Real-time Simulations to Evaluate the RPAS Contingencies in Shared Airspace
(WP-E project ERAINT)

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RPAS particularities

Flight plan stages

- Civil RPAS applications: Surveillance, SAR, terrain mapping…
RPAS particularities

The mission stage\(^1\)

- VFR-like missions in an IFR environment.

\(^1\)Courtesy of NASA (V. Ambrosia); Google Earth background image used by permission to the NASA Wildfire Research and Applications Partnership project.
# RPAS particularities

## Performance dissimilarities

<table>
<thead>
<tr>
<th>Performance Parameter</th>
<th>RPAS</th>
<th>Manned Aircraft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cruise airspeed</td>
<td>↓↓↓</td>
<td>↑↑↑</td>
</tr>
<tr>
<td>Rate of climb</td>
<td>↓↓↓</td>
<td>↑↑↑</td>
</tr>
<tr>
<td>Cruise altitude</td>
<td>≈</td>
<td>≈</td>
</tr>
<tr>
<td>Endurance</td>
<td>↑↑↑</td>
<td>↓↓↓</td>
</tr>
</tbody>
</table>

![Diagram showing altitude and range for different types of aircraft: MUAV, TUAV, VTOL, MALE, HALE]
RPAS particularities

Other issues

- Datalink related:
  - Communication latency.
  - Lost-link.

- Contingency related:
  - Loss of control/navigation capabilities.
Introduction

2 ERAINT

3 Step B: Contingency Management

4 Simulation Exercises results

5 Conclusion
ERAINT Project scope

The (not-so-simple) acronym

- ERAINT: Evaluation of RPAS-ATM Interaction in non-segregated airspace

Main goals

- To provide an environment that permits to analyse some of the Roadmap\(^2\) identified gaps from the RPAS-ATM interaction point of view.

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\(^2\)Roadmap for the Integration of civil RPAS into the European Aviation System
ERAINT Project scope

Specific objectives

- Separation provision.
- Response to RPAS contingencies.
- Lost-link procedures.
- Impact of changes on filled flight plan at a tactical level.

3 mainly gaps EC-1.1, EC-1.2, EC-3.1, EC-3.2, EC-5.1, EC-5.3 and EC-6.1
Outline

1. Introduction
2. ERAINT
3. Step B: Contingency Management
4. Simulation Exercises results
5. Conclusion
RPAS integration. The contingency perspective


<table>
<thead>
<tr>
<th>Aircraft type</th>
<th>Contingency type</th>
<th>Contributed to the accident?</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQ-1B</td>
<td>LL</td>
<td>No</td>
</tr>
<tr>
<td>MQ-1B</td>
<td>LL + EP</td>
<td>Yes (EP)</td>
</tr>
<tr>
<td>MQ-1B</td>
<td>LL + Others</td>
<td>Yes (All)</td>
</tr>
<tr>
<td>MQ-1B</td>
<td>EF</td>
<td>Yes</td>
</tr>
<tr>
<td>MQ-1B</td>
<td>EF</td>
<td>Yes</td>
</tr>
<tr>
<td>MQ-1B</td>
<td>EF</td>
<td>Yes</td>
</tr>
<tr>
<td>MQ-1B</td>
<td>EP</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Managing contingencies on an RPAS is more complex than on manned aviation:

- The automated nature of the vehicle.
- Communication latency.
- Reduced situational awareness.

We evaluate two different contingency types:

- an engine failure
- a command and control communication failure (without affecting its airworthiness).
Step B: Contingency Management

Context of validation

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4 E. Pastor et al. *In-Flight Contingency Management for UAV*, JACIC 2012
Step B: Contingency Management

Context of validation

- We evaluate the use of flight intent technology in support to contingency management
Step B: Contingency Management

Validation experiment

- Validation through real-time simulations (ISIS+ environment\(^5\)).
- Real airspace structure.
- Busy live traffic sample (30\(^{th}\) August, 1000Z - 1200Z).

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Step B: Contingency Management

Validation experiment

- Scenario 1 (baseline): No RPAS operating.
- Scenario 2: RPAS with engine failure, no flight intent.
- Scenario 3: RPAS with engine failure, with flight intent.
- Scenario 4: RPAS with lost link, no flight intent.
- Scenario 5: RPAS with lost link, with flight intent.
Simulation exercise definition

Exercise preparation
Simulation exercise definition

Exercise preparation

<table>
<thead>
<tr>
<th>Mission type</th>
<th>Surveillance Palma</th>
<th>Surveillance Iceland</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPAS type</td>
<td>MQ-9 (MALE)</td>
<td>RQ-4 (HALE)</td>
</tr>
<tr>
<td>FIR involved</td>
<td>Barcelona (LECB)</td>
<td>Denmark (EKDK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maastricht (EDYY)</td>
</tr>
<tr>
<td># active sectors</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Remarks:
- Palma mission will mainly impact with traffic departing/arriving from/to LEPA, LEMH, LEIB.
- Iceland mission will mainly impact with en-route traffic.
Simulation exercise definition

Exercise preparation: Selected sectors for Palma mission
Simulation exercise definition

Exercise preparation: Selected sectors for Iceland mission
Outline

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5. Conclusion
Simulation Exercises results: Viability of the contingency operation

Remarks

- The development of contingency RPAS operation is viable and resulting into limited ATC workload impact.
- Coupled or chained contingencies will require further investigation.
Remarks

- Simulations demonstrated that flight intent is a key technology enabler for contingency management.
Remark

- RPAS contingency procedures should be similar to those of manned aircraft and have to provide an adequate level of safety and predictability.
- The concept of operation will be divided, at least, in three separated areas:
  - The airport selection.
  - The contingency trajectory to be followed.
  - The RPAS pilot ATC dialogue along the operation, before, at the time of and during the contingency.
Simulation exercises results: RPAS 4D Trajectory Prediction

Remarks

- The integration of RPAS into non segregated airspace should involve the creation of BADA-based APM for RPAS.

- Issues:
  - No one really knows exactly the flight performances of future RPAS
  - the information on performance of currently flying RPAS is not flowing smoothly.
  - BADA 3 or BADA 4? (RPAS APM just arrived to 3.13)
Conclusions and further work

- RPAS integration as a challenge:
  - Providing continual separation and contingency management are critical requirements for the integration.
  - Simulations demonstrated that contingency management is viable and resulted into limited ATC workload impact.
  - Simulations permitted to develop an initial concept of operations for RPAS trajectory intent when RPAS is suffering a contingency.
  - RPAS-specific aircraft performance models are also needed (at least, we have BADA 3).
Thank you for your attention!!