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Detect and Avoid (DAA)

Annex 10 Volume IV Part II





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Detect and Avoid – The Big Picture

- RPAS Panel Scope: International IFR
 - RPAS = RPA, RPS, and C2 Link with Remote Pilot In Command (RPIC)
- Annex 2 drives the need for Detect and Avoid
- Annex 6 sets DAA carriage and operational requirements
- Annex 10 sets technical requirements on DAA equipment
- DAA Manual provides detail to SARPs
- PANS-OPS and PANS-ATM provide DAA procedures for Remote Pilots and ATC



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New Annex 10 Volume 4 PartII

Chapter 2	General DAA Provisions	DAA high level requirements
Chapter 3	Traffic Surveillance Function	DAA required functions
Chapter 4	DAA Remain-Well-Clear Function	
Chapter 5	Collision Avoidance Function	
Chapter 6 to Chapter 9	For future use	Internal and external DAA interoperability
Chapter 10	Interoperability	
Chapter 11	DAA performance	Performance requirements for the remain-well-clear function and the Collision Avoidance function
Chapter 12	Monitoring	Continuous DAA system monitoring



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Chapter 2

General DAA Provisions



Basis for Technical Provisions on DAA

- To enable operations with **RPA that are at least as safe as operations with manned aircraft** with respect to **avoiding conflicting traffic**
 - The proposal emphasizes DAA for conflicting traffic that requires a dedicated risk mitigation capability for IFR flight in controlled airspace and aerodromes.
 - Other hazards referenced in the RPAS Manual may be addressed through the use of existing aircraft systems (e.g. weather radar, TAWS, etc.) or through operational limitations on the flight route. (Future editions of Annex 10, Volume IV, Part 2 may address SARPs for hazard management equipment that is unique to RPAS).
 - Operational requirements for DAA are addressed in Annex 6, Part 4.
 - Amendment to operational procedures may be required, which will be discussed with other expert groups and will be included in PANS-ATM and PANS-OPS.



Conflict management

2.1 A10V4P II

A DAA system shall allow the remote pilot to fulfil the responsibilities concerning avoidance of collisions with airborne conflicting traffic as described in Annex 2.



This means:

DAA fulfils the Collision Avoidance layer of conflict management and, when appropriate, fulfils the Separation Provision layer of conflict management.

Conflict management layers (Extracted from Doc 9854)

2.7.8 Conflict management is applied in three layers, comprising:

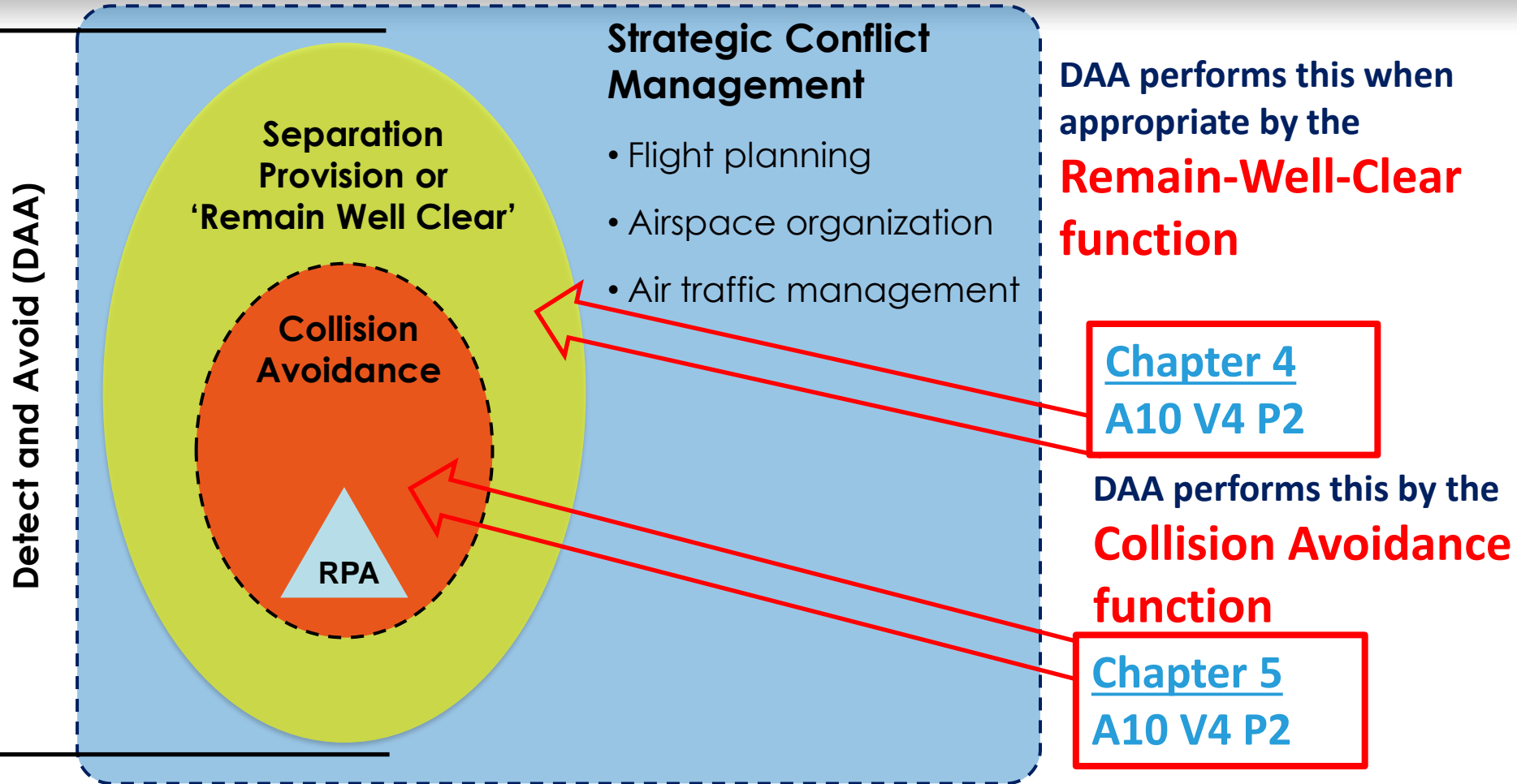
a) strategic conflict management;

b) separation provision; and

c) collision avoidance.

**DAA performs this when appropriate by the
Remain-Well-Clear function**

**DAA performs this by the
Collision Avoidance function**



In addition to those two DAA functions, DAA system includes "Traffic Surveillance".

Chapter 3 A10 V4 P2



Intended function/required function of DAA

2.2 Functional Requirements

To fulfil RWC function and CA function, DAA systems:

- Process intruders (2.2.3),
- Provide alerting and manoeuvre guidance against threat (2.2.4)
- Provide output data (2.2.5)

2.3 DAA Manoeuvre

2.4 Cyber Security for DAA

2.5 Human Factors for DAA

2.6 Atmospheric conditions for DAA

- Sensors requirements in any atmospheric conditions that is within the DAA approval

2.7 DAA during Interception

- With capability in which Pilot can inhibit DAA manoeuvres during an interception



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DAA MANOEUVERING (2.3)

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.**

- ☐ When the DAA manoeuvre command is automatically executed by the flight computer, then the DAA system shall inform the remote pilot of the commanded manoeuvre.

Details on the information to be provided to the remote pilot will be contained in the DAA Manual.



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Chapter 3

Traffic Surveillance Function



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Chapter 3 Traffic Surveillance Function

3.2.1 Surveillance of Cooperative aircraft

- SSR Transponder, ADS-B Out equipped aircraft(1090MHz, VDL Mode 4, UAT) and other cooperative Surveillance Sources



Reference to existing provisions in A10V3,V4

Specific to RPAS

3.2.2 Surveillance of Non-cooperative aircraft

- 3.2.2.1 Detection and tracking requirements
- 3.2.2.2 Airborne primary surveillance radar equipped own aircraft
- 3.2.2.3 Electro Optical Equipped Own aircraft

3.2.3 Consideration for ground based surveillance

- Mostly future work



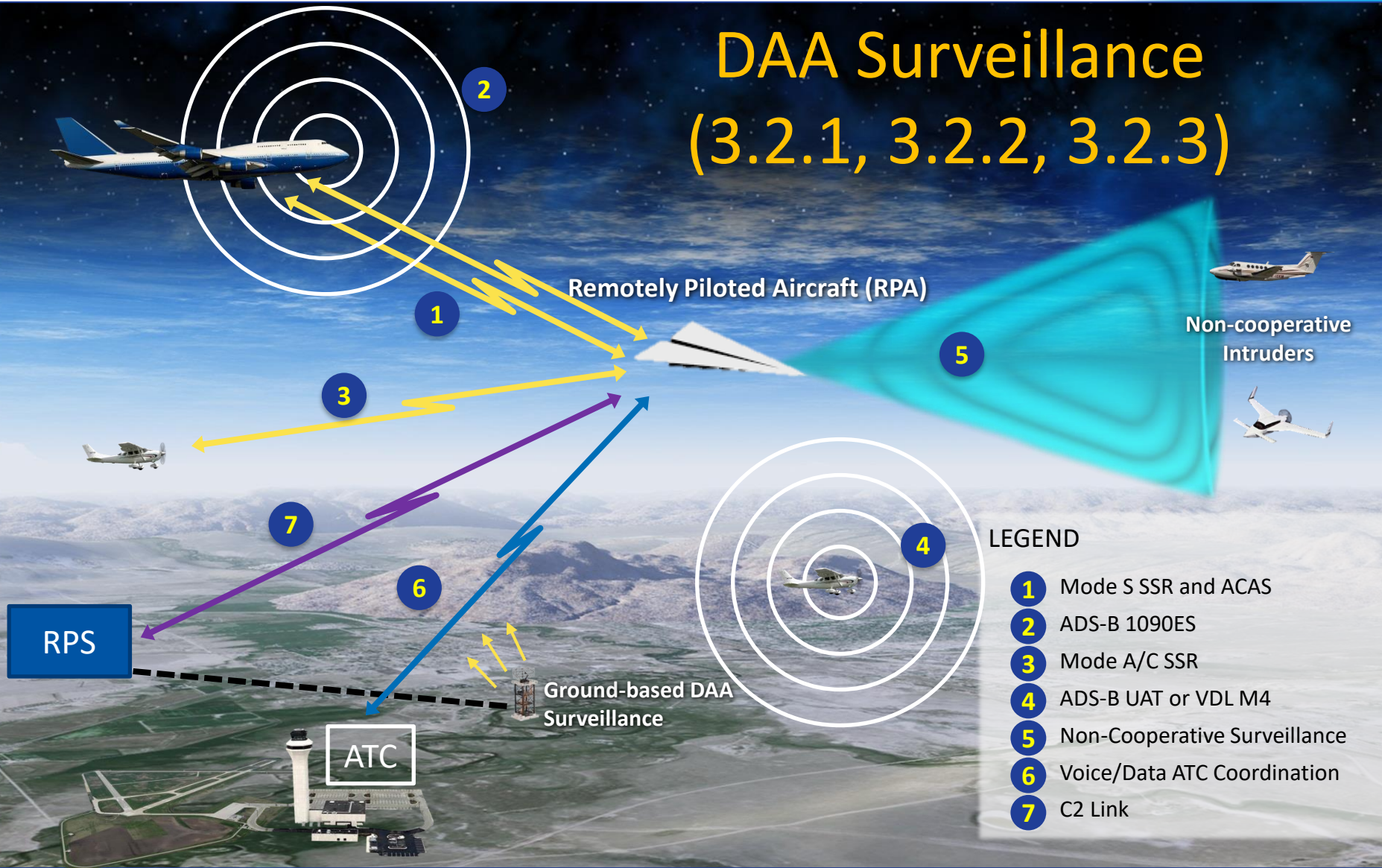
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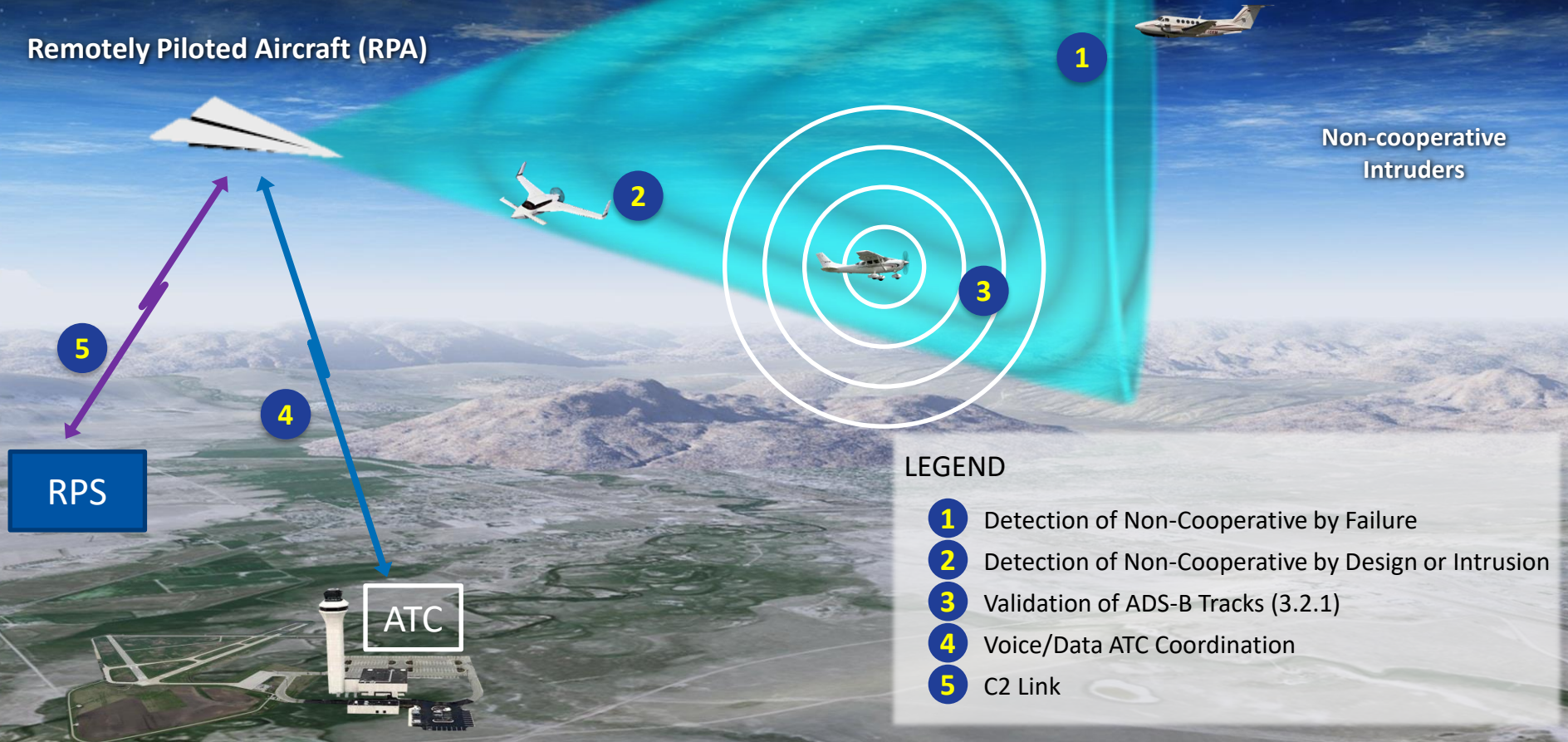


DAA Surveillance (3.2.1, 3.2.2, 3.2.3)





DAA Non-Cooperative Surveillance (3.2.2)





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Chapter 4 and Chapter 5

DAA RWC Function and CAS Function



Structures of A10V4 Part II

Chapter 4 and Chapter 5

CH4: RWC FUNCTION

Modeling of DAA RWC (from 4.1 to 4.3)

- 4.1 DAA Well Clear
- 4.2 Remote Pilot Model (Using validated pilot model)
- 4.3 Standard Encounter Model

Each developer is required to model their DAA RWC by using those requirements.

Technical Requirements for the RWC function (4.4)

CH5: COLLISION AVOIDANCE FUNCTION

Modeling of DAA CAS (from 5.1 to 5.3)

- 5.1. NEAR MID AIR COLLISION
- 5.2 Remote Pilot Model (Using validate pilot model)
- 5.3 Standard Encounter Model

Each developer is required to model DAA CAS by using those requirements.

Technical Requirements for the CAS function (5.4)



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Chapter 4

DAA RWC Function



What is Remain Well Clear?

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

RMC provide:

- timely alerting the pilot of possible encounters with other traffic and
- giving the remote pilot guidance a) to apply right of way and 2) to remain well clear of these.

When separation is not provided by ATC, the RWC function provides the separation layer of conflict management.



Technical Requirements for the RWC function

RWC 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**. (4.4.1)
- ☐ provide information, including one or more actions for the RPA to pass well clear, for the remote pilot to select and then execute. (4.4.2)

Alerts and manoeuvre guidance generated by the DAA system for the RWC 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.



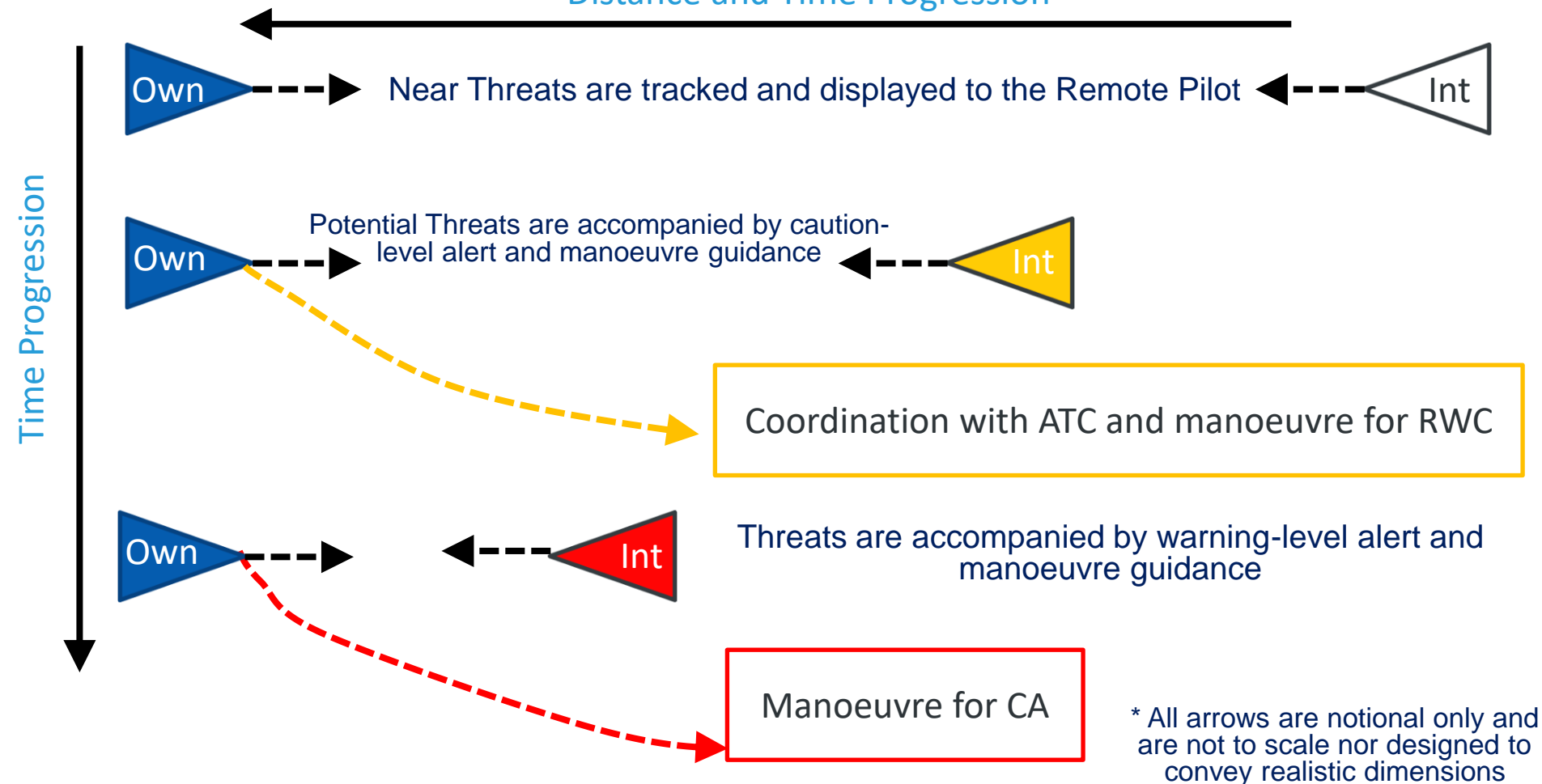
What kind of RWC alerts from DAA?

- ☐ DAA system shall provide a **caution level alert** and associated **manoeuvre guidance** to the remote pilot when a potential threat is present. (4.4.4)
 - ☐ Procedure is for Remote Pilot to contact ATC
- ☐ **The validation state** of track data used to generate the caution level alert **shall be displayed to the remote pilot.** (4.4.4.1)



Progression of DAA alerts and manoeuvre guidance

Distance and Time Progression





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DAA Manoeuvre Guidance

Remain Well Clear

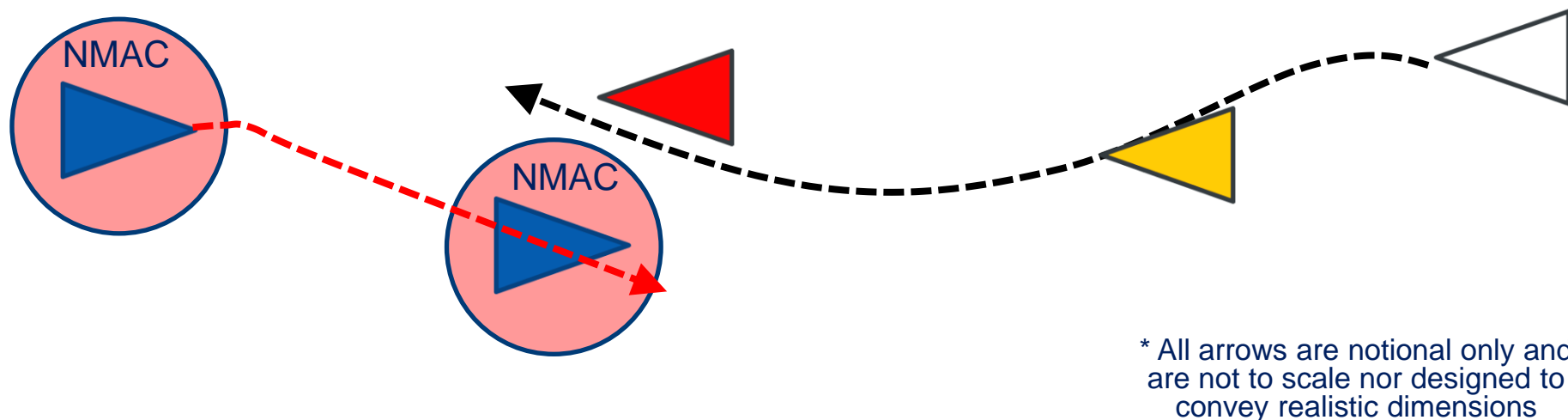
- Caution-level Suggestion to Remote Pilot
- Facilitates Communication with ATC
- Vertical and/or Horizontal
- Remote Pilot responsible for Right of Way Rules

Collision Avoidance

- Warning-level Command to Remote Pilot
- No ATC approval required, like ACAS
- Vertical and/or Horizontal



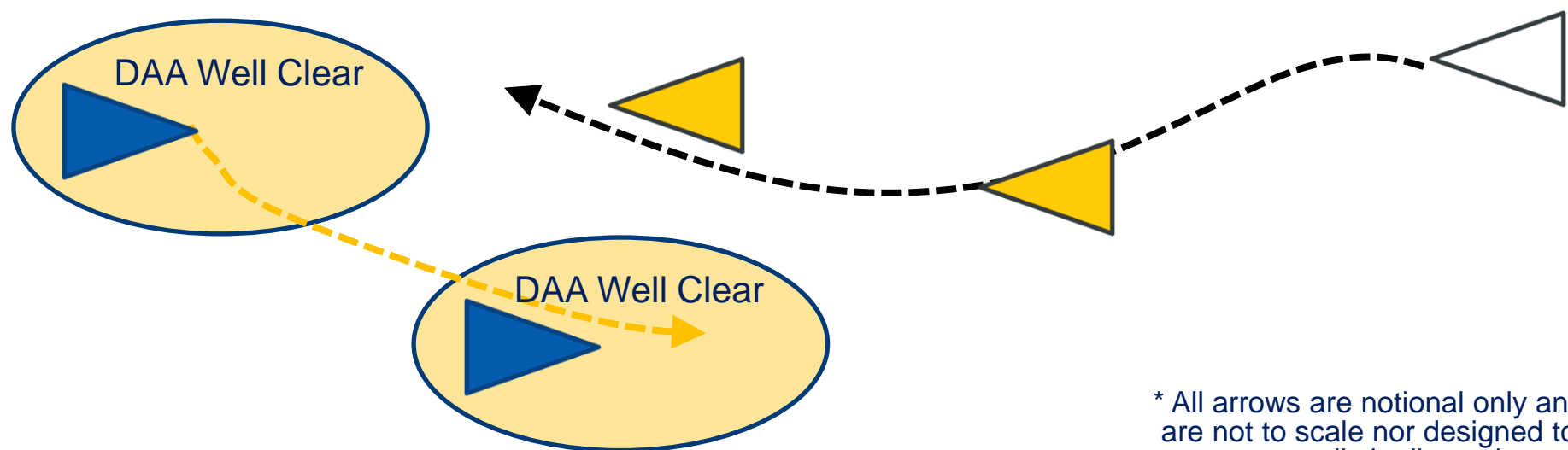
DAA Performance measured in simulation



Remote Pilot Model (5.2) and Encounter Model(s) (5.3) used to measure Collision Avoidance Function against NMAC (5.1)



DAA Performance measured in simulation



* All arrows are notional only and are not to scale nor designed to convey realistic dimensions

Remote Pilot Model (4.2) and Encounter Model(s) (4.3) used to measure RWC Function against “DAA Well Clear” (4.1)



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Chapter 5

DAA CAS Function



Technical Requirements for the CAS function

DAA CAS 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. (5.4.1)
- ☐ Only generate a DRA against all independently tracked or validated threats. (5.4.2)
- ☐ provide **a warning level alert** and associated **DRA** to the remote pilot. (5.4.3)



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Chapter 6 to Chapter 9

For future use



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Chapter 10

INTEROPERABILITY



CHAPTER 10 INTEROPERABILITY

10.2 **INTERNAL** DAA INTEROPERABILITY

- To ensure the two DAA functions, sensors and supporting subsystems of the DAA system work together as intended.

10.3 **EXTERNAL** DAA INTEROPERABILITY

- To ensure the seamless integration of RPA operations in the current ATM system.



10.3 **EXTERNAL** DAA INTEROPERABILITY

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 **will be minimized** when designing and introducing DAA systems.
- c) **The effectiveness of current safety barriers**, in particular ACAS, **will not be jeopardized**.



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Chapter 11

DAA PERFORMANCE



CHAPTER 11. DAA PERFORMANCE

11.2 GENERAL PROVISIONS RELATING TO DAA PERFORMANCE, considering all airspace classes,

- The **nominal collision avoidance risk ratio** shall be measured against a collision avoidance volume defined by NMAC volume.
- The **nominal remain-well-clear (RWC) risk ratio** shall be measured against the DAA Well Clear
- Reused concepts from ACAS and adapted for DAA

Risk Ratio

$$= \frac{\text{Conditional probability of an event occurring with the mitigation in place}}{\text{Conditional probability of the same event occurring without the mitigation in place}}$$



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CHAPTER 11. DAA PERFORMANCE

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

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

(A10V4 P1: 4.4.3 Reduction in the risk of collision)

The collision avoidance logic shall be such that the expected number of collisions is reduced to the following proportions of the number expected in the absence of ACAS:

a) when the intruder is not ACAS equipped	0.18
b) when the intruder is equipped but does not respond	0.32
c) when the intruder is equipped and responds	0.04.

When the intruder is non-cooperative

0.3



CHAPTER 11.DAA PERFORMANCE

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

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.	0.4
When the intruder is non-cooperative.	0.5



11.3 PERFORMANCE IN ENCOUNTERS OUTSIDE OF NOMINAL CONDITIONS

11.3.1 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:

- a) Intruder velocity; and
- b) Intruder manoeuvrability.



11.4 C2 LINK CONSIDERATIONS

- The operational transactions required by the DAA system shall be defined and incorporated into the C2 Link specification.
- The DAA system shall operate within the C2 Link performance allocated to DAA, with consideration to the Quality of Service Required (QoS).



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Chapter 12

Monitoring Function



Chapter 12 Monitoring Function

The DAA system shall monitor

- its own health to determine DAA system's current operational status.
- the status of the C2 Link quality of service delivered (QoSD).
- C2 link interruptions if the manoeuvre commanded by the CAS function is designed to be initiated automatically by the DAA system during the lost C2 Link decision state or the lost C2 Link state