RPAS-ATM Integration Demonstration

Final Workshop

Integrated System for DAA and Situational Awareness

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Summary

- DAA System Overview
- DAA System Architecture
- DAA Performance Req: Traffic Avoidance
- Outcomes
- On-going and future developments
- DAA Flight Exercises Overview
- DAA Flight Exercises Results
DAA System Overview

The system uses sensory **ADS-B In** inputs to assess the situation in the surrounding airspace. The ADS-B data are processed in order to:

→ **Traffic Avoidance (TrA)**
- **assess risk of future separation breach with the surrounding aircraft**
  
  If a **loss of separation** is predicted, the system alerts the Remote Pilot and automatically proposes a separation recovery manoeuvre; the Remote Pilot is then in charge of evaluating the feasibility of the proposed manoeuvre in order to implement it manually or automatically.

→ **Collision Avoidance (CA)**
- **assess risk of imminent collision with the surrounding aircraft**
  
  If a **risk of collision** is predicted, the system alerts the Remote Pilot and automatically elaborates a collision avoidance manoeuvre with respect to the most priority aircraft; the manoeuvre, due to its emergency nature, is automatically implemented but the Remote Pilot can abort it and take the direct control of the vehicle, at any moment.

→ **Enhanced Situational Awareness (ESA)**
- **provide the pilot with a traffic picture based on the identified risks and the compatibility with ACAS system on-board the surrounding aircraft**
  
  The system continuously performs the monitoring of the traffic in order to provide enhanced situational awareness to the Remote Pilot.
  
  The system continuously performs the **TCAS compatibility check**, aimed to provide a prediction of the Resolution Advisory activation by the surrounding traffic vehicles equipped with TCAS. Based on the outcome of this check, the system behavior is accordingly modified in order to assure that no nuisance maneuvers, disturbing the TCAS elaborated manoeuvre, are generated by the system.
The integrated system receives, from the on-board ADS-B IN device, traffic position and velocity data about surrounding ADS-B OUT equipped traffic. The integrated system is proposed to operate in the context of a DO-317B Surveillance Processing application, aimed to perform the processing of the raw data provided by the ADS-B IN.

The Remote Pilot receives traffic information through the Human Machine Interface (HMI) that allows him to build his situational awareness, based on all the information related to the surrounding traffic collected, elaborated and suitably sorted, according to the associated severity level of risk. The integrated system receives the Remote Pilot commands through HMI interface, allowing him to accept the TrA proposed manoeuvre and to abort the on-going CA manoeuvre.
The Traffic Avoidance functionality can be defined as the tactical capability of keeping the RPAS vehicle away from other airborne aircraft by at least the separation minima defined by EUROCONTROL:

**Specification RPA11:** “Where an RPA pilot is responsible for separation, he should, except for aerodrome operations, maintain a minimum distance of 0.5 NM horizontally or 500 ft vertically between his RPA and other airspace users [...]”.

**TrA Volume**

Cylindrical volume of airspace, centered on the traffic aircraft, with a horizontal radius of 0.5 NM and a vertical height of 500 ft.

Additional **extra-size** depending on the closure rate between the conflicting aircraft, due to uncertainties affecting sensor measurements and aircraft maneuvering.

The Traffic Avoidance functionality is compliant with the Rules of the Air (RoA).
**Conflict detection condition**

- the direction of the relative velocity vector intersects the separation volume **AND**
- the two aircraft are approaching each other.

**Conflict resolution strategies**

- Planar strategy: track angle modification
- Vertical strategy: altitude modification
- Velocity strategy: IAS modification

[PROPOSED TO THE REMOTE PILOT]

**RPAS pilot interaction**

- Aircraft involved in TrA manoeuvre visualization on CDTI and MFD
- Loss of separation alert visualization on PFD
- TrA manoeuvre acceptance input
- TrA manoeuvre references visualization on CDTI and MFD
1) The integrated system for Traffic Avoidance, Collision Avoidance and Situational Awareness successfully provides the RPAS RFO with the functionalities of:

- **Traffic Avoidance**, including detection of possible predicted loss of separation wrt surrounding vehicles and provision of suitable conflict resolution manoeuvre [TRL 6];

- **Collision Avoidance**, including detection of imminent collision threats and automatic escape manoeuvre wrt the highest propriety threat [TRL 5, tested in the RAID Real Time Simulation campaigns];

- **Situational Awareness**, including the identification of surrounding traffic vehicles associated severity (threats, conflicts, traffic) and indication of forecasted activation of TCAS in surrounding vehicles [TRL 6].

2) The use of the DAA system is **well manageable** by the RFO, even if in the Flight Tests a **partial increase of workload** with respect to Real Time Simulations has been assessed.

3) The **DAA system** emphasized its **effectiveness** in both Real Time Simulation campaigns and Flight Trials.

4) In the Flight Trials, in some cases, the **DAA system successfully managed** unexpected extremely **demanding conflict geometries**, due to the difficulties experienced in reproducing the planned encounters between FLARE and intruder.

5) The **Surveillance Application** implemented in the DAA system resulted **fundamental** in order to manage the ADS-B IN provided data and to assure proper DAA system performances.
On-going and future developments

**Current and future activities** aimed to significantly enhance the integrated system for Situational Awareness, Traffic Avoidance and Collision Avoidance include:

- paradigm shift from purely geometric approach to a **multiobjective approach** in the elaboration of the TrA (primarily) and CA manoeuvres, in order to increase the efficiency;

- consideration of **fixed obstacles** (terrain avoidance) and/or **no fly zones** in the manoeuver elaboration for both TrA and CA;

- integration of airborne based systems with **ground based systems**, for both TrA (primarily) and CA functionalities;

- consideration of the **RoA in the CA** manoeuvre elaboration;

- consideration of **multi-treath CA resolution** strategy.
## Planned Flight/Trial

<table>
<thead>
<tr>
<th>Flight/Trial</th>
<th>Operative Scenario</th>
<th>FLARE RPAS</th>
<th>Manned Int</th>
</tr>
</thead>
<tbody>
<tr>
<td>8A</td>
<td>Separation partially delegated to RFO, head-on approach with manned intruder, ownship climbing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8B</td>
<td>Separation partially delegated to RFO, lateral approach with manned intruder, ownship climbing</td>
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<td></td>
</tr>
</tbody>
</table>
The DAA system has been used as:

1. **Support** to the RFO decision making in recovering the separation condition according to the DAA considered separation volume
2. **Automatic system** (under RFO clearance) implementing the self-separation manoeuver

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**The decision about how to use the DAA system was under the RFO responsibility**

### 3 manual manoeuvre

- In one case the RFO preferred vertical resolution strategy instead of the planar one proposed by the DAA system

### 3 RFO delegation to DAA for automatic manoeuvre

- In one case the DAA system issued a collision warning during the execution of the separation manoeuvre, due to the extremely demanding conflict geometry preventing the possibility to avoid breaching the separation volume

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The tested geometries in some cases have been **very different** from the planned ones and very demanding (extremely close distance between aircraft when the separation maneuver started), due to relevant difficulties in managing the implementation of the prescribed aircraft configuration (in particular in lateral approach geometries)
FTC13 (May 5th, 2016): Flight Trial 6B, lateral encounter

- Loss of separation alert on PFD
- Manoeuvre acceptance input
- Manoeuvre references on CDTI and MFD

<table>
<thead>
<tr>
<th>Relative distance between aircraft at first resolution manoeuvre proposal</th>
<th>4588 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested manoeuvre strategy</td>
<td>variation of track (right turn of 42 deg, updated up to 50 deg due to the very close distance between aircraft)</td>
</tr>
<tr>
<td>RFO interaction with DAA system</td>
<td>manoeuvre accepted by RFO and automatically implemented by DAA</td>
</tr>
<tr>
<td>RFO decision time</td>
<td>3 s</td>
</tr>
<tr>
<td>Minimum relative distance reached during the self-separation manoeuvre</td>
<td>1190 m</td>
</tr>
<tr>
<td>Duration of manoeuvre</td>
<td>55 s</td>
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</table>
**FTC14b (May 6\textsuperscript{th}, 2016):** Flight Trial 8A, head-on encounter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Relative distance between aircraft at first resolution manoeuvre proposal</td>
<td>9184 m</td>
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<tr>
<td>Suggested manoeuvre strategy</td>
<td>variation of track (right turn of 15 deg)</td>
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<tr>
<td>RFO interaction with DAA system</td>
<td>manoeuvre accepted by RFO and automatically implemented by DAA</td>
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<tr>
<td>RFO decision time</td>
<td>7 s</td>
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<tr>
<td>Minimum relative distance reached during the self-separation manoeuvre</td>
<td>1436 m</td>
</tr>
<tr>
<td>Duration of manoeuvre</td>
<td>119 s</td>
</tr>
</tbody>
</table>

- Loss of separation alert on PFD
- Manoeuvre acceptance input
- Maneuvre references on CDTI and MFD