functions with or without other surveillance information.

DAA Caution Alert. A caution-level of alert for conditions that require immediate remote pilot awareness and less urgent subsequent remote pilot response. A DAA caution alert for conflict traffic hazards supports a subsequent response to ensure DAA Well Clear.

Rationale: In line with established airworthiness criteria, the alerting distinguished between Caution Level Alert, i.e. an alert indicating that immediate remote pilot awareness and subsequent flight crew response is required and Warning Level alerts, indicating that immediate remote pilot awareness and subsequent flight crew response is required. Further guidance on alerting may be found in FAA AC 25.1322 and EASA AMC 25.1322.

DAA Interoperability. The capability of one DAA system to operate in airspace with other collision avoidance systems or DAA systems without negatively impacting the other systems or the safe and orderly flow of air traffic.

Rationale: Reference RTCA / EUROCAE Draft MASPs for interoperability of airborne Collision Avoidance (CA) systems (v5.3) and RTCA DO-365, Appendix M. Revised from the definition of "Interoperability".

DAA Remain-Well-Clear (RWC): The ability to detect, analyse and manoeuvre in order to ensure that a RPA is not being operated in such proximity to other aircraft as to create a collision hazard.

Rationale: Modified from the RPAS Manual §10.12.3 (also RTCA DO-365) definition with the use of "such proximity to other aircraft as to create a collision hazard" from Annex 2, paragraph 3.2.1 (Proximity) and other wording changes to shorten the definition.

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

Rationale: Reference is made to RPASP/12 WP3 and Flimsy 1.

DAA Warning Alert. A warning-level of alert for conditions that require immediate remote pilot awareness and immediate remote pilot response. A DAA warning alert for conflict traffic supports a response to one or more recommended manoeuvres to avoid a threat.

Note: The DAA RA is the manoeuvre guidance provided in association with a DAA warning.

Rationale: In line with established airworthiness criteria, the alerting distinguished between Caution Level Alert, i.e. an alert indicating that immediate remote pilot awareness and subsequent flight crew response is required and Warning Level alerts, indicating that immediate remote pilot awareness and subsequent flight crew response is required. Further guidance on alerting may be found in FAA AC 25.1322 and EASA AMC 25.1322.

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.

Rationale: Slight modification from definition in RTCA DO-365 that emphasizes the boundary is used in a DAA system. The term 'boundary' was intentionally used to make it clear that DWC is not a fixed physical volume around an aircraft, but rather a boundary based on a time-variant relationship between the own aircraft and intruder and/or a spatial boundary

Explicit Coordination. Coordination in which each aircraft in an encounter uses real-time exchange of information to ensure compatible RAs.

> **Rationale:** RTCA DO-365, Appendix M.17, the source for interoperability MASPS to be published by EUROCAE and accepted by RTCA.

Field of regard: The total area at any given range that a sensing system can perceive with adequate resolution. The field of regard is typically much larger than the sensor's field of view. For a stationary sensor that is not scanning, the field of regard and field of view coincide.

> **Rationale:** While Field of View is not defined in any existing ICAO documents, it is a standard technical term, which is often called “surveillance volume” or “surveillance coverage” in other ICAO material. It is required to distinguish between Field of Regard and Field of View in these SARPs because of the addition of three dimensional scanning surveillance sensors. The term ‘area’ is intentionally used, as its use is common in industry.

Field of view: The total area at any given range that a sensing system can perceive with adequate resolution at a single point in time.

> **Rationale:** Field of View is used as a term in Annex 2 but is not defined. While Field of View is not defined in any existing ICAO documents, it is a standard technical term, which is often called “surveillance volume” or “surveillance coverage” in other ICAO material. It is required to distinguish between Field of Regard and Field of View in these SARPs because of the addition of three dimensional scanning surveillance sensors.

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.

> **Rationale:** This definition is a modified version of the one found in RTCA DO-365, Appendix M.17, the source for interoperability MASPS to be published by EUROCAE and accepted by RTCA.

Loss of DAA Well Clear: Any time another aircraft penetrates the DAA Well Clear boundary of the own aircraft RPA.

> **Rationale:** Reference RTCA DO-365, but revised from “own aircraft UAS” to “own aircraft RPA”.

Near Midair Collision (NMAC). Two aircraft simultaneously coming within 30 meters (100 ft.) vertically and 150 meters (500 ft.) horizontally.

Note. – Reference is made to RTCA DO-185B/EUROCAE ED-143

Rationale: Reference RTCA DO-185B and EUROCAE ED-143 to provide the volume of airspace around the threat aircraft that the RPA DAA collision avoidance function keeps the RPA from entering during its closest point of approach.

This volume has been established for ACAS for over 40 years.

Non-Cooperative Aircraft. Aircraft that are not equipped with an electronic means of identification (e.g., a transponder) or not operating such equipment due to malfunction or deliberate action.

Rationale: Reference RPAS Manual.

Surveillance Volume. The volume of airspace where the DAA sensors can detect and track intruders. The surveillance volume may be different for each sensor.

Rationale: There is no formal definition in DO-365 except the Note from Appendix A on DAA equipment (pdf page 348 of 838). The word "onboard" has been omitted from that note to allow a broader range of sensors to be included and "DAA" is added in front of "sensors" to point out that the sensors support DAA.

CHAPTER 2. GENERAL PROVISIONS RELATING TO DETECT AND AVOID (DAA)

Rationale: The first edition of Part 2 emphasizes DAA for conflicting traffic that requires a dedicated risk mitigation capability for IFR flight in controlled airspace and aerodromes. Other hazards are documented in the ICAO Global Air Traffic Management Operational Concept (Doc 9854) and referenced in the RPAS Manual. These hazards may be addressed through the use of existing aircraft systems (e.g. weather radar, TAWS, etc.) or through operational limitations on the flight route. Operational requirements for DAA are addressed in Annex 6, Part 4. Future editions of Annex 10, Volume IV, Part 2 may address SARPs for hazard management equipment that is unique to RPAS.

There will be several sections that are "reserved" to act as "placeholders"

Note 1. – Annex 6 Part IV contains carriage and operational requirements for DAA.

Note 2. – Operational procedures for DAA are found in PANS-OPS and PANS-ATM.

Note 3. - Guidance material relating to the Detect and Avoid system is contained in the Detect and Avoid (DAA) Manual.

2.1 DAA WITHIN GLOBAL AIR TRAFFIC MANAGEMENT

2.1.1. [Standard] A DAA system shall allow the remote pilot to fulfil the responsibilities concerning avoidance of collisions with airborne conflicting traffic as described in the first paragraph of §3.2, §3.2.1, and §3.2.2 of Annex 2.

<u>Rationale:</u> This is a fundamental requirement that anchors the DAA system in the responsibilities of the Pilot in Command as described in Annex 2 §3.2, first paragraph, as well as §3.2.1 and §3.2.2. This is considered necessary, at the beginning of Annex 10, to ensure that regulators understand the context that this equipment is being defined within. Annex 2 change proposals include use of a DAA system: "Nothing in these rules shall relieve the pilot in command [...], in the case of RPAS, compliance with these rules including collision avoidance manoeuvres will be based on detect and avoid "

Specific rules of Annex 2 §3.2 are included here because §3.2 in its entirety is not applicable to DAA systems, specifically 3.2.3 and beyond.

2.2 FUNCTIONAL REQUIREMENTS

2.2.1 [Standard] A DAA system shall provide two functions, the Collision Avoidance function and the Remain-Well-Clear function.

Note 1. – The Global Air Traffic Management Operational Concept (Doc. 9854) describes three layers of Conflict Management. Within this context, DAA fulfils the Collision Avoidance layer of conflict management and, when appropriate, fulfils the Separation Provision layer of conflict management.

Rationale: Basic requirement on DAA functionality in order for the pilot to fulfil the responsibilities as defined in Annex 2, *§3.2*. Annex 2 change proposals include the use of a DAA system.

The Remain-Well-Clear (RWC) function enables the remote pilot to comply with the responsibilities for 'good airmanship' and the right of way rules of Annex 2, and more particularly, the first paragraph of section 3.2, as well as the requirements of 3.2.1 and 3.2.2, by timely alerting the pilot of possible encounters with other traffic and giving the remote pilot guidance to apply right of way and to remain well clear of these. When separation is not provided by ATC, the RWC function provides the separation layer of conflict management.

The Collision Avoidance (CA) function serves the same purpose as the ACAS function defined in Annex 10, Volume IV, part 1, namely to allow the remote pilot to avoid a collision after all other mitigations to prevent a collision have failed. The CA function fulfils the Collision Avoidance layer of conflict management.

Within the context of the Global Air Traffic Management Operational Concept (Doc. 9854) §2.7.8 describes the three layers of conflict management.

2.2.2. [Standard] The DAA system shall be capable of performing its required functions in the intended air traffic environment.

Note 1. – Characteristics of the air traffic environment include, inter alia, density of traffic, relative airspeeds, manoeuvrability, and airspace structure.

Note 2. – The minimum number of aircraft to be considered for each component of the DAA system, may vary depending on the intended function of each component.

Note 3. - Additional information can be found in the DAA Manual (Doc. XXXX).

Rationale: The number of aircraft that the DAA system will need to perform surveillance, display, and provide alerting and guidance against must be considered as part of the system development process as it will affect many parts of the system. This is similar, in concept, to the requirements on traffic density in Annex 10, Volume IV, §4.3.2.1.1, Table 4-1. However, there is a desire to allow flexibility for operators to be able to select the DAA system that is most appropriate for their operation, which will vary with air traffic environment. ICAO is foreseen to give further guidance on trade-offs for adequate numbers in guidance material. Standardization bodies is foreseen to give further guidance on adequate numbers in standards.

2.2.3. [Standard] The DAA system shall be capable of processing multiple intruders simultaneously for the purpose of identifying all near threats, potential threats, and threats.

Rationale: This is a critical part of the intended function of the DAA system, as stated in §2.2.2. This also aligns with the threat classification scheme.

2.2.4. [Standard] The DAA System shall be capable of providing alerting and manoeuvre guidance against all identified threats and potential threats to ensure DAA performance.

Rationale: Alerting and Guidance provided to the remote pilot is a critical part of the intended function of the DAA system, as stated in §2.2.2. This also aligns the alerting and guidance scheme with the threat classification scheme.

In order for an aircraft to become a threat or potential threat, then the DAA system will first have to detect and track that aircraft, which is consistent with the definition in Chapter 1, hence the addition of the word "identified".

2.2.5. [Recommended Practice] The DAA system should provide output data to the flight data recorder.

Note. – Data elements that may be considered for recording are provided in the DAA manual.

Rationale: The DAA system may just need to output the data for the purpose of data recording; the data does not need to be recorded inside the DAA system, it may also be recorded on an external recorder. Data elements that could be output for recording are provided in the DAA manual.

Current Annex 6 Part IV draft requires all RPA to be equipped with a Recording System (RPA RS)

2.3 DAA MANOEUVRING

Note. – Except where the State of the Operator has approved RPAS operations without automated collision avoidance, Annex 6 requires the RPA to be capable of performing automated collision avoidance manoeuvres.

2.3.1 [Standard] When the DAA manoeuvre command is automatically executed by the flight computer, the DAA system shall inform the remote pilot of the commanded manoeuvre.

Note. – Further details on the information provided to the remote pilot is contained in the DAA Manual.

Rationale: This requirement supports the remote pilot in command's responsibility to be aware of critical functions onboard the RPA and monitor this manoeuvre. More detail will be provided in the DAA Manual, but it is anticipated that at least information on the type, direction, and magnitude of the manoeuvre will be required to be displayed to the pilot.

PANS-OPS and PANS-ATM may need to be updated to include requirements on how the remote pilot will use this information.

The phrase "by the flight computer" is maintained in this Standard in order to draw a distinction between functions that are intended for the DAA system and functions that are intended for other components of the RPAS and/or the remote pilot. This is not mean to imply an order of events and may be difficult for the reader to visualize how this requirement will be met without a functional decomposition graphic, so that needs to be considered in the DAA Manual.

2.3.2 [Standard] When the DAA manoeuvre command is automatically executed by the flight computer, the DAA System shall command the flight computer to return the aircraft to a stable state in level flight once clear of the conflict.

Note. –The Remote Pilot's actions after the conflict is resolved are addressed in PANS-OPS.

Rationale: This standard is intended to ensure that the RPA returns to a predictable and stable state following the execution of an automated DAA manoeuvre. This aids the remote pilot in further navigation of the RPA, or, in case of a Lost C2 Link state, provides aircraft behaviour that is compatible with the onboard navigation system and other contingency functions. Further navigation, either by the remote pilot or onboard navigation system, may be a standardized procedure or may require coordination with ATC. The goal is to clearly draw the transition from functions that are intended for the DAA system and those functions that are intended for other systems. This is also intended to cover the situation in which the remote pilot is commanding a manoeuvre and the flight computer is executing it, so that as the pilot comes back into the loop for further navigation after the conflict is resolved, the RPA is in a stable state.

For example, in ACAS installations that are auto-coupled to the flight guidance system, ACAS issues the "Clear of Conflict" command, this is interpreted as a 0 VSI command, which is executed by the flight guidance system.

2.3.3 [Standard] A DAA system capable of an automatically executed manoeuvre command shall include a function that provides the remote pilot with the capability to:

a. inhibit or abort an automated DAA flight trajectory, and
b. Intervene or redirect the flight trajectory.

Note 1. – Annex 6, Part 4 contains operational requirements for the remote pilot's use of the DAA system.

Note 2. – The off-nominal case of a lost C2 Link state is addressed in Chapter 11.

Rationale: This standard covers automatically initiated manoeuvres and the PIC ability to intervene. The intention of this standard is to cover nominal operational situations, when the C2 Link is active and available. During a lost C2 Link state, the remote pilot will not be able to perform these actions, but that does not stop the system from having the function to allow those actions to happen.

Notwithstanding the automation of some or all of the functions in a DAA system, maintaining the remote pilot's responsibility to act as Pilot in Command, necessitates that some functionality still be present in the RPAS design, even if automation may appear to alleviate those functions.

Annex 6, Part 4, Section 3, §3.2.4 is the current location of the DAA operational requirements. The discussion of DAA manoeuvre automation is contained in RPASP/7-WP/7-Flimsy 1.

2.4 CYBER SECURITY FOR DAA

2.4.1 [Standard] Measures to protect against cyber threats, including technical and operational means, shall be observed throughout the design and operational use of the DAA system, taking into account information exchanges between DAA system components.

Note 1. – Guidance material on cybersecurity principles can be found in Chapter 18 of the Aviation Security Manual (Doc 8973), Cyber Threats to Critical Aviation Information and Communication Technology Systems.

Note 2. – Security requirements for the C2 Link are contained in Annex 10 Vol 6.

Rationale: It is assumed that the entire RPAS will need to be designed, developed, and operated in a manner that observes cybersecurity principles, but the working group considers that DAA will require special attention from designers and regulators.

Annex 17: §4.9 Measures relating to cyber threats

4.9.1 Each Contracting State shall ensure that operators or entities as defined in the national civil aviation security programme or other relevant national documentation identify their critical information and communications technology systems and data used for civil aviation purposes and, in accordance with a risk assessment, develop and implement, as appropriate, measures to protect them from unlawful interference.

4.9.2 Recommendation.—Each Contracting State should ensure that the measures implemented protect, as appropriate, the confidentiality, integrity and availability of the identified critical systems and/or data. The measures should include, inter alia, security by design, supply chain security, network separation, and the protection and/or limitation of any remote access capabilities, as appropriate and in accordance with the risk assessment carried out by its relevant national authorities.

Special attention needs to be paid to the information exchanges within the DAA system, since as conceived currently, the system will be distributed among the RPA and RPS. Most recently, the standard "The exchange of information between components of the DAA system shall be secure", but the Secretariat decided to merge it with 2.4.1 by adding the "including information exchanges between DAA system components" and moving the notes up to 2.4.1.

2.4.2 [Standard] If surveillance data is not collected through an independent means, then any such data shall be independently validated prior to use in issuing warning alerts and associated manoeuvre guidance.

Note 1. – Mode-S interrogations/replies, primary radar, electro-optical sensors are all considered independent means of collecting surveillance data to track aircraft.

Note 2. - ADS-B over 1090ES validation is addressed in § 3.2.1.2.1.4.

Note 3. – ADS-B over VDL Mode 4 validation is addressed in § 3.2.1.2.2.3

Note 4. - ADS-B over UAT validation is addressed in § 3.2.1.2.3.3

Rationale: DAA traffic surveillance provides a potentially vulnerable point in the DAA system and methods for validating surveillance data already exist in ACAS, therefore it requires special consideration for DAA.

2.5 HUMAN FACTORS FOR DAA

2.5.1 [Standard] Human Factors principles shall be observed in the design of the DAA system.

Note. -- Guidance material on Human Factors principles can be found in the Human Factors Training Manual (Doc 9683) and Circular 249 (Human Factors Digest No. 11 — Human Factors in CNS/ATM Systems).

Rationale: It is assumed that the entire RPAS, and especially the RPS, will need to be designed, developed, and operated in manner that observes human factor principles, but the working group considers that DAA will require special attention from designers and regulators.

2.6 ATMOSPHERIC CONDITIONS

Note 1. – The atmospheric conditions, discussed in this section, are distinct from the environmental conditions typically discussed in airworthiness requirements.

Note 2. – Sensors to detect and track cooperative aircraft are not currently considered in this section because the active and passive surveillance systems described in Annex 10 Volume IV Part 1 and in Annex 10, Volume III, Part 1, Chapter 6, §6.9 are considered to meet their functional and performance requirements in all atmospheric conditions.

Rationale: Sub-chapter on Atmospheric conditions could cover more than conflicting traffic in the future. This is why it belongs to Chapter 2.

Annex 2 currently makes provisions for a pilot, with natural limitations associated with unaided human eyes, to perform “see and avoid” when they are able recognizing that atmospheric conditions may decrease the effectiveness of the pilot. This section attempts to replicate these provisions when sensors are used to enable the Remote Pilot to perform the same functions.

It is assumed that existing active (e.g. ACAS) and passive (ADS-B) surveillance systems function in all-weather environments and so the working group wants to ensure that they maintain that capability as part of a DAA system.

If a RPAS is going to be approved to operate in “extreme” weather environments (e.g. Hurricanes), this requirement may need to be revisited along with the certification of the RPA for that extreme environment.

2.6.1 [Standard] Sensors to detect and track non-cooperative aircraft shall meet their functional and performance requirements in visibility conditions commensurate with Visual Meteorological Conditions (VMC), as defined in Annex 2 §3.9 "VMC visibility and distance from cloud minima".

2.6.2 [Recommended Practice] Sensors to detect and track non-cooperative aircraft should be designed such that performance degradations, if any, are;

a. proportionate to degradations in atmospheric conditions, and
b. not so abrupt as to appear as if the sensor has failed.

Note 1. – It is recognized that in adverse atmospheric conditions, the DAA system may have reduced overall performance.

2.6.1 Rationale: It is generally accepted that Visual Meteorological Conditions (VMC), as defined in Annex 2 §3.9 "VMC visibility and distance from cloud minima", are established and defined to set the conditions under which natural human vision allows the pilot onboard an aircraft to perform their responsibilities under Annex 2 and especially their "see and avoid" responsibilities. The intent of this requirement is to ensure that sensors used to detect and track non-cooperative aircraft (e.g. Radar, Optical. Infrared, Acoustic, etc.…) perform their function in and through those same atmospheric conditions, at a minimum. "Through" is the key word, as this atmospheric condition will be present through the entire volume of airspace that the electromagnetic signals travel. An aircraft operating in IMC (i.e. atmospheric conditions worse than VMC) is required to have an altitude reporting transponder and therefore will be cooperative. Therefore, non-cooperative aircraft will only be operating in atmospheric conditions appropriate for the airspace class and the non-cooperative sensor will need to be able to function through that atmosphere. This means that the atmospheric condition must be, in the worst case, applicable for both the own aircraft and the intruder. For example, if the own aircraft is flying in airspace where "3 mile visibility" is the regulatory minimum for VFR flight, then a non-cooperative aircraft could be encountered, in the worst case, when both the own aircraft and the non-cooperative intruder are flying through an atmospheric volume where "3 mile visibility" would be observed, independent of the distance between. In this example, the atmospheric phenomenon (e.g. rain or dust) causing the observed "3 mile visibility" would be the worst condition between them, because if a "cloud" was between them, then the "cloud clearance" requirements would apply, and natural human vision would not be expected to facilitate "see and avoid" through the "cloud".

<u>2.6.2 Rationale:</u> Sensors should not "stop working" when the atmospheric conditions degrade beyond VMC, but this RP needs to be worded in a positive way.

It is worth recognizing that onboard pilots will experience both graceful degradation in their ability to see other aircraft (e.g. reduction in flight visibility) and abrupt degradation in their ability to see other aircraft (e.g. flying into a cloud).

2.7 DAA DURING INTERCEPTION

Reserved.

Note 1. – Interception procedures are detailed in Annex 2 §3.8 and Appendix 2 of Annex 2. The remote pilot can be notified of an interception by radio, a telephone call or other means.

Note 2. – At the time of writing there are no solutions to externally control an RPA during a lost C2 Link state. This includes inhibiting DAA manoeuvres in such situations.

<u>Rationale:</u> This concept is still being matured, but it is important to put a placeholder in Annex 10 Volume IV Part 2 so that people know that we are thinking about it and waiting for ICAO to finalize a CONOPS for RPAS Interception.

The issue in off-nominal conditions such as a Lost C2 Link state and/or lost voice radio communication are not resolved.

No visual procedures can apply to DAA equipped RPAS as DAA for conflicting traffic do not necessarily provide visual means.
Non-visual procedure for interception should apply during nominal conditions with operational DAA, C2 and voice radio communication. Nominal DAA operation has pilot in the loop operations and should thus not limit the RPA ability to comply during an interception.

CHAPTER 3. TRAFFIC SURVEILLANCE

3.1 GENERAL PROVISIONS RELATING TO SURVEILLANCE FOR DAA

3.1.1. [Standard] The DAA system shall provide traffic surveillance of cooperative and non-cooperative aircraft.

Rationale: In International IFR operations, most aircraft will be compliant with Annex 6 and be equipped with an altitude reporting transponder (i.e. cooperative). However, there may also be aircraft, which either legally, illegally, or accidently do not have an operative transponder (i.e. non-cooperative) and the DAA system must detect and track those aircraft as well. This standard serves to highlight this point and make it very clear to designers and regulators.

It should be noted that "surveillance" is used as a verb in this sentence, not as a noun referring to the surveillance system. It is the intention for the DAA System to utilize parts of the (legacy transponder-based) Surveillance System, but not that the Surveillance System would become part of the DAA System. “Traffic surveillance” is used here and throughout the SARPs to differentiate from legacy uses of the term “surveillance”.

3.1.2. [Standard] The DAA system shall provide sufficient surveillance coverage to meet the performance criteria in §11.1, considering the intended flight envelope of the own aircraft.

Note. – In order to meet the performance criteria, the intended flight envelope may have to be limited or the surveillance coverage may have to be expanded.

Rationale:

There is a recognition that the addition of a DAA system onto a RPA may limit the flight envelope over which that aircraft can be operated. In the context of International IFR operations, this may mean that the full flight envelope of a particular RPA is not utilized because of procedural limitations, regulatory limitations, or equipment limitations. For example, a transport category aircraft, which have a very wide certified flight envelope (e.g. airspeed up to 600 KIAS), could be converted to a RPA, but with the addition of a DAA System designed for aircraft with a maximum airspeed of 400 KIAS, would have its intended flight envelope limited so that manoeuvres do not exceed the surveillance capabilities. Such a system may be retrofitted onto this aircraft and flight envelope limitations imposed with the intention that a future system could be enhanced to allow for the full flight envelope to be covered. The idea is to ensure that the surveillance coverage matches the operational approval of the RPA. Annex 6 uses the term “certified flight envelope” several times, so we used “intended flight envelope” to recognize that the flight envelope may be restricted.

Determining performance will also include considering many other things, such as the air traffic environment, and these are covered in Chapter 11 or, in the case of air traffic environment, in 2.2.2.

3.2 SURVEILLANCE SENSORS

3.2.1 Surveillance of Cooperative aircraft

3.2.1.1 SSR transponder equipped aircraft

Note. - Secondary Surveillance Radar (SSR) system characteristics are defined in Annex 10 Volume IV Part 1 §3.1.

Rationale: Given that equipage with an altitude reporting transponder is a minimum requirement for international IFR operations, equipage with a secondary surveillance radar is a minimum requirement in order to interrogate those transponders and receive replies while building a track. This section intends to remain consistent with the existing Annex 10 Vol IV.

It is not the intention to mandate that RPAS equip with the same antennas used by ACAS, but the signal characteristics and spectrum management usage of a SSR for DAA will have to be consistent with Vol 4 3.1 in order to ensure compatibility, performance, and interoperability.

Annex 6 Part VI requires RPAS to carry a SSR Transponder. Practically, a SSR transponder will be required to meet 3.2.1.1.2.

3.2.1.1.1 [Standard] The field of view of the sensors used to detect SSR transponder-equipped traffic shall not be less than +/- 180 degrees in azimuth relative to the longitudinal axis of the aircraft and +/-15 degrees in elevation relative to the own aircraft's pitch plane.

Note. – Aircraft installation considerations, such as surveillance blockage, can be found in the DAA Manual.

Rationale: Existing technology for detecting and tracking cooperative aircraft enables coverage beyond normal windscreen requirements, therefore this technology can easily be utilized.

Most recently, this standard contained the note "*Note. – This requirement exceeds the requirement in Annex 10, Volume IV, Part 1 §4.3.2.1.1(a), which contains track establishment requirements for ACAS. RTCA DO-185B / ED-143 contains additional requirements for antenna performance from +10 to +20 degrees elevation" but this was removed because it caused more confusion and the Sec. can use this in response to questions.*

This standard is consistent with §3.2.2.1.5 but applied to the surveillance of SSR transponder equipped aircraft to highlight the fact that existing transport category aircraft have pilot field of view limitations that should form the minimum basis for DAA traffic surveillance, although performance assessments may necessitate larger field of regards.

3.2.1.1.2 [Standard] With the exception of the minimum field of view requirement which is covered in 3.2.1.1.1, the surveillance of SSR transponders shall meet, at a minimum, the performance requirements contained in Annex 10 Volume IV Part 1 §4.3.2.1, "Surveillance performance requirements".

Rationale: Requirements for air-air surveillance of SSR transponder equipped aircraft already exist in Annex 10 Volume IV, therefore these should at least be met, and however, additional DAA-specific analysis may necessitate higher levels of performance. Since we don't fully understand the types of RPAS that will conduct international IFR operations, then we are trying to set a minimum requirement (Part 1 4.3.2) while making it clear to the reader that additional considerations may be required.

3.2.1.1.3 [Standard] The DAA system shall have interference control that complies with Annex 10 Vol IV Part 1 §4.3.2.2, or equivalent measures to avoid harmful interference with other SSR interrogators.

Note. – Further guidance on interference control is provided in the DAA Manual.

Rationale: Early versions of ACAS identified a requirement to reduce interrogations to ensure a higher density of equipped aircraft and the same functionality will be needed for DAA systems. Ideally, DAA systems can adopt the existing interference control requirements for ACAS, so as to not introduce additional spectrum congestion then would be introduced by another ACAS-equipped aircraft. However, the Interference Control requirements in Part I §4.3.2.2 may overly constrain interrogations for DAA functions. Significant analysis will be required to show that interference control techniques other than those required in Part 1 §4.3.2.2 can be introduced safely.

The goal of this standard is to limit SSR transponder interrogations to an acceptable level to avoid harmful interference with other SSR interrogators.

3.2.1.2 ADS-B OUT equipped aircraft

Note. – Within the context of this document, ADS-B OUT is used in the generic sense and can refer to transmissions utilizing Mode S Extended Squitter, VDL Mode 4, or UAT.

3.2.1.2.1 Mode S Extended Squitter (ES) equipped aircraft

Note 1. – Mode S Extended Squitter transmitting system characteristics are defined in Annex 10 Volume IV Chapter 5.

Note 2. - Mode S Extended Squitter receiving system characteristics (ADS-B IN and TIS-B IN) are defined in Annex 10 Volume IV §5.2.

3.2.1.2.1.1 [Standard] The DAA system shall use passive surveillance of cooperative aircraft, as defined in Annex 10 Volume IV Part 1 §4.5.

Rationale: Recent versions of ACAS have identified the use of passive surveillance (i.e. ADS-B) as an effective way to mitigate spectrum congestion and interference, therefore those requirements also apply to DAA systems. The criteria for passive surveillance of Annex 10 Volume IV, Part 1, §4.5 are considered suitable for DAA.

3.2.1.2.1.2 [Recommended Practice] The DAA system should contain a Class A3 ADS-B capability as defined in Annex 10 Volume IV Part 1 §5.1.1.2.

Rationale:

Recommended Practice on ADS-B out and in.
This Recommended Practice has been included in order to achieve the highest range (up to 90 NM) and the most efficient use of spectrum. The higher range meets all the operational use cases for ADS-B and also improves visibility for ATC and other airspace users.

3.2.1.2.1.3 [Standard] The field of view of the sensors used to detect 1090 Mode S extended squitter shall not be less than +/- 180 degrees in azimuth relative to the longitudinal axis of the aircraft and +/-15 degrees in elevation relative to the own aircraft's pitch plane.

Rationale:

The coverage requirements are similar to those for surveillance of SSR transponder equipped aircraft, see section 3.2.1.1.1. Existing ADS-B IN technology for detecting and tracking ADS-B OUT aircraft enables coverage beyond normal windscreen requirements, therefore this technology can easily be utilized.

This standard is consistent with §3.2.2.1.5 but applied to the surveillance of Mode S ES equipped aircraft to highlight the fact that existing transport category aircraft have pilot field of view limitations that should form the minimum basis for DAA traffic surveillance, although performance assessments may necessitate larger field of views.

3.2.1.2.1.4 [Standard] The DAA system shall validate the position of an intruder reported by 1090 MHz extended squitter by meeting the requirements contained in Annex 10 Volume IV Part 1 §4.5.1.3.1 or by means of the sensors used to provide surveillance of non-cooperative aircraft with equivalent revalidation rate as described in Annex 10 Volume IV Part 1 §4.5.1.

Note 1. – ADS-B track data is used to display traffic information (see §3.4.1) and to issue a caution level alert (see §4.4.1), even if it is not validated, but a DRA is only issued if validation has been achieved (see §5.4.2).

Note 2. – Further guidance on validation of ADS-B track data is provided in the DAA Manual.

Rationale: This requirements flows from §2.3.3 and follows existing Part I SARPs.

In ACAS, passive surveillance data (ADS-B 1090ES) will show up as traffic but a RA will not be issued against it.

The following principles apply:

- Non validated passive surveillance data is used for traffic information (3.4.1)
- Non validated passive surveillance data is used for RWC - clearance from ATC required to manoeuvre in controlled airspace (4.4.1)
- Non validated passive surveillance data cannot be used for CA. (5.4.2)

Primary Radar (or other sensor for non-cooperative aircraft surveillance) may be used instead of the SSR to validate ADS-B track data, but it will have to meet the same timing requirements as in Part 1.

3.2.1.2.2 VHF Digital Link (VDL) Mode 4 equipped aircraft

Note 1. – The requirements for VDL Mode 4 are specified in ICAO Annex 10 (Aeronautical Communications), Volume III (Communications Systems), Part I (Digital Data Communication System), Chapter 6.

Note 2. - Additional information on VDL Mode 4 is contained in the Manual on VHF Digital Link (VDL) Mode 4 Technical Specifications (Doc 9816).

Note 3. - The VDL Mode 4 airborne equipment standards are contained in ETSI EN 302 842 standards.

3.2.1.2.2.1 [Standard] The DAA system shall receive VDL Mode 4 ADS-B messages where the use of VDL Mode 4 is required on the basis of a regional air navigation agreement.

Rationale: VDL M4 is considered a viable means of receiving traffic information for DAA systems and if it is allowed in a region, it may enhance the DAA system performance and so is used along with the other surveillance sources. Having more surveillance information may improve DAA performance.

This Standard only becomes a requirement if/when a State or Region requires the use of VDL Mode 4.

There are currently no States or Regions that require the use of VDL Mode 4, but there may be in the future.

3.2.1.2.2.2 [Recommended Practice] The DAA system should receive VDL Mode 4 ADS-B messages where the use of VDL Mode 4 is available on the basis of a regional air navigation agreement.

Rationale: VDL M4 is considered a viable means of receiving traffic information for DAA systems and if it is allowed in a region, it may enhance the DAA system performance and so is used along with the other surveillance sources. Having more surveillance information may improve DAA performance.

This Recommended Practice only becomes applicable if/when a State or Region allows the use of VDL Mode 4.

There is currently at least one State that allows the use of VDL Mode 4, but there may be more in the future.

3.2.1.2.2.3 [Standard] The DAA system shall validate, the track data provided by VDL Mode 4 by independent means, with equivalent revalidation rate as described in Annex 10 Volume IV Part 1 §4.5.1.

Note 1. – ADS-B track data is used to display traffic information (see §3.4.1) and to issue a caution level alert (see §4.4.1), even if it is not validated, but a DRA is only issued if validation has been achieved (see §5.4.2).

Note 2. – The VHF Digital Link (VDL) Mode 4 Technical Specifications (ICAO Doc. 9816) provides requirements on ADS-B VDL Mode 4 validation method based on estimation of distance between aircraft using VDL Mode 4 signal carrying the position data and time stamps.

Note 3. – Reference is made to the DAA Manual for further guidance on the use of VDL Mode 4.

Rationale: VDL M4 is considered a viable means of receiving traffic information for DAA systems and if it is allowed in a region, it may enhance the DAA system performance and so is recommended to be used along with the other surveillance sources. Having more surveillance information may improve DAA performance.

While VDL M4 can be internally validated by comparing a time difference of arrival, this relies on a timestamp created using GNSS time. This dependence on GNSS has caused several authorities around the world to determine that this validation method is not secure enough to be used in safety critical applications, therefore "internal validation" is not considered in this requirement. This minimum requirement is only meant to address “revalidation rate”, not the other aspects of use of passive surveillance in DAA, as defined in Part 1 4.5.1. Initial validation is covered by the requirements in Chapter 4 and Chapter 5, this is section is only mean to cover revalidation. The quantitative thresholds in Part 1 4.5.1 may not be applicable to DAA systems, depending on the timelines and RWC and CA thresholds, but the revalidation rates are applicable.

3.2.1.2.3 Universal Access Transceiver (UAT) equipped aircraft.

Note 1. - UAT SARPs are documented in ICAO Annex 10 (Aeronautical Communications), Volume III (Communications Systems), Part I (Digital Data Communication System), Chapter 12.

Note 2.— Details on technical requirements related to the implementation of UAT SARPs are contained in Part I of the Manual on the Universal Access Transceiver (UAT) (Doc 9861). Part II of the Manual on the Universal Access Transceiver (UAT) (Doc 9861) (in preparation) will provide additional guidance material.

3.2.1.2.3.1 [Standard] The DAA system shall receive UAT messages where the use of UAT is required on the basis of a regional air navigation agreement.

Rationale: UAT is considered a viable means of receiving traffic information for DAA systems and if it is allowed in a region, it may enhance the DAA system performance and so is used along with the other surveillance sources. Having more surveillance information may improve DAA performance.

This Standard only becomes a requirement if/when a State or Region requires the use of UAT.

There are currently no States or Regions that require the use of UAT, but there may be in the future.

3.2.1.2.3.2 [Recommended Practice] The DAA system should receive UAT messages where the use of UAT is available on the basis of a regional air navigation agreement.

Rationale: UAT is considered a viable means of receiving traffic information for DAA systems and if it is allowed in a region, it may enhance the DAA system performance and so is used along with the other surveillance sources. Having more surveillance information may improve DAA performance.

This Recommended Practice only becomes applicable if/when a State or Region allows the use of UAT.

There is currently at least one State that allows the use of UAT, but there may be more in the future.

3.2.1.2.3.3 [Standard] The DAA system shall validate, the track data provided by UAT by independent means, with equivalent revalidation rate as described in Annex 10 Volume IV Part 1 §4.5.1.

Note 1. – ADS-B track data is used to display traffic information (see §3.4.1) and to issue a caution level alert (see §4.4.1), even if it is not validated, but a DRA is only issued if validation has been achieved (see §5.4.2).

Note 2. – Reference is made to the DAA Manual for further guidance on the use of UAT.

Rationale: UAT is considered a viable means of receiving traffic information for DAA systems and it is allowed in a region, it may enhance the DAA system performance and so is recommended to be used along with the other surveillance sources. Having more surveillance information may improve DAA performance.

When it is mandated by a State in defined portions of airspace, the state vector and other information from conflicting traffic provides valuable input for the safe operation of a DAA system.

While UAT can be internally validated by comparing a time difference of arrival, this relies on a timestamp created using GNSS time. This dependence on GNSS has caused several authorities around the world to determine that this validation method is not secure enough to be used in safety critical applications, therefore "internal validation" is not considered in this requirement. This minimum requirement is only meant to address "revalidation rate", not the other aspects of use of passive surveillance in DAA, as defined in Part 1 4.5.1. Initial validation is covered by the requirements in Chapter 4 and Chapter 5, this is section is only mean to cover revalidation. The quantitative thresholds in Part 1 4.5.1 may not be applicable to DAA systems, depending on the timelines and RWC and CA thresholds, but the revalidation rates are applicable.

3.2.1.3 Other Cooperative Surveillance Sources

RESERVED

3.2.2 Surveillance of non-cooperative aircraft

3.2.2.1 Detection and tracking requirements

Note. - Sensors are a part of the DAA system to detect and track non-cooperative aircraft (§3.1.1) to support the collision avoidance function (Chapter 5) and remain-well-clear function (Chapter 4). The use of sensor(s) to detect and track non-cooperative aircraft contributes to the overall performance of the DAA system in all airspace classes by sending track information for the purpose of alerting and guidance (§4.4 and §5.4) to enable DAA manoeuvres in nominal (§11.1) and off-nominal (§11.2) encounters with airborne conflicting traffic.

Note. – Standards 3.2.2.1.1, 3.2.2.1.2, and 3.2.2.1.3 are meant to be descriptive adjectives to connect the typical size and performance of non-cooperative aircraft.

3.2.2.1.1 [Standard] The sensors used for the surveillance of non-cooperative aircraft shall detect and track small-sized non-cooperative aircraft with a true airspeed of up to 100 knots, with full surveillance performance.

Note 1. – Non-cooperative aircraft of a small size are typically represented by unpowered gliders, balloons, and hang-gliders, all of which are more difficult to detect due to their small physical or electronic properties and are expected not to have an airspeed that exceeds 100 knots. Refer to the DAA Manual for further discussion.

Note 2. – Encounters with aircraft outside of the criteria defined in the standard, where less than full surveillance performance would be expected, should be considered as defined in §11.2.

Rationale: Unlike cooperative aircraft surveillance, the physical characteristics of a non-cooperative aircraft are important in developing sensors to meet these requirements. The numbers are based on collected radar data is US, but is included here under the assumption that aircraft design and operational use are relatively similar around the world. There is a "long tail" in the distribution of aircraft speeds for a particular aircraft category (e.g. gliders) and that operational considerations will impact those speeds (e.g. racing). This set of requirements is aiming to define sensor requirements, not necessarily define or bound categories of aircraft. These speeds are representative of a reasonable upper bound where "full surveillance performance" would be required. The use of the phrase “small-sized” to describe non-cooperative aircraft in this standard is not meant to imply a category of aircraft, it is a descriptive adjective only.

While DAA systems would be expected to meet the full performance requirements for threats with these size and speed characteristics, protection would still be provided for aircraft outside of these bounds.

3.2.2.1.2 [Standard] The sensors used for the surveillance of non-cooperative aircraft shall detect and track medium-sized non-cooperative aircraft with a true airspeed of up to 130 knots, with full surveillance performance.

Note 1. – Non-cooperative aircraft of a medium size are typically represented by single-engine aeroplanes and helicopters and are expected not to have an airspeed that exceeds 130 knots. Refer to the DAA Manual for further discussion.

Note 2. – Encounters with aircraft outside of the criteria defined in the standard, where less than full surveillance performance would be expected, should be considered as defined in §11.2.

Rationale: Unlike cooperative aircraft surveillance, the physical characteristics of a non-cooperative aircraft are important in developing sensors to meet these requirements. The numbers are based on collected radar data is US, but is included here under the assumption that aircraft design and operational use are relatively similar around the world. There is a "long tail" in the distribution of aircraft speeds for a particular aircraft category (e.g. gliders) and that operational considerations will impact those speeds (e.g. racing). This set of requirements is aiming to define sensor requirements, not necessarily define or bound categories of aircraft. These speeds are representative of a reasonable upper bound where "full surveillance performance" would be required. The use of the phrase “medium-sized” to describe non-cooperative aircraft in this standard is not meant to imply a category of aircraft, it is a descriptive adjective only.

While DAA systems would be expected to meet the full performance requirements for threats with these size and speed characteristics, protection would still be provided for aircraft outside of these bounds.

3.2.2.1.3 [Standard] The sensors used for the surveillance of non-cooperative aircraft shall detect and track large-sized non-cooperative aircraft with a true airspeed of up to 170 knots, with full surveillance performance.

Note 1. – Non-cooperative aircraft of a large size are typically represented by twin-engine aeroplanes and are expected not to have an airspeed that exceeds 170 knots. Refer to the DAA Manual for further discussion.

Note 2. – Encounters with aircraft outside of the criteria defined in the standard, where less than full surveillance performance would be expected, should be considered as defined in §11.2.

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Rationale: Unlike cooperative aircraft surveillance, the physical characteristics of a non-cooperative aircraft are important in developing sensors to meet these requirements. The numbers are based on collected radar data is US, but is included here under the assumption that aircraft design and operational use are relatively similar around the world. There is a "long tail" in the distribution of aircraft speeds for a particular aircraft category (e.g. gliders) and that operational considerations will impact those speeds (e.g. racing). This set of requirements is aiming to define sensor requirements, not necessarily define or bound categories of aircraft. These speeds are representative of a reasonable upper bound where "full surveillance performance" would be required. The use of the phrase “large-sized” to describe non-cooperative aircraft in this standard is not meant to imply a category of aircraft, it is a descriptive adjective only.

While DAA systems would be expected to meet the full performance requirements for threats with these size and speed characteristics, protection would still be provided for aircraft outside of these bounds.

3.2.2.1.4 [Standard] The sensors shall continue to provide surveillance of non-cooperative aircraft with no abrupt degradation in surveillance performance as any one of the condition bounds defined in 3.2.2.1.1, 3.2.2.1.2, or 3.2.2.1.3 is exceeded.

Rationale: Similar requirement to current Annex 10, Volume IV, Part 1, Paragraph 4.3.2.1.1.1 and Annex 10, Volume IV, Part II paragraphs 2.5.3 and 11.2.1.

“4.3.2.1.1.1 ACAS shall continue to provide surveillance with no abrupt degradation in track establishment probability as any one of the condition bounds defined in 4.3.2.1.1 is exceeded.”

3.2.2.1.5 [Standard] The field of regard of the sensors used to detect non-cooperative traffic shall be no less than +/- 110 degrees in azimuth and +/-15 degrees in elevation relative to the RPA body axis, but may need to be increased in order to comply with §3.1.2 and §11.1.2.

Note. – More than one sensor may be needed to meet the field of regard requirement for non-cooperative traffic surveillance.

Rationale: In today's manned aircraft operating internationally under IFR, the pilot is only physically able to see non-cooperative aircraft that appear in the windscreen, therefore, to ensure equivalence, those requirements should form the basis for the minimum standard. For slow moving RPA, analysis shows that a larger field of regard may be required to meet an overall level of safety performance.

3.2.2.1.6 [Standard] Transmissions from sensors used to detect non-cooperative aircraft shall be controlled to avoid harmful interference to systems necessary to support safety and regularity of air navigation, on-board other aircraft or in use by ATC.

Rationale: This technical interoperability requirement is added here rather than Chapter 10 for continuity in this section.

Recently, this standard only covered non-cooperative sensors, but it was felt that it should cover both cooperative and non-cooperative. However, cooperative sensors are already covered with requirements for Interference Control and Hybrid Surveillance for Active Surveillance. It is also covered for ADS-B in the design of those standards already and will be met by meeting those standards.

Used Annex 10 Vol 3 §4.3.2.1 as a template: The total emissions of the AES necessary to meet designed system performance shall be controlled to avoid harmful interference to other systems necessary to support safety and regularity of air navigation, installed on the same or other aircraft.

3.2.2.2 Airborne primary surveillance radar equipped own aircraft

Note 1. - An airborne Primary Surveillance Radar is a conventional radar sensor that illuminates a large portion of space with an electromagnetic wave and receives back the reflected waves from targets within that space.

Note 2. – Non-cooperative sensors can be of different technologies which have specific characteristics that may impact their performances that needs to be considered. The ability for an airborne primary surveillance radar to detect and track aircraft will depend on physical size, aircraft construction material, encounter angle, background, and other factors. Guidance in determining an appropriate RADAR cross section for radar design can be found in the DAA Manual.

Note 3. – RTCA DO-366 "MOPS for Air-to-Air Radar for Traffic Surveillance" provides an example of a MOPS for an airborne primary surveillance radar used in a DAA System.

3.2.2.2.1 [Standard] The airborne primary surveillance radar shall meet its range performance requirement in at least four millimetres of rain per hour (mm/hr).

Rationale: 4 mm/hr of rain has been shown to be the maximum condition that human can see 3 NM, which forms a reasonable baseline for VMC conditions in which non-cooperative aircraft would be present.

3.2.2.2.2 [Standard] The airborne primary surveillance radar shall operate only within frequency bands which are appropriately allocated to the aeronautical radio-navigation service (ARNS) and protected by the ITU Radio Regulations for the purpose of air-to-air primary surveillance radars.

Rationale: Safety critical surveillance application requires protected spectrum.

Modelled on Annex 10 Vol III 4.3.1.1: When providing AMS(R)S communications, an AMS(R)S system shall operate only in frequency bands which are appropriately allocated to AMS(R)S and protected by the ITU Radio Regulations.

3.2.2.3 Electro Optical Equipped Own aircraft

RESERVED

Note. – The ability for an electro optical sensor to detect and track a non-cooperative aircraft depends on physical size, aircraft construction material, encounter angle, background, and other factors. Guidance in determining an appropriate size for electro optical sensor design can be found in the DAA Manual.

Rationale: It is widely accepted that an Electro Optical (either in visible or infrared bands) sensor could provide some or all of the surveillance capability for non-cooperative aircraft and several research projects have been developing this technology for over a decade. This research has not yet yielded a civilian performance standard, therefore, the working group has determined that it is not yet ready to be included in annex 10.

The concept of using an electro optical sensor for DAA only considers image processing collocated with the sensor so that tracks can be sent via the C2 Link, not raw video images.

3.2.3 Consideration for ground based surveillance

3.2.3.1 [Recommended Practice] Ground-based surveillance should augment airborne surveillance in conditions where airborne surveillance cannot provide the required performance.

Note. – Further considerations for ground based surveillance are provided in the DAA Manual (Doc XXXX).

Rationale: Additional coverage and data will improve DAA capability and performance. It is recognized that gaps in airborne surveillance coverage (e.g., close to the ground during landing phase) can be filled using operational means or procedures, such as airspace design (e.g., Class A or Class B) or airport movement limitations.

3.2.3.2 Ground-based Surveillance Performance

RESERVED

Note. - RTCA DO-381 provides an example MOPS for a ground-based primary surveillance radar to be used as part of a DAA System.

Rationale: There are currently no published standards for a ground-based primary surveillance radar to be used in a DAA System, however RTCA SC-228 is currently working on a MOPS for such a system and it is anticipated to be published before these SARPS.

3.3 GENERAL PROVISION RELATING TO TRACKING FOR DAA

3.3.1 [Recommended Practice] The DAA system should be able to discern the source of the tracking information it is presenting to the remote pilot.

Rationale: This Recommended Practice is intended to provide additional information to the pilot on source and characteristics of detected intruders for traffic awareness and assessment (e.g. Non-cooperative intruders might not be known to ATCO). PANS-OPS and PANS-ATM may provide clear guidance to Pilots and ATCO's as to how to handle DAA tracks differently depending on the source of the track information.

3.3.2 [Standard] The tracker used as part of DAA system shall output a single track per intruder.

Note. – One means of meeting this requirement is to meet the performance requirements contained in RTCA DO-365 §2.2.3.2.2.

Rationale: It will be possible for the DAA system to contain multiple surveillance sources and therefore, it will be necessary for the tracks to be combined.

Annex 10 Vol IV 7.1.2.1: "The system shall display only one track for each distinct aircraft on a given display."

3.4 DISPLAY OF AIRBORNE TRAFFIC

3.4.1 [Standard] The DAA system shall provide the remote pilot with a display of traffic information to support the remote pilot to take appropriate actions including safe execution of DAA manoeuvres.

Note 1. – Appropriate actions in response to the traffic information displayed also include coordination with ATC, if required.

Note2. - This Standard may affect compliance with §11.1.2

Note 3. - Traffic information may include such elements as symbols, data tags, data blocks, etc.

Rationale: A display is one of the key means for providing information to the pilot. This standard supports, but is independent from, the CA and RWC functions.

The display provides sufficient awareness of surrounding traffic to enable compliance with the Annex 2 chapter 3 requirement for 'vigilance for the purpose of detecting potential collisions'.

3.4.2 [Standard] The system shall provide the remote pilot with a DAA Traffic display capable of displaying at least the eight intruders with the highest priority.

Note. – Reference is made to the DAA Manual for further guidance on Traffic awareness and prioritisation.

Rationale: The number of eight aircraft is consistent with RTCA DO-365.

3.4.3 [Standard] The traffic display shall ensure that traffic information associated with an intruder causing a caution level alert, and other intruders as defined in §3.4.2, are always made visible to the remote pilot.

3.4.4 [Standard] The traffic display shall ensure that traffic information associated with an intruder causing a warning level alert, and other intruders as defined in §3.4.2, are always made visible to the remote pilot.

Rationale: This requirement is necessary because the alert (and guidance) may be displayed separately from the traffic information, but the pilot will need to be able to associate the traffic information with the alert that is being generated. The pilot also needs to be aware of the other intruders when there is an alert.

Using "traffic information" here clearly links this requirement back to the Traffic Display, rather than to the CA or RWC functions.

3.4.5 [Recommended Practice] The traffic display should present traffic using different symbols in cases where the source of the information directly affects the remote pilot's response.

Rationale: To provide additional information to the pilot on source and characteristics of detected intruders for traffic awareness and assessment. E.g. Non-cooperative intruders might not be known to ATCO.

CHAPTER 4. DAA REMAIN-WELL-CLEAR FUNCTION

4.1 DAA WELL CLEAR

4.1.1 [Standard] The DAA system performance shall be measured against the respective DAA Well Clear (DWC).

Note. – The DAA Well Clear boundary may vary with operational environment, (e.g. airspace structure, separation standards) and type of equipment. Refer to the DAA Manual for further guidance on the definition and validation of DWC.

Rationale: A standard for measuring RWC performance is needed. 'Respective' is intending that for different operational environments, DWC may differ. Example: ACAS-II sensitivity levels have been tuned to enable operation in US and European airspaces.

This was modified to mirror 5.1.1 more closely. Removed "quantitative standards" because this was confusing here. There is an open question as to who would approve DWC and how they would do it, so more information needs to be provided in the DAA Manual and coordination with RPASP-ATMOPS Task Force.

4.1.2 [Standard]The DAA system shall use a quantitative definition of DAA Well Clear (DWC) compatible with airspace design, applicable separation minima, and air traffic service provisions, to minimize disruption to ATM.

Note 1. – A quantitative definition of DAA Well Clear (DWC) may depend on the class of airspace, the equipage of the own aircraft and intruder, air traffic services, and other factors.

Note 2. – It may be necessary to adapt the DAA Well Clear (DWC) to different environments, e.g. terminal areas versus en-route airspace.

Rationale: This standard was developed based on the condition that the RPA is operating under IFR in controlled airspace, including the terminal controlled area, and receiving separation services. However it is recognized that certain circumstances will require the RPA to transit through uncontrolled airspace, in which case this standard would still apply, but certain considerations in this standard may not be consequential. The goal is to enable seamless integration and limit disturbance to other traffic.

Different DWC are foreseen to cope with different scenarios, environments and other aspects. However interoperability between DAA systems and other aircrafts and ATC are also required. This should preferably be harmonized. More information needs to be provided in the DAA Manual and coordination with RPASP-ATMOPS Task Force.

"Airspace design" is included to capture characteristics such as closely spaced approach procedures and areas where controlled airspace is directly next to uncontrolled airspace.

4.1.3 [Standard] In order to minimize nuisance resolution advisories on other aircraft, the quantitative definition of DAA Well Clear (DWC) shall be defined with consideration of the warning alert thresholds of collision avoidance systems installed on other aircraft.

Rationale: Requirement on compatibility with equipment on other aircraft, including ACAS II, in order to enable seamless integration with other airspace users.

The main collision avoidance system in worldwide operation in ACAS II, but other collision avoidance systems may proliferate in the coming years and this standard should remain applicable.

4.1.4 [Recommended Practice] A single quantitative definition of DAA Well Clear (DWC) should be prescribed for all DAA-equipped aircraft operating in the same operational environment when encountering a cooperative aircraft.

Note. – The operating environment referred to in this recommended practice includes, inter alia, airspace class, procedure design, applicable separation minima, and air traffic service provisions.

Rationale: The goal is for all DAA-equipped aircraft operating in a particular airspace to be measured against the same DWC, but this a RP because States may have good reasons to allow more than one.

It is recognized that it may be necessary to have more variants, e.g. one for cooperative and another for CA equipped aircraft. This helps in ensuring seamless integration. It is also recognized however that harmonization offers benefits to all stakeholders.

4.1.5 [Recommended Practice] A single quantitative definition of DAA Well Clear (DWC) should be prescribed for all DAA-equipped aircraft operating in the same operational environment when encountering a non-cooperative aircraft.

Note. – The operating environment referred to in this recommended practice includes, inter alia, airspace class, procedure design, applicable separation minima, and air traffic service provisions.

Rationale: The goal is for all DAA-equipped aircraft operating in a particular airspace to be measured against the same DWC, but this a RP because States may have good reasons to allow more than one.

Non-cooperative aircraft are separated here because pilots performing "see and avoid" and ATC treats these aircraft differently. A non-cooperative aircraft is most likely flying under VFR and is not ACAS II equipped (or the ACAS II is not operative) and therefore the standard in 4.1.3 doesn't have a practical impact. This may result in the need for two different DWC in the same airspace, one against cooperative aircraft and one against non-cooperative aircraft. Some studies have shown that this will most likely result in a smaller DWC against non-cooperative aircraft compared to against ACAS II-equipped aircraft.

4.2 REMOTE PILOT MODEL

4.2.1 [Standard] The remain well clear alert generated by the DAA system shall take into account the anticipated remote pilot response, which may include coordination with ATC.

Note 1. – Aspects to consider for the pilot response include, inter alia, recognition, comprehension and reaction times.

Note 2. – Procedures for remote pilot coordination with ATC during RWC are covered in PANS-ATM and training guidance for remote pilot action during RWC is covered in PANS-OPS.

4.2.2 [Recommended Practice] A validated standard pilot model should be used to evaluate DAA system performance with regard to the Remain-well-clear function.

Note 1. – In order to ensure remote pilot response times consistent with the standard pilot model as defined in Annex 10 Volume IV, Part 1, DAA system developers and RPAS developers may have to compensate for architectural considerations specific to RPAS, such as C2 Link latency.

Note 2. – These models may be dependent on the level of remote pilot control, the type of human machine interface, the type of manoeuvre command, interaction with ATC and other factors.

Rationale: The evaluation of DAA systems with the goal of discerning overall performance, will include a model of human performance (i.e., all of the actors in the encounter timeline), therefore it will be important that these models be standardized internationally so that various systems can be evaluated consistently. There is a parallel set of requirements in Chapter 5 for the Collision Avoidance function.

Although Annex 10 Vol IV Part 1 contains detailed models for Active Surveillance, Working Group 3 decided to not prescribe those models for DAA in order to leave designers flexibility in achieving the surveillance performance requirements.

These models may be dependent on the level of remote pilot control, the type of human machine interface, the type of manoeuvre command, interaction with ATC and other factors.

4.3 STANDARD ENCOUNTER MODEL

4.3.1 [Recommended Practice] A validated encounter model, or a set of validated encounter models, similar to the model defined in Annex 10 Volume IV Part 1 §4.4.2.6 for ACAS, but adapted to RPA operations, should be used when evaluating the effect of the Remain Well Clear function of a DAA system on the risk of collision and its compatibility with ATM.

Rationale: Encounter models are used to validate the performance of the DAA system, as well as to validate compatibility with separation criteria and other ATM practices. Reference is also made to Annex 10, Volume IV, Part, 1 §4.4.4. The encounter models that had been developed for the validation of ACAS II in the US and Europe, are already being updated to account for the particularities of RPAS operations, to allow validation of the DAA RWC function. There is a parallel set of requirements in Chapter 5 for the Collision Avoidance function.

Although Annex 10 Vol IV Part 1 contains detailed models for Active Surveillance, Working Group 3 decided to not prescribe those models for DAA in order to leave designers flexibility in achieving the surveillance performance requirements.

4.4 REQUIREMENTS for the REMAIN-WELL CLEAR FUNCTION

4.4.1 [Standard] The Remain-Well-Clear function shall provide timely alerts and manoeuvre guidance to assist the remote pilot in ensuring that the RPA will pass well clear of cooperative and non-cooperative aircraft.

Note. - Reference is made to the DAA Manual for further guidance on the Remain Well-Clear (RWC) function.

Rationale: Overarching requirement on what the Remain Well-Clear (RWC) function does. One of the two functions of the DAA system is Remain Well Clear.

4.4.2 [Standard] The DAA Remain Well-Clear (RWC) function shall provide information, including one or more actions for the RPA to pass well clear, for the remote pilot to select and then execute.

Note. – Procedures for performing RWC in controlled airspace, including coordinating with ATC, are contained in PANS-ATM.

Rationale: The RWC function requires the pilot to be in the loop, supported by controls and information from displays and alerting that enable the pilot to evaluate options, coordinate with ATC when separation services are being provided, execute the approved option, and/or continue to monitor the traffic geometry to maintain well clear of traffic, taking additional RWC action as needed.

The phrase "coordinate with ATC, as required" was recently removed from the Standard because it will be covered in PANS-ATM and PANS-OPS.

The interaction between the Remote Pilot and ATC when conducting RWC, should be contained in PANS-ATM. Need to consider RWC Training in PANS-OPS.

4.4.3 [Standard] Alerts and manoeuvre guidance generated by the DAA system for the remain-well-clear function shall;

a) be consistent with the certified performance limitations and manoeuvre capabilities of the RPA, and;
b) take account of expected remote pilot response time and the time required to coordinate with ATC where necessary, and;
c) support maintaining and regaining DAA well clear.

Rationale: This standard defines the basic criteria for the manoeuvre guidance provided by the RWC function to consider and provide in order to ensure usefulness and effectiveness.

In this standard, "normal performance and manoeuvre capabilities" is referring to that which is expected in the normal operation of the aircraft, not necessarily the extremes to which an aircraft would be tested as part of a certification program. For example, we don't expect a RPA to have to intentionally enter a spin. This was changed to "certified" to better capture the intent and align with commonly used airworthiness terminology.

"Communicate" was replaced with "coordinate" to better capture intent of interaction between Remote Pilot and ATC.

4.4.4 [Standard] The DAA system shall provide a caution level alert and associated manoeuvre guidance to the remote pilot when a Potential Threat is present.

Rationale: This standard requires the DAA system to provide a caution-level alert to the pilot when the closest point of approach is projected to be within the DWC. The RWC alerts are caution level because at this moment during the timeline to CPA, the potential threat does not pose a collision hazard. The pilot does not need to take immediate action, but may be required to contact ATC when separation services are received and a manoeuvre is required.

This requirement is not prescriptive with regard to colour (as in Part 1 4.3) because the colour will be dictated by human factors analysis, cockpit design, and certification.

4.4.4.1 [Standard] The validation state of track data used to generate the caution level alert shall be displayed to the remote pilot.

Note. – This requirement is intended to indicate whether the DAA system is able to provide a DRA (warning level alert) after a RWC (caution level) alert.

Rationale: ADS-B track data can be used to issue caution level alert even if it is not validated, but must be validated before a warning level alert is issued. However, this introduces a situation in which a caution level alert will not progress to a warning level alert, even when the encounter geometry would justify it if the track was validated. RTCA DO-385 (ACAS XA MOPS) have dealt with this situation by adding a requirement to display validation state in such cases, which is mirrored in this Standard. DAA is a different situation in that for ACAS XA, the procedure when an un-validated TA-only track is displayed to the pilot, the procedure will be for the pilot to visually search for the traffic, knowing that the only collision protection is "see and avoid". In the case of DAA, the non-cooperative sensor will detect and track the intruder within the designed performance capability, regardless of the validation state and therefore the pilot may not have any different expected behaviour.

There may be legitimate encounters where ADS-B OUT is allowed but an altitude reporting transponder is not required, where an intruder will generate a RWC alert, but may be outside of the design criteria of the non-cooperative sensor (e.g. faster than design speeds), and therefore will not be tracked until later in the encounter, potentially later then a DRA would be generated if it were a valid track.

Options in high altitude positively controlled airspace (5nmi separation minimum):

1) RWC alert and guidance, target un-validated, pilot monitors similar to today's ACAS TA procedure and waits for DRA. It never comes and nothing happens. IF the track is never validated, then that means that it was a false track.
2) RWC alert and guidance, target un-validated, pilot is aware that the track is un-validated and uses that information to communicate and coordinate with ATC. ATC either confirms that it has a SSR track, a PSR track, or no track. If PSR track or no track, the ATC would give pilot discretion to manoeuvre as they deem necessary.
3) RWC alert and guidance, target un-validated, pilot has observed several or many un-validated tracks and is suspicious of intentional interference of ADS-B. Pilot uses DAA information to communicate and coordinate with ATC. Same as #2.

CHAPTER 5. COLLISION AVOIDANCE FUNCTION

5.1 [Standard] The design, verification, and validation of the collision avoidance function shall follow well-established and recognized processes.

Note: Guidance on the processes applied to existing Airborne Collision Avoidance Systems are contained in Attachment 1.

Rationale: After numerous discussions with the Airborne Collision Sub Group of the Surveillance Panel, it was decided that they will develop material that will be made into an Attachment to these SARPs. This Attachment will describe the process that ACAS X has gone through, as an example of a robust and internationally-accepted process that was jointly developed between RTCA and EUROCAE with support from FAA and EASA. The SP/ACSG wants to ensure that any future DAA system, especially the collision avoidance function, goes through a similar level of robustness and scrutiny before being accepted by a State for operations under IFR.

The plan endorsed by the ICAO Secretariat is for these SARPs to go to inter-Panel coordination, after approval by the RPASP, and the SP/ACSG will provide the material for Attachment 1 as part of their comments to these SARPs.

5.2. NEAR MID AIR COLLISION

5.2.1. [Standard] The DAA system performance shall be measured against the Near Mid Air Collision (NMAC) volume.

Rationale: The proposed standard keeps, and validates for DAA, the same NMAC volume used to assess the collision risk mitigation performance of ACAS as defined in Annex 10, Vol. IV, Part I.

NMAC volume is defined as “Two aircraft simultaneously coming within 30 meters (100 ft.) vertically and 150 meters (500 ft.) horizontally.”, which is the same as RTCA DO-185/EUROCAE ED-143

5.3. REMOTE PILOT MODEL

5.3.1. [Standard] The DAA Resolution Advisory (DRA) generated by the DAA system shall take into account the anticipated pilot response.

Note. – Aspects to consider for the pilot response include recognition, comprehension and reaction times.

Rationale: For the DAA Resolution Advisory (DRA) to be timely and the collision avoidance to be effective, the pilot response and any delays and latencies need to be accounted for.

Although Annex 10 Vol IV Part 1 contains detailed models for Active Surveillance, Working Group 3 decided to not prescribe those models for DAA in order to leave designers flexibility in achieving the surveillance performance requirements

5.1.1 [Recommended Practice] A validated standard pilot model should be used to evaluate DAA system performance with regard to the collision avoidance function.

Note 1. – In order to ensure remote pilot response times consistent with the standard pilot model, DAA system developers and RPAS developers may have to compensate for architectural considerations specific to RPAS, such as C2 Link latency.

Note 2. – To remain consistent with the ACAS Pilot Model defined in Annex 10 Volume IV Part 1 §4.4.2.5, the DAA Remote Pilot Model captures the assumed or programmed response from when the DAA Resolution Advisory (DRA) is generated to when a command in response to the DAA Resolution Advisory (DRA) is performed by the flight computer. More detail is contained in the DAA Manual.

Rationale: The ACAS Pilot model captures the response, both in time and aircraft acceleration, from when the RA is generated (i.e. displayed to the Pilot) to when the pilot responds with control input (i.e. pulls back on the stick). This ACAS model did not consider the latency between control input and aircraft manoeuvring because on legacy aircraft, it is nearly instantaneous. Therefore the analogy for RPAS, assuming a C2 Link and digital flight computer avionics, is the time from when the DAA equipment generates the DAA Resolution Advisory (DRA), to when the flight computer performs the commanded manoeuvre with the aircraft actually manoeuvring nearly right after that. If the RPA is designed such that substantial latency exists between the flight computer command and RPA manoeuvring, then that would need to be considered by the designers and certification authorities.

Such models should include:

a) response to own aircraft vertical commands (automated and/or manual);

b) response to own aircraft horizontal commands (automated and/or manual);

c) response to combined own aircraft vertical and horizontal commands (automated and/or manual); and,

d) response by the flight crew on intruders equipped with a collision avoidance functions (both manned and unmanned).

5.1.2 [Recommended Practice] The standard pilot model of response to vertical resolution advisories , as defined in Annex 10 Volume IV Part 1 §4.4.2.5, should be considered when evaluating DAA system performance in response to coordinated vertical resolution advisories issued by the collision avoidance function.

Rationale: The pilot model as defined in Annex 10 Volume IV Part 1 §4.4.2.5 represents a reasonable expectation of pilot's normal reaction to RAs. Where the response following an alert is automated, this model defines the expected execution of the manoeuvre.

In order for the manoeuvres of both own aircraft and intruder to be well coordinated, it is important that the timeline between alert and execution of the manoeuvre command at the aircraft and the expected performance to be achieved during the execution of the manoeuvre, match.

5.2 STANDARD ENCOUNTER MODEL

5.2.1 [Recommended Practice] A validated encounter model, or set of validated encounter models, similar to the model defined in Annex 10 Volume IV Part 1 §4.4.2.6 for ACAS, but adapted to RPA operations, should be used when evaluating the effect of the collision avoidance function in a DAA system on the risk of collision and its compatibility with air traffic management.

Note. – These models generally contain many different encounter scenarios, including encounters with non-cooperative aircraft.

Rationale: Encounter models are used to validate the performance of the DAA system, as well as to validate compatibility with separation criteria and other ATM practices. Reference is also made to Annex 10 Volume IV Part 1 §4.4.4. The encounter models that had been developed for the validation of ACAS II in the US and Europe, are already being updated to account for the particularities of RPAS operations, to allow validation of the DAA CA function.

Although Annex 10 Vol IV Part 1 contains detailed models for Active Surveillance, Working Group 3 decided to not prescribe those models for DAA in order to leave designers flexibility in achieving the surveillance performance requirements

5.3 REQUIREMENTS for the COLLISION AVOIDANCE FUNCTION

5.3.1 [Standard] The collision avoidance function shall provide timely DAA resolution advisories (DRA) to assist the remote pilot in avoidance of mid-air collisions with cooperative and non-cooperative aircraft.

Note. – Reference is made to the DAA Manual for further guidance on the collision avoidance (CA) function.

Rationale: The alert and manoeuvre guidance generated by the collision avoidance function is collective referred to as the DAA resolution advisory (DRA).

5.3.2 [Standard] The DAA system collision avoidance function shall only generate a DAA Resolution Advisory (DRA) against all independently tracked or validated threats.

Note 1 – Mode-S interrogations/replies, primary surveillance radar, electro-optical sensors are all considered independent means of tracking threats.

Note 2. – Reference is made to § 3.2.1.2.1.4, § 3.2.1.2.2.3 and § 3.2.1.2.3.3 for validation of ADS-B data.

Note 3. - The requirement does not exclude the fusion of track data from multiple sources.

Rationale: If a DAA Resolution Advisory (DRA) is generated against a threat that is tracked through ADS-B, the track data needs to have been validated to prevent DAA Resolution Advisories (DRA's) issued based on spoofed or erroneous data. Data originating from independent sources identified in Note 1 does not require validation.

The addition of the word "only" ensured that a DRA is not issued against a track that is not independently tracked or validated threats.

5.3.3 [Standard] The DAA system shall provide a warning level alert and associated DAA Resolution Advisory (DRA) to the remote pilot.

<u>Rationale:</u> This standard requires the DAA system to provide a warning-level alert to the pilot when the closest point of approach is projected to be within the NMAC volume. The DAA Resolution Advisory (DRA) alerts are warning level because at this moment during the timeline to CPA, the threat poses an imminent collision hazard. The pilot is required to take immediate action to avoid a collision.

This standard is directed to the remote pilot because warning level nature of the DRA is only important in the context of the human factors associated with the remote pilot.

5.3.4 [Standard] The DAA Resolution Advisory (DRA) warning alert and associated manoeuvre guidance shall continuously be displayed to the remote pilot.

<u>Rationale:</u> The pilot should have the ability to monitor compliance with the DAA Resolution Advisory (DRA) manoeuvre. Moreover, the alert and guidance should not be masked by other display elements.

5.3.5 [Standard] Once a DAA system collision avoidance function has generated the DAA Resolution Advisory (DRA) against a threat or threats it shall be either maintained or modified until the conditions necessitating the DAA Resolution Advisory (DRA) are no longer valid.

<u>Rationale:</u> Similar requirement to the requirement found in Annex 10 Vol IV, Part 1, section 4.3.5.1.2. Considered relevant to both ACAS and DAA's CA function.

5.3.6 [Standard] The DAA Resolution Advisory (DRA) generated by the DAA system shall be within the certified manoeuvring capability of the RPA.

<u>Rationale:</u> Similar requirement to Vol IV, Part 1, 4.3.5.4, which states "The RA generated by ACAS shall be consistent with the performance capability of the aircraft."

There may be a variety in the performance of the various types of RPAs. Hence it is not possible to define a single set of performance criteria, as was done in Vol IV, Part 1, §4.3.5.4. The intent is to ensure that the DAA commanded manoeuvre is considering the performance of the RPA on which it is installed.

5.3.7 [Standard] When a DAA Resolution Advisory (DRA) has been generated, the DAA shall transfer to its Mode S transponder an RA report for transmission to the ground and transmit periodic RA broadcasts.

Rationale: Similar requirement to Vol IV, Part 1, 4.3.6.2.1, which states, "When an ACAS RA exists, ACAS shall:

a) transfer to its Mode S transponder an RA report for transmission to the ground in a Comm-B reply (4.3.11.4.1); and

b) transmit periodic RA broadcasts (4.3.7.3.2)."

CHAPTER 6. HAZARDOUS WEATHER AVOIDANCE FUNCTION

RESERVED

Note. –. There are no unique standards for DAA systems that provide a hazardous weather avoidance function in the current edition. However, airborne weather radar that satisfies Annex 6, Part 1 SARPs may be integrated into an RPAS to detect thunderstorms or other potentially hazardous weather conditions along the route. Suitable existing de-icing and/or anti-icing devices that alert the pilot of the need to operate a system in the potential presence of icing may also be integrated into RPAS to detect this hazardous weather condition. Annex 6, Part 1 SARPs are shown in section 6.11 ("Pressurized aeroplanes when carrying passengers - weather radar"), Appendix 3, Section 2 ("Systems and equipment"), and section 6.8 ("All aeroplanes in icing conditions").

Rationale: "Hazardous meteorological conditions" is one of the 5 hazards that is mitigated by the DAA capability according to the RPAS Manual, but detailed equipment requirements are not included at this time. Some information could be provided from existing ICAO references for equipment used on aircraft to help pilot's detect and avoid the respective weather hazards. There may be no need for equipment designed specifically for RPA.

CHAPTER 7. TERRAIN AND OBSTACLE AVOIDANCE FUNCTION

RESERVED

Note. - There are no unique standards for DAA systems that provide a terrain and obstacle avoidance function in the current edition. However, ground proximity warning systems and forward looking terrain avoidance function that satisfy Annex 6, Part 1 SARPs may be integrated into an RPAS to detect and avoid terrain and obstacles along the route. Applicable Annex 6, Part 1 SARPs are shown in section 6.15 ("Aeroplanes required to be equipped with ground proximity warning systems (GPWS)").

Rationale: "Terrain and Obstacles" is one of the 5 hazards that is mitigated by the DAA capability according to the RPAS Manual, but detailed equipment requirements are not included at this time.

Some information could be provided from existing ICAO references for equipment used on aircraft to help pilot's detect and avoid terrain and obstacles. There may be no need for equipment designed specifically for RPA.

CHAPTER 8. SURFACE OPERATIONS HAZARDS AVOIDANCE FUNCTION

RESERVED

Note. - There are no unique standards for DAA systems that provide a ground operations function in the current edition. However, ground operations functions compliant with the basic surface situation awareness (SURF) application in RTCA DO-317B / EUROCAE ED-194A (Minimum Operational Performance Standards for Aircraft Surveillance Applications System) may be integrated into an RPAS in a 1090ES ADS-B surveillance environment to support remote pilot decisions for surface movement of the RPA and to reduce the possibility of runway incursions and collisions.

Rationale: "Ground operations" is one of the 5 hazards that is mitigated by the DAA capability according to the RPAS Manual, but detailed equipment requirements are not included at this time.

Some information could be provided from existing ICAO references for equipment used on aircraft to help pilot's detect and avoid other aircraft on the ground. There may be no need for equipment designed specifically for an RPA, but the equipment may be need to be supplemented by a visual observer.

The information provided in the note does not provide sufficient mitigations to address all risks associated with ground operations, but is offered here as guidance.

CHAPTER 9. AVOIDANCE OF OTHER AIRBORNE HAZARDS

RESERVED

Note. - There are no unique standards for DAA systems that provide a function for other airborne hazards in the current edition. However, existing systems that satisfy Annex 6, Part 1 SARPs may be integrated into an RPAS, as needed, to mitigate the risk for other airborne hazards along the route. Applicable Annex 6, Part 1 SARPs are shown in section 6.21 ("Turbo-jet aeroplanes - forward-looking wind shear warning system").

Rationale: "Other airborne hazards" is one of the 5 hazards that is mitigated by the DAA capability according to the RPAS Manual, but detailed equipment requirements are not included at this time.

Some information could be provided from existing ICAO references for equipment used on aircraft to help pilot's detect and avoid one or more of these hazards.

The information provided in the note does not provide sufficient mitigations to address all other airborne hazards, but is offered here as guidance.

The word "function" is not included in this Chapter because this "Other airborne hazards" section is still not well defined. In the future, as other airborne hazards are avoided with standardized functions, then this Chapter can be modified.

CHAPTER 10. INTEROPERABILITY

Note 1. - The SARPs in this chapter cover interoperability. Interoperability is subdivided into internal DAA interoperability, ensuring that the two functions, sensors and supporting subsystems of the DAA system work together as intended, and external DAA interoperability, which intends to ensure the seamless integration of RPA operations in the current ATM system. For the latter case, three leading principles apply:

a) *The introduction of a DAA equipped RPA will not impose an undue burden on the aviation system that may be associated with the operation of a manned aircraft.*
b) *The impact on other actors in the aviation system, including ATC is minimized when designing and introducing DAA systems.*
c) *The effectiveness of current safety barriers, in particular ACAS, will not be jeopardised.*

Note 2. – The leading principles for external DAA interoperability also apply to Chapter 11.

Rationale: When RPASP WG3 started addressing Detect and Avoid in the context of ICAO SARPS, we started with establishing leading principles that were applied in the subsequent development of the SARPs. These leading principles have been provided in the introduction to chapters 10 and 11 to allow the reader to better understand the context of the SARPs.

This introduction has been included here, and the rationale is that this is essential information for the SARPs in this chapter and that the chapter cannot be properly understood without this material. If it is in the manual, then most readers will not go there to read it and will not be able to properly understand this chapter.

10.1 INTERNAL DAA INTEROPERABILITY

10.1.1 [Standard] When two or more hazards are present at the same time, the DAA system with inputs from the various DAA functions, shall provide the remote pilot with the appropriate alerts and manoeuvre guidance.

Note. - This standard aims to set priorities, absolute or weighted, of alerts for various threats (e.g. terrain, traffic, weather), however the priorities may be different from current manned aircraft schemes.

Rationale: There are multiple functions within a DAA system, which may interact and must be interoperable. In traditional manned aviation, as new functions and safety features have been introduced, an established set of priorities and overrides have emerged to ensure that the most critical and timely alerts are displayed to the pilot. The priorities for unmanned aviation may be different if the consequences associated with particular hazards are considered differently.

This standard does not seek to set this priority, only make it clear that a priority will be needed and that designers and regulators will need a common understanding before DAA systems can be introduced.

10.1.2 [Standard] Within a DAA system the alerts and the manoeuvre guidance generated by the Remain-Well-Clear (RWC) function shall be consistent with those generated by the collision avoidance function.

Note. - Criteria to determine consistency between the CA and RWC function are discussed in the DAA Manual

Rationale: Several Standards Development Organizations designing DAA systems have found that special attention is required to engineer the Remain Well-Clear (RWC) and Collision Avoidance (CA) alerting and guidance such that they are compatible and conform to human factors principles. For example, it would be very confusing to the remote pilot, and potentially hazardous for the development of the encounter, if the RWC guidance is suggesting a right turn and then CA guidance directs a left turn. This manoeuvre sense switching may be appropriate for safety reasons, or could be the result of poor system design.

While there will inevitability be two-way interactions between these functions within the DAA system, this Standard is aiming at capturing the “one-way” interaction from RWC to CA, which is considered a minimum requirement.

10.2 EXTERNAL DAA INTEROPERABILITY

10.2.1 [Standard] The DAA system shall be interoperable with all Annex 10 compliant Collision Avoidance Systems.

Note. - EUROCAE ED-264 /RTCA DO-376 - Minimum Aviation System Performance Standards (MASPS) for the Interoperability of Airborne Collision Avoidance Systems (CAS) provides a means of compliance with this Standard.

Rationale: RTCA SC-147 and EUROCAE WG75 have undertaken an effort to develop interoperability requirements. It is critical to assure that the DAA system and the ACAS are compatible to allow for safe execution of coordinated manoeuvres.

SP/ACSG has requested that this Standard be included to ensure interoperability with Annex 10 compliant ACAS.

10.2.2 [Recommended Practice] The DAA System should inform DAA/ACAS installed on other aircraft of limited ability or inability to perform a DAA Resolution Advisory (DRA).

Note: Reference is made to the DAA Manual for further guidance on messaging inability or limited ability to other DAA and ACAS systems.

Rationale: The current ACAS system has a means to indicate inability to perform Resolution Advisories (RA's) or that the aircraft has limited ability to manoeuvre. This requirement applied the same principle to DAA. This is a system-to-system requirement, and the remote pilot may not necessarily be aware of this state.

10.2.3 [Standard] The collision avoidance function shall limit as much as practicable the disruption to ATM.

Note. – The requirements contained in Annex 10 Volume IV Part 1 §4.4.4 provide metrics for determining compatibility with ATM, which may be applicable for the collision avoidance function of a DAA system.

Rationale: Similar to ACAS, this requirement ensures that the design of the DAA Collision Avoidance function takes into account aspects, such as airspace design in its alerting algorithm. The exact wording has been taken from Vol IV, Part 1

Most recently, this standard said "be compatible with ATM procedures as much as practicable so as to limit disruption to the provision of separation services and the orderly flow of traffic" but that was replaced by "limit as much as practicable the disruption to ATM" in order to simplify the wording the align with the wording in Part 1 4.4.5, which states "Recommendation.— The collision avoidance logic should be such as to reduce as much as practicable the risk of collision (measured as defined in 4.4.3) and limit as much as practicable the disruption to ATM (measured as defined in 4.4.4)."

Right now, we are separating these requirements between Chapter 10 and Chapter 11.

10.2.4 [Standard] When manoeuvre guidance is generated by the remain-well-clear function and presented as a specific command, then it shall be compatible with Annex 2 §3.2.2, Right-of-way requirements.

Rationale: The RWC function should support the remote pilot in applying the Right of Way (RoW) requirements, as stated in §2.1.1.

Most recently, this was a recommended practice, but the secretariat wants to make sure that if designers are going to implement this function, then it does comply with ROW rules. This also means that the note "*The remote pilot remains responsible for complying with the right of way requirements."* can be removed, not because the remote pilot is no longer responsible, just that the note is not appropriate.

There remains a technical challenge in the DAA community of interest to defining the ROW rules in a quantitative way that can be implemented by developers within a DAA system. While there is concern that this will be a difficult standard to meet, several SDO's are developing specific performance requirements for implementing ROW rules.

10.2.5 [Recommended Practice] A Remain-Well-Clear (RWC) function should be interoperable with other DAA systems.

Note 1. – Interoperability could be achieved through implicit or explicit coordination and does not imply a requirement to coordinate.

Note 2. -Reference is made to the DAA Manual for further guidance on interoperability.

Rationale: This is a parallel requirement to Collision Avoidance (CA) Interoperability for (Remain Well-Clear (RWC) but is not necessarily a coordination requirement. This requirement could be met with an implicit coordination scheme, or just by having all pilots follow the rules of the air. This is a Recommended Practice because technical means of achieving this interoperability have not been developed. In addition, coordination may be relying on remote pilots to interpret and implement the right of way rules.

10.2.6 [Recommended Practice] DAA equipment that utilizes explicit coordination techniques should minimize spectrum usage.

Note. – Efficient use of the limited frequency spectrum resources requires that the bandwidth used for the explicit coordination techniques be kept at a minimum and that the coordination link be available to other users when not in use.

Rationale: There is also a requirement to minimize spectrum usage for surveillance. This requirement is specific for coordination between two or more DAA systems.

There is not a requirement for DAA systems to explicitly coordinate, but designers may choose those techniques to ensure performance. This has been made a RP because it will be difficult to measure the extent to which designers are able to “minimize” spectrum usage.

10.2.7 [Standard] The Remain-Well-Clear (RWC) function shall be compatible with ATM as much as practicable so as to limit disruption to the provision of air traffic services.

Note. – This requirement compliments §10.2.3 but may be assessed independently, if appropriate.

Rationale: This requirement is intended to ensure that the design of the DAA Remain Well Clear function takes into account aspects, such as airspace design, separation criteria and etcetera, in its alerting and guidance algorithms.

“air traffic services” captures the intent that was previously in this standard related to “separation services and orderly flow of traffic”

CHAPTER 11. DAA PERFORMANCE

Note 1. - This chapter covers performance requirements for the two functions of the DAA system: the remain-well-clear function and the Collision Avoidance function. The objective of the standards and recommended practices in this section is to enable operations with RPA that are at least as safe as operations with manned aircraft with respect to avoiding conflicting traffic. DAA performance is measured in a risk ratio, consistent with the manner in which the performance of ACAS is defined in Annex 10 Vol IV, Part I, Section 4.4.3. The performance allocated to the Remain Well-Clear function also serves to enable seamless integration of the RPA with manned aviation without undue task load to other airspace users and those who provide ATC or Air Traffic Services. Here, the leading principles referred to in the introduction of Chapter 10 apply.

Note 2. - DAA performance should not be confused with system development assurance. The former is addressed in this section and defines the proportionate number of encounters that are resolved by the logic in comparison to the expected number that would be resolved in the absence of a DAA system. DAA performance is demonstrated through simulation and validation: the effectiveness of the logic (i.e. the DAA algorithms) is verified through simulation of a large number of varying encounters defined in an encounter model. Development assurance criteria, on the other hand, define the level of rigor of the processes that are applied to establish, manage, validate and verify system or equipment level requirements. The level of rigor is expressed in a Development Assurance Level (DAL). These are generally established as part of the airworthiness approval process and are either established in the guidance material (e.g. FAA AC, EASA AMC) or through a Failure Hazard Assessment (FHA) performed by the applicant for airworthiness approval. Further information on development assurance can be found in SAE ARP 4754A / EUROCAE ED-79A.

11.1 GENERAL PROVISIONS RELATING TO DAA PERFORMANCE

11.1.1 [Standard] The nominal collision avoidance risk ratio shall be measured against a collision avoidance volume defined by the Near Mid Air Collision (NMAC) volume.

Rationale: The proposed standard maintains the NMAC volume used to assess the collision risk mitigation performance of ACAS. This is consistent with the historic practice in the verification and validation of ACAS.

This is consistent with RTCA DO-365 and airspace collision risk safety analyses performed by States.

11.1.2 [Standard] The nominal collision avoidance risk ratio shall be demonstrated for the following two cases, considering all airspace classes in which the RPA is intended to operate:

a. Collision avoidance function only
b. Remain well clear function and collision avoidance function

Rationale: ACSG of the Surveillance Panel has determined that it is important that the CA RR be demonstrated with only the collision avoidance function active, since it will not be certain that when operating under IFR, the Remote Pilot will receive a clearance amendment from ATC in response to a RWC alert. 11.2.2(a) addresses this concern.

11.2.2(b) addresses a concern that the CA RR must also be demonstrated with both RWC and CA functions to ensure that the addition of the RWC function does not cause the total DAA system to degrade beyond the CA RR requirements in 11.2.3.

11.1.3 [Standard] The nominal collision avoidance risk ratio shall be demonstrated to comply with the following logic risk ratios against NMAC:

When the intruder is equipped with an SSR Transponder, ACAS or DAA CA Function, or other recognised cooperative systems as required by the State of Operation.	See Volume IV, Part I, Section 4.4.3
When the intruder is non-cooperative.	0.3

Note 1. - The metrics represent the risk ratio against all intruders and is not limited to the field of view.

Note 2. – Reference is made to the DAA Manual for further guidance on risk ratios.

Rationale: Reference is made to WP4 to RPASP/12.

11.1.4 [Standard] The nominal remain-well-clear (RWC) risk ratio shall be measured against DAA Well Clear (DWC), considering all airspace classes in which the RPA is intended to operate.

Note. – Section 4.1 contains a set of requirements that DAA Well Clear (DWC) meets.

Rationale: Reference is made to WP4 to RPASP/12.

Requirements for DAA Well Clear are defined in Section 4.1 although a single number is not defined. It is expected that DAA Well Clear will be quantitatively defined in technical standards adopted by States and/or Regions.

11.1.5 [Standard] The DAA System's Remain Well-Clear (RWC) function shall demonstrate the following logic risk ratios against DAA Well Clear (DWC):

When the intruder is equipped with an SSR Transponder, ACAS or DAA CA Function, or other recognised cooperative systems as required by	0.4

the State of Operation.

When the intruder is non-cooperative. 0.5

Note 1. - The metrics represent the risk ratio against all intruders and is not limited to the field of view.

Note 2. - Reference is made to the DAA Manual for further guidance on risk ratios.

Rationale: Reference is made to WP4 to RPASP/12.

11.1.6 [Standard] The DAA system shall demonstrate alerting behaviour that is acceptable to the State of Design.

Note 1. – Undesired alerting behaviour includes missed alert, late alert, short alert, early alert and incorrect/nuisance alert.

Note 2. - Reference is made to the DAA Manual for further guidance on determining acceptability of alerting behaviour.

Rationale: Alerting behaviour including behaviour in test cases, overall alert rates or other measures must comply with criteria established by the State of Design. The criteria may be defined in current or future RTCA or EUROCAE DAA standards.

11.2 PERFORMANCE IN ENCOUNTERS OUTSIDE OF NOMINAL CONDITIONS

Note. – The DAA system is designed with a defined set of criteria to assess performance as required in §11.1, including models of intruders and encounters, but encounters may occur outside of these criteria, in which case the system should still function but may not meet the nominal performance requirements.

11.2.1 [Recommended Practice] The DAA system should continue to provide collision protection such that degradations, if any, are proportionate to the exceedance of the condition bounds used in designing the system, including Intruder velocity and Intruder manoeuvrability, while considering the performance degradation requirements listed in §3.2.2.2.1.4.

Note 1. - Condition bounds to be considered in designing a DAA system are further discussed in the DAA Manual.

Note 2. – Typical off-nominal encounters are described in the DAA Manual and include situations such as: lower than VMC flight visibility and distance from cloud criteria, intruder speeds higher than the regulations permit, aircraft with low conspicuity, etc.

Rationale: The intent of this recommended practice is to emphasise that it is still better to have a DAA operating with proportionally degraded performance in out of bound conditions than to have no DAA capability at all in these cases. It has not been defined as a standard, because it has been proven to be very difficult to define exact requirements on how the DAA should operate in out of bound conditions.

11.3 C2 LINK CONSIDERATIONS

Note. –C2 Link SARPs can be found in Annex 10 Vol VI

11.3.1 [Standard] The operational transactions required by the DAA system shall be defined and incorporated into the C2 Link specification of the RPAS.

Note. - The C2 Link specification is built up by the RPAS designer, considering all of the operational transactions required on the C2 Link to achieve safe operations. Further guidance is found in the C2 Link Manual and DAA Manual.

Rationale: RPASP/WG3 (DAA) and WG2 (C2) want to make sure that these systems are developed with mutual consideration for the limitations and constraints that the other system faces. For example, DAA surveillance systems should not send “raw data” (e.g. 4k High Definition Video, or unprocessed radar returns) through the C2 Link. Such a choice would drastically limit the volume of RPAS operations in a given airspace due to the limited spectrum availability and C2 Link protection constraints.

11.3.2 [Standard] The DAA system shall operate within the C2 Link performance allocated to DAA, with consideration to the Quality of Service Required (QoSR).

Note. – Quality of Service Required (QoSR) is defined as airspace and system design performance targets allocated to the C2 Link to safely implement an RPAS operational capability. These targets include but may not be limited to: availability, continuity, integrity and transaction expiration time. These targets may vary with airspace and phase of flight.

Rationale: The DAA system must be designed taking into account performance constraints of the C2 link.

11.3.3 [Standard] The DAA System shall send only essential DAA information through the C2 Link.

Note. - Essential DAA information includes, but may not be limited to, traffic track data, alerting, guidance, and system health and status. Further guidance is found in the DAA Manual.

Rationale: Since the spectrum resource for C2 Link purpose is constrained, and because of the need to maintain a high C2 Link performance, it is important that DAA system designers minimize the Operational transactions on the C2 Link required for the DAA function and therefore it is important to only send essential DAA information. Since the DAA system architecture will play a very big role in what pieces of information are "critical", there is a desire to not be too prescriptive in the SARPs.

CHAPTER 12. MONITORING

12.1 SYSTEM MONITORING FUNCTION

12.1.1 [Standard] The DAA system shall have its own health monitoring function to determine the system's current operational status.

Rationale: The DAA system is considered to provide a safety critical function. Its health status should therefore be continuously monitored.

12.1.2 [Standard] The DAA system shall continuously monitor the status of the C2 Link quality of service delivered (QoSD).

Rationale: The airborne and/or ground-based components of the DAA system need to know the real-time performance of the C2 Link so that monitoring functions of the DAA system can measure against pre-defined thresholds. In the example of GNSS, if GNSS fails, then every system that relies on GNSS will flag a failure. Likewise, if C2 Link fails, then every other system that relies on the C2 Link for its function will indicate a failure.

12.1.3 [Standard] When the manoeuvre commanded by the collision avoidance function is designed to be initiated automatically by the DAA system during the lost C2 Link decision state or the lost C2 Link state, then the DAA system shall continuously monitor for interruptions in the C2 Link.

Note 1. – Interruptions are defined in Annex 10 Volume VI as "Any temporary situation where the C2 Link is unavailable, discontinuous, introduces too much delay, or lacks integrity; but where the Lost C2 Link Decision Time has not been exceeded."

Rationale: The logic programmed by the DAA and RPAS designer to trigger an automatic response to DAA Resolution Advisories (DRA's)'s will be based on whether or not one-way latency in QoSD is exceeding QoSR and whether or not the TET has been exceeded. This Standard has been reviewed with WG2 for consistency. It is understood that interruptions are not contained in QoSD.

12.2 MONITORING RESPONSE

12.2.1 [Standard] The DAA health monitoring function shall provide an alert to the remote pilot to indicate that the system has failed or is operating in a degraded or standby/off mode

Note. - The determination as to what degraded subsystem performance or failures affect the operational state of the DAA system can vary with the design of each DAA system.

Rationale: Proposed requirement is similar to the requirement found in Annex 10 V4 P1 paragraph 4.3.10.1 which require ACAS monitoring function to provide a warning under certain conditions. Failure of the DAA however will trigger the initiation of contingency procedures to mitigate the risk of mid-air collision in case of a failed or degraded DAA system.

For example, a failure in one subsystem (e.g. active SSR transponder surveillance) may result in a "Degraded" operational status whereby a failure in another subsystem (e.g. airborne primary radar) may cause a "Failure" status. The effects of subsystem failures, including the potential failure of more than one subsystem, will need to be accounted for in the high-level DAA operational monitoring function.

12.2.2 [Standard] When the DAA health monitoring function detects an off-nominal operational state, the DAA system shall inhibit functions that may result in unsafe operation of the DAA system.

Rationale:

The proposed requirement is based on Annex 10 V4 P1 paragraph 4.3.10.3 which require ACAS monitoring function to have a response to the flight crew and to ACAS interrogations and Modes S ACAS operational status transmissions. Assume that (b) here covers the cases of (b) and (c) from 4.3.10.3

Requirements are restated at a higher level to address additional responses that are needed for a DAA system.

12.2.3 [Standard] When the manoeuvre commanded by the collision avoidance function is designed to be initiated automatically by the DAA system during the lost C2 Link state and the DAA health monitoring function detects that the C2 Link performance is not meeting its QoSR or is experiencing interruptions, then the DAA system shall automatically command a DAA Resolution Advisory (DRA) when it is generated.

Note 1. – Annex 6 Part 4 contains operational requirements for DAA in case of degraded C2 Link. Automated execution of a collision avoidance manoeuvre may not be required by the State of Operation.

Note 2. – The C2 Link SARPS are found in Annex 10 Vol VI.

Rationale: This standard supports compliance with Annex 6 Part 4, if automated execution of a collision avoidance manoeuvre would be required by the State of Operation.

There are three decisions about DRA automation that designers and regulators are going to have to make. The first is whether or not to automate DRA response during a normal C2 Link state (i.e. C2 Link is active and meeting all QoSR metrics), this could enhance pilot response and reduce workload. The second is whether or not to automate DRA response during a lost C2 Link decision state, where the C2 Link has been interrupted but the operational state of the RPA has not changed, this could ensure continuity throughout a DAA encounter and could ensure consistency before the lost C2 Link state. The third is whether or not to automate DRA response during the lost C2 Link state, where the RPA enters a different operational state and where regulators may want the DAA system to behave differently to ensure predictability from the perspective of other airspace users and service providers.

This Standard only considers DAA systems that have been designed to automate DRA response during "lost C2 Link state", not "lost C2 Link decision state", in order to be consistent with Annex 6 Part IV, which states:

[Insert paragraph number] The RPA shall be equipped with an automated system that performs appropriate collision avoidance manoeuvres, except where the collision avoidance responsibilities of the remote pilot can be adequately exercised otherwise.

[Insert paragraph number] Notwithstanding the provisions in [Insert number], the State of the Operator may approve RPAS operations without automated collision avoidance, based on the results of a specific safety risk assessment conducted by the operator which demonstrates how an equivalent level of safety will be maintained. The specific safety risk assessment shall include at least the:

a) reliability of the C2 Link;

b) diversity of multiple links, if installed;

c) reliability of other systems that are required to allow the remote pilot to exercise control of the RPA flight trajectory

Note: The presence of any single-point failures in one or more RPAS systems that could lead to frequent and/or long-duration loss of the pilot's ability to control the RPA flight trajectory will require an automated means to conduct manoeuvres to avoid conflict traffic.

Designers and regulators will have to decide how to handle DRA response during a lost C2 Link decision state, but it is not addressed here because there is so much flexibility in the trade-offs between C2 Link decision state time and QoSR.

ATTACHMENT 1: COLLISION AVOIDANCE DEVELOPMENT PROCESS

Reserved

Rationale: After numerous discussions with the Airborne Collision Sub Group of the Surveillance Panel, it was decided that they will develop material that will be made into an Attachment to these SARPs. This Attachment will describe the process that ACAS X has gone through, as an example of a robust and internationally-accepted process that was jointly developed between RTCA and EUROCAE with support from FAA and EASA. The SP/ACSG wants to ensure that any future DAA system, especially the collision avoidance function, goes through a similar level of robustness and scrutiny before being accepted by a State for operations under IFR.

The plan endorsed by the ICAO Secretariat is for these SARPs to go to inter-Panel coordination, after approval by the RPASP, and the SP/ACSG will provide the material for Attachment 1 as part of their comments to these SARPs.