RPAS-ATM Integration Demonstration

Real-Time Simulations results: project objectives & Status

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**Consortium**

CIRA (Italian Aerospace Research Center)
MATS (Malta ANSP)
Deep Blue (Italian SME)
University of Malta
NAIS (Italian SME)
NIMBUS (Italian SME)

**Sub-contractors**

FALCONLOG (Remote Pilot)
IDEAE (Safety Manager & Intruder)
Introduction and high level demonstration objectives

- RAID is one of 9 European projects co-financed by SESAR Joint Undertaking

- Duration 2013-2016

- **To demonstrate and evaluate the impact of RPAS integration in un-segregated airspace on the ATM environment:**
  - Assess impact of RPAS integration in un-segregated airspace on safety, procedures, ATM stakeholders.
  - Demonstrate an innovative system developed by CIRA for Detect And Avoid (DAA) ADS-B based, providing traffic-collision detection & avoidance.
  - Evaluate the effects of disturbances on GNSS signal/Command and Control (C2L) link.
The RPAS Reference Mission

**RPAS trajectory:**

Point to point route between take-off and the mission area. Then the RPAS will follow a systematic target seeking pattern until the target is identified. Then the RPAS is supposed to follow the target (unknown route for an unknown time), then it will return to a predefined return flight route.
3 Demo Exercises:

• Ex #1 → Real Time Simulated Flights with Human in the Loop (Pilot & Air Traffic Controller), organized in 7 scenarios.

• Ex #2 → 2 Final Flight Trials, only RPAS involved, 2 scenarios

• Ex #3 → 6 Final Flight Trials, RPAS + 2 cooperative traffic vehicles, 4 scenarios

• Ex #1 Completed. 50 real time simulated flights over the 15 originally planned.

• Ex #2 & Ex#3 In preparation. Under discussion with SESAR JU and Italian Authorities, the possibility to perform all flight exercises in Italy instead of Malta, without any change of the flight scenarios with respect to the approved Demo Plan.
Final Flight Demonstration: Operational Conditions

**RPAS Mass:** 550 Kg  
**RPAS Data-Link:** LOS  
**RPAS Flight:** IFR  
**Working Altitude:** 2000-5000 Ft  

**Vehicles Involved:**
- CIRA OPV FLARE as RPAS under test, operated under an Experimental PtF to be released by ENAC  
- 2 Cooperative (i.e ADSB-OUT equipped) traffic vehicles one manned & one un-manned  

**Departure/Arrival terrain:** Standard civil airport or local area for VTOL (different or same as departure)
A geographically distributed simulation setup using VPN connections for both simulation data and voice communication.

RPAS simulator including a full RP cockpit (@CIRA)

2 Traffic simulators (@CIRA & @MATS)

ATCo working position simulators, including radar simulator (@MATS)
Real Time Simulation Campaign

- 2 experienced RPAS pilots and 4 MATS Air Traffic Controllers (ATCo) involved
- 50 flights, each of about 20 min, organized in 7 scenarios
- Tested both nominal and off-nominal conditions (GPS spoofing or LOS data-link jamming)
- The Flying Test Area is situated 6KM (about 3.1NM) south east of Luqa aerodrome in MALTA, having a square shape with 10NM sides. The vertical limits are from Mean Sea Level (MSL) to an altitude of 3000FT.
- Simulated traffic conditions: medium-high density commercial traffic usually operating in the selected area.
The final real-time simulation report includes the evaluation of a list of key-indicators based on the collected data:

- **Safety** (human errors, system failures, external factors,...)
- **Security** (regulatory, capacity, personnel, ...)
- **Human Performance** (human roles, human and system, implementation impediments, ...)
- **DAA System Performance** (distance between RPAS and intruder at Closest Point of Approach, number of separation volume infringements, maximum deviation from nominal flight path, ...)

**Data collected:**

- Questionnaires filled by pilots and ATCo
- Audio/video recordings
- Time-histories for position-velocity variables of aircraft in simulations
- Log files for RPAS under test
## RTS: The 7 Test Scenarios

<table>
<thead>
<tr>
<th>Scenario #</th>
<th>Scenario description</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>En-Route Operations</strong> of the RPAS, entering and leaving a TSA from/to an unrestricted managed airspace</td>
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<tr>
<td>2</td>
<td>En-Route Operations of the RPAS in presence of potentially <strong>conflicting manned</strong> traffic</td>
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<tr>
<td>3</td>
<td>Detect and Avoid <strong>Collision Avoidance</strong></td>
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<tr>
<td>4</td>
<td>Detect and Avoid <strong>Traffic Avoidance – One manned</strong> vehicle involved</td>
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<tr>
<td>5</td>
<td>Detect and Avoid <strong>Traffic Avoidance – Multiple manned</strong> vehicles involved</td>
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<tr>
<td>6</td>
<td>Detect and Avoid <strong>Traffic Avoidance – Unmanned</strong> vehicle involved</td>
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<tr>
<td>7</td>
<td>En-Route Operations of the RPAS, under <strong>C3L security threats</strong> (spoofing, jamming)</td>
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Test Scenario Example – Collision Avoidance

SCN 3 – TESTS 6, 7, 8, 9

- Collision Avoidance management by DAA

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<thead>
<tr>
<th>Test 6</th>
<th>Test 7</th>
<th>Test 8</th>
<th>Test 9</th>
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</thead>
<tbody>
<tr>
<td>CIRA simulated traffic</td>
<td>1 head-on</td>
<td>1 lateral</td>
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</table>

- Planned mission
  - DAA maneuvers automatically RPAS
  - RPO monitors RPAS and provides advice to Test Controller

Altitude: 1000 m
RPAS TAS: 35 m/s
INTRUDER TAS: 35 – 70 m/s

RPAS Altitude: 760 – 1240 m
TAS: 35 m/s
Test Scenario Example – Traffic Avoidance

**SCN 5 – TEST 27**

- Separation Assurance Management by DAA automatic implementation

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<tr>
<th>CIRA simulated traffic</th>
<th>1 head-on and 1 lateral</th>
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</table>
| Planned mission        | • DAA proposes a manoeuvre to RPO  
                          • RPO evaluates and accepts  
                          • DAA maneuvers automatically the RPAS and  
                            RPO provide advice to Test Controller |

RPAS Altitude: 1000 m
Intruder 1 Altitude: 1000 m
Intruder 2 Altitude: as indicated
TAS: 35 m/s