

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

E. Pastor M. Pérez-Batlle
P. Royo R. Cuadrado C. Barrado

4th SESAR Innovation Days

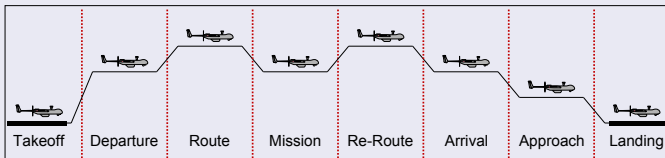
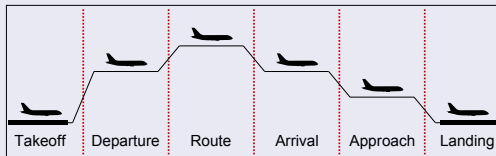


Universitat Politècnica de Catalunya (Barcelona-Tech)

RPAS peculiarities

Flight plan stages

- Civil RPAS applications: Surveillance, SAR, terrain mapping...



RPAS peculiarities

The mission stage¹

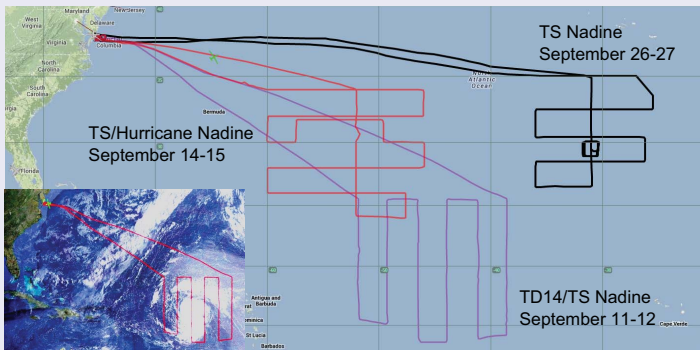
- VFR-like missions in an IFR environment.



¹Courtesy of NASA (V. Ambrosia); Google Earth background image used by permission to the NASA Wildfire Research and Applications Partnerships project.

RPAS peculiarities

The mission stage²

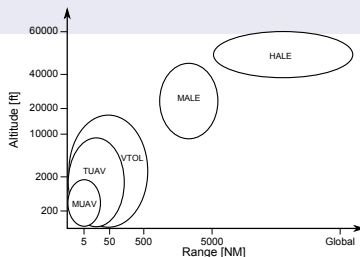


²Courtesy of NASA

RPAS peculiarities

Performance dissimilarities

Performance Parameter	RPAS	Manned Aircraft
Cruise airspeed	↓↓↓	↑↑↑
Rate of climb	↓↓↓	↑↑↑
Cruise altitude	≈	≈
Endurance	↑↑↑	↓↓↓



RPAS peculiarities

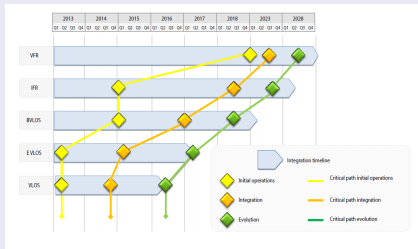
Other issues

- Datalink related:
 - Communication latency.
 - Lost-link.
- Contingency related:
 - Loss of control/navigation capabilities.

RPAS Integration. State-of-the-art

Gaps for the integration of civil RPAS into the European aviation system³ have been identified. They are related to:

- **EC 1:** Methodologies for the validation of RPAS safety objective.
- **EC 2:** Secure c2, data links, etc.
- **EC 3:** Insertion of RPAS into the ATM, D&A, situational & weather awareness.
- **EC 4:** Security issues attached to the use of RPAS.
- **EC 5:** Safe automated monitoring, support to decision making and predictability of behaviour.



³European RPAS Steering Group. *Roadmap for the integration of civil Remotely Piloted Aircraft Systems into the European Aviation System*, Jun 2013

Outline

- 1 Introduction
- 2 ERAINT
- 3 Step A: Separation Management
- 4 Simulation Exercises results
- 5 Conclusion

ERAINT Project scope

The (not-so-simple) acronym

- ERAINT: **E**valuation of **RPAS-ATM INT**eraction in non-segregated airspace

Main goals

- To provide an environment that permits to analyze the Roadmap identified gaps from the RPAS-ATM interaction point of view.

ERAINT Project scope

Specific objectives⁴

- Separation provision.
- Response to RPAS contingencies.
- Lost-link procedures.
- Impact on the controller's workload and airspace capacity

⁴mainly gaps EC-1.1, EC-1.2, EC-3.1, EC-3.2, EC-5.1, EC-5.3 and EC-6.1

ERAINT Project scope

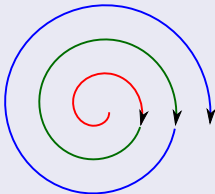
Project organization



ERAINT

ICARUS Research Group
UNIVERSITAT POLITÈCNICA DE CATALUNYA

Nexodynamics



Step A: Separation management

Step B: Contingency management

Step C: Impact on ATM capacity

- **Step-A:** En-route separation management with open and close instructions an proactive participation of the RPAS through strategic trajectory negotiation (12 months - finished in Sep.).
- **Step-B:** Contingency management with automatic/autonomous operation by the RPAS with active RPAS-ATC negotiation (12 months).
- **Step-C:** Strategies to access non-segregated controlled airspace limiting negative impact of the RPAS operation to airspace capacity (6 months).

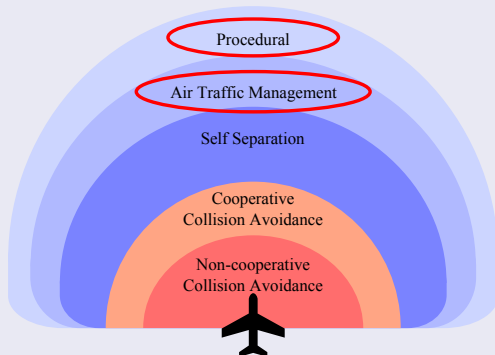
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Step A: Separation Management

Context of validation

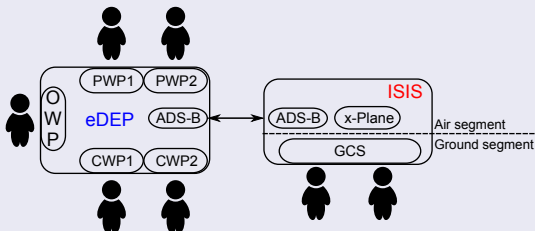
- Separation provision mechanisms:
 - Separation target: 5 NM / 1000 ft.



Step A: Separation Management

Validation experiment

- Validation through real-time simulations (ISIS+ environment⁵).
- Real airspace structure.
- Busy live traffic sample (30th august, 1000Z - 1200Z).

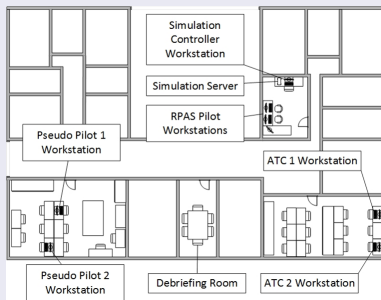


⁵P. Royo et al. *ISIS+: A Software-in-the-Loop Unmanned Aircraft System Simulator for Nonsegregated Airspace* Journal of Aerospace Information Systems Vol. 10 No. 11 Nov. 2013

Step A: Separation Management

Validation experiment

- Validation through real-time simulations (ISIS+ environment).
- Real airspace structure.
- Busy live traffic sample (30th august, 1000Z - 1200Z).



Step A: Separation Management

Validation experiment

- Scenario 1: No RPAS operating.
- Scenario 2: RPAS (no flight intent⁶).
- Scenario 3: RPAS (flight intent).

SUPPORTED SURVEILLANCE AND COMMUNICATION TECHNOLOGIES.

Scenario ID	Surveillance systems	Communications
Scenario 1	PSR / SSR	RTF
Scenario 2	PSR / SSR	RTF
Scenario 3	PSR / SSR / ADS-C	RTF / Limited datalink

⁶A list of 4-D points with the predicted aircraft future location

Simulation exercise definition

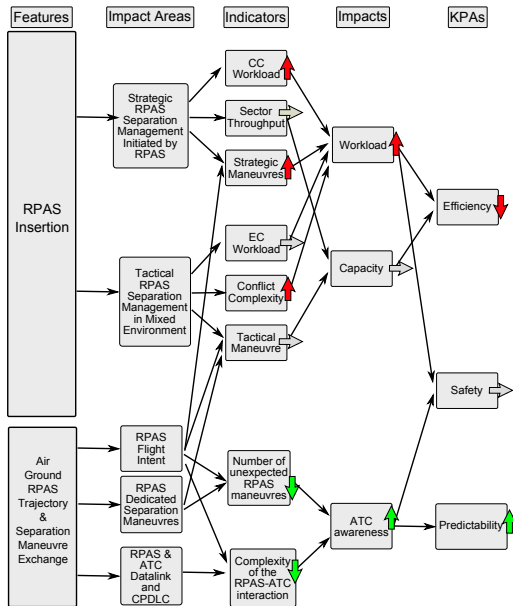
Expected benefits per stakeholder

- Controllers:
 - Asses the viability of the RPAS integration.
 - Identify the specific separation strategies used.
 - Asses what information is necessary and sufficient to meet the needs of the concept.
 - Asses that no negative impact on operation is derived from the use of the new CWP/HMI.

Simulation exercise definition

Expected benefits per stakeholder

- Research:
 - Validate the relevance of the RPAS-ATC simulation environment.
 - Understand up to which level the RPAS can be a pro-active vehicle.
 - Validate that RPAS missions can be carried out when operating in shared airspace.
 - Validate which types of separation manoeuvres are best suited for RPAS.
- SJU:
 - Obtain assurance that the RPAS integration concepts under consideration are feasible.



Simulation exercise definition

Choice of metrics and indicators

METRICS AND INDICATORS AVAILABLE FOR STEP A.

Activity	Pre Simulation	During Scenario	Post Scenario	Post Simulation
Separation Scenario	Brief	Observer checklist (errors / discrepancies) ISA STCA ADS-B Recording RPAS Recording	Scenario Debrief CAPAN taskload Workload scale	Day debrief User acceptance
Baseline Scenario	Brief	Observer checklist (errors / discrepancies) ISA STCA ADS-B Recording	Scenario Debrief CAPAN taskload Workload scale	

21 / 34

Simulation exercise definition

Exercise preparation

Mission type	Surveillance	Ferry
RPAS type	MQ-9 (MALE)	RQ-4 (HALE)
FIR involved	Barcelona (LECB)	Barcelona (LECB) Marseille (LFMM) Rome (LIRR)
# active sectors	2	2

■ Remarks:

- Surveillance mission will mainly impact with traffic departing/arriving from/to LEPA, LEMH, LEIB.
- Ferry mission will mainly impact with en-route traffic.

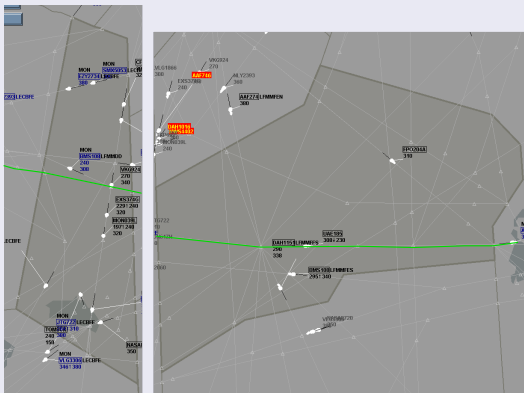
Simulation exercise definition

Exercise preparation: Selected sectors for surveillance mission



Simulation exercise definition

Exercise preparation: Selected sectors for ferry mission



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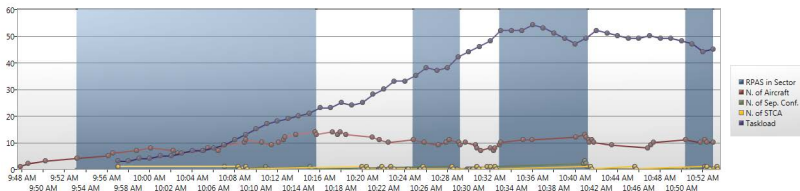
Simulation Exercises results: Taskload and workload extracts

Remarks

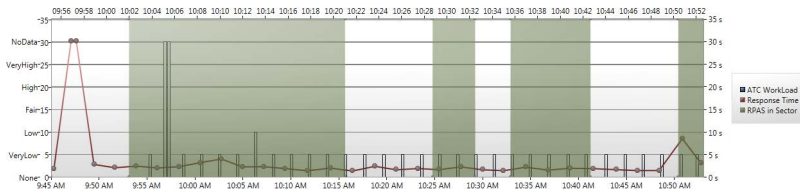
- Ferry mission taskload shows that the selected scenario does not include significant traffic.
 - CAPAN levels are fairly low.
 - Practical experience during simulation indicated that no major conflicts existed during that ferry operation.
- Surveillance mission showed much more potential for separation conflicts.
 - CAPAN taskload metric values (due to the additional RPAS activity) increase.
 - ISA workload metric values slightly increase.

Simulation exercises results: Taskload and workload extracts

Taskload for sector LECBNW2-CSX.



Workload



Simulation Exercises results: Mission, traffic overview and ATC procedures

- RPAS missions: Satisfactory level of realism.
- Difficulties to establish a proper RPAS-ATC communication when requesting flight plan variations related to the mission. Specifically:
 - How to specify the area of operations?
 - How to communicate that a mission operation was requested?

Simulation exercises results: Representation and complexity of scenarios

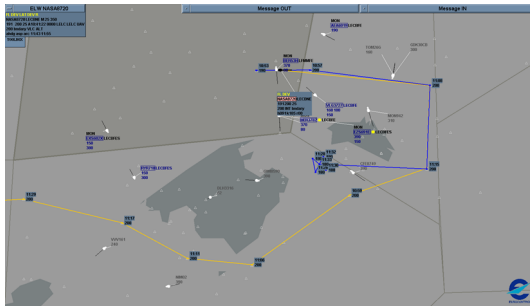
- Traffic workload:
 - It reflects a standard demand for an ordinary summer day.
 - Arrival and departing flows are complementary (typical HUB operations in LEPA).
- RPAS incorporation in simulation:
 - It slightly increased the complexity of the scenario to the controller.
 - The RPAS flight plan was well defined with clear boundaries.
 - It increased the controller's workload.
 - The number of ATC instructions were increased.
 - The tactic planning required to prepare the descending traffic clearances was highly increased.

Simulation exercises results: Intent design and use by the RPAS

- Three levels of flight intentions were simulated:
 - 1st level:
 - Only the initial flight plan was available and the mission updating was not reflected in eDEP.
 - The pilot transmitted via radio the intentions and, after receiving a clearance, started to fly the new route.
 - **Effects:** Radio usage was increased. Fair ATCo situational awareness.
 - 2nd level:
 - The pilot transmitted via radio the intentions and, after receiving a clearance, started to fly the new route.
 - The intentions, which were already being flown by the RPAS, were received in eDEP and shown to the ATC.
 - **Effects:** Radio usage was still high. ATCo situational awareness improved.

Simulation exercises results: Intent design and use by the RPAS

- Three levels of flight intentions were simulated:
 - 3rd level:
 - Intentions could be visualized in eDEP before being cleared by ATC.
 - **Effects:** Radio usage was kept in nominal levels. ATCo situational awareness still improved.



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Conclusions and further work

- Conclusions:
 - Mission, traffic and ATC procedures are realistic enough both from the ATC and RPAS perspectives.
 - Regarding the complexity of the scenarios, it reflected a standard demand that did not represent an excessive complexity.
 - The dynamism of the RPAS mission could negatively impact on the controller workload.
 - Simulation environment and the used tools are also realistic and useful, in particular the RPAS flight intentions which has initially demonstrated to reduce the impact of the RPAS integration.
- Further work:
 - Further experiments need to be developed in order to analyze the impact of the RPAS integration to the flight efficiency of the surrounding traffic.

Thank you for your attention!!