INVIRCAT
A Concept of Operations to Efficiently Integrate IFR RPAS into the TMA

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At a Glance

Duration: 30 months, July 2020 – December 2022
Consortium: 7 partners from 5 EU member states

DLR
EUROCONTROL
Italian Aerospace Research Centre
Isdefe
nlr
deepblue consulting & research
ISSNOVA

Deliverables: 20 (10 public)
Milestones: 6
Schedule

Start

July 2020

Dec 2020

SOTA & Use Cases

May 2021

Initial CONOPS

Nov 2021

Validation

Final CONOPS

Mar 2022

June 2022

Conclusions & Recommendations

Dec 2022

End

INVIRCAT - IFR RPAS Control in Airports and TMA - EASN Conference 02/09/2021
Project Scope

INVIRCAT develops a CONOPS to integrate RPAS into the existing ATM environment and infrastructures within the TMA and airports under IFR.

With special regards to
• The impact of latency,
• Automatic Take-off and Landing (ATOL), and
• Handover of RPA control between Remote Pilot Stations (RPS) in airspace classes A, B, and C

Source: Letondal et. Al., Flights in my hands [...], 2013

Source: European ATM Masterplan
**Key Assumptions**

**Remotely Piloted Aircraft System (RPAS)**

**RPAS Traffic Class VI:**
Describes Operations in EASA’s UAS category ‘Certified’ under Instrument Flight Rules

Requirements

- Ability to meet the set performance requirements in the network, TMA, and airport
  - Manned transport aircraft enabled to fly unmanned
  - New types of aircraft
- Capability of flying SIDs and STARs
- Ability to meet CNS airspace requirements
- Two-way communication with ATC
- Ability to contact ATC in regard to special conditions as
  - data link loss
  - emergency or
  - controlled termination of flight
- DAA equipment that is compatible with existing ACAS systems
- Flight plan including information such as
  - type of RPAS
  - planned contingency procedure
  - contact phone number

Key Assumptions
Remotely Piloted Aircraft (RPA)

In addition we assume the RPA to have
• a fixed-wing structure
• an airworthiness certificate and a type certificate
• a single Command and Control (C2) link

and to be
• equipped with a system that allows IFR landings without visual aid
• equipped with an Automatic Take-Off and Landing System (ATOL)
• able to conduct taxi operations on their own power
Key Assumptions
Remote Pilot (RPIL)

The RPIL must
• be adequately trained and certified
• refrain from using on-board cameras for flight-critical operations
• always fly under IFR, and not request, accept or perform any visual procedures
• always be monitoring the RPA and override automated functions if required

In addition, one RPIL may only control one RPA at any given time.
Key Assumptions
Air Traffic Control (ATC)

This CONOPS aims to have as little impact to current ATC operations as possible

Additional assumptions are that ATC
• must be adequately trained in RPAS procedures, and
• must be able to contact the RPIL at any time

Apron and Tower Simulator, Source: DLR
Interfaces

**RPIL to RPS (HMI)**
Allows the RPIL to monitor and control the RPAS

**RPS to ATC**
Enables communication between the RPIL and ATC in TMA
- Mainly voice communication (VHF, SATCOM or ground connection)
  - Backup needed (e.g. phone land line)
- CPDLC only usable for non-critical flight phases (e.g. taxiing, departure clearance)

**RPS to RPA**
Allows Command and Control (C2) of the RPA via a datalink connection

**RPA to aircraft (Detect and Avoid)**
Aims to provide
- situational awareness to the RPIL (analogue Sense and Avoid)
- separation provision (Remain Well Clear)
- collision avoidance when separation provision failed (compatible with ACAS)

Covered by PJ13 & URClearED
## Interfaces

### Communication and C2 link Architecture

<table>
<thead>
<tr>
<th>Pictogram</th>
<th>RPS location</th>
<th>Link</th>
<th>Technology</th>
<th>Estimated expected Latency*</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="RLOS Pictogram" /></td>
<td>In RLOS of airport</td>
<td>Communication</td>
<td>Radio</td>
<td>290ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2</td>
<td>Radio</td>
<td>1s</td>
</tr>
<tr>
<td><img src="image" alt="SATCOM Pictogram" /></td>
<td>Remote</td>
<td>Communication</td>
<td>SATCOM</td>
<td>700ms</td>
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<tr>
<td></td>
<td></td>
<td>C2</td>
<td>SATCOM</td>
<td>2s</td>
</tr>
<tr>
<td><img src="image" alt="Ground via Gateway Pictogram" /></td>
<td>Remote</td>
<td>Communication</td>
<td>Ground</td>
<td>150ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2</td>
<td>Ground + Radio</td>
<td>1.5s</td>
</tr>
</tbody>
</table>

* In the TMA, Communication: one way latency, C2: round trip latency

Airport Infrastructure

In general, large RPAS require the use of runways and taxiways and operate in a manner similar to manned aircraft.

Special requirements

- Navigation requirements
  - Precision navigation systems for taxi, take-off and landing
- Communication requirements
  - E.g. Interface from ground connection to VHF (party line)
- RPS logistical requirements
  - Office space and utility capacity

Requirements similar to manned aircraft

- Runway use and length requirements
- Fuel and maintenance requirements
Description of Operations

Civil and military operations (point to point or local area)

INVIRCAT scope

- Taxi to/from runway/parking position
- Take-off and Departure using SIDs
- Arrival using STARs, and Holding
- Approach and Landing

Source: Letondal et. Al., Flights in my hands [...], 2013
Operational Challenges

Nominal Operations

• Increased work load due to Communication and C2 link latency
• Reduced situational awareness due to lack of human senses of RPIL
  • No use of visual aids for take-off and landing
• Reduced airspace capacity to due to increased separation requirements (RPA performance figures)

Non-Nominal Operations

• Risk of RPAS specific contingencies (i.e. Communication and C2 link failure)
Handover RPS to RPS

System requirements

- Receiving RPS must be active and available
- C2 link must be compatible
- Reliable voice communication link between the transferring and receiving RPIL

Operational considerations

- Coordination between the respective RPILs
  - Status of the RPAS and location of the RPA
  - Changes or limitations to the intended flight or RPA performance
  - Pending or ongoing ATC instructions execution
- Coordination with ATC
  - Voice communication backup number

Take-off and Landing Assistance

To avoid Pilot Induced Oscillation (PIO) the RPIL has to refrain from the use of visual aid during take-off and landing.

ATOL systems shall automatically perform operations during take-off, initial climb, approach, landing, and missed approach flight phases - in nominal and some contingency situations.

Support systems may be e.g.
- Onboard equipment
  - Electro-optical systems
  - Infrared systems
  - Laser altimeters
- Precision approach systems
  - GLS
    - GAST
    - Multi-constellation solutions
  - ILS
    - CAT III
Handling of non-nominal Situations

Procedures from manned aviation, when possible for
- Propulsion Failure - Single Engine RPAS
- Propulsion Failure - Multi Engine RPAS
- Automatic Take-Off and Landing System (ATOL) Failure
- Missed Approach
- Conflict
- Fuel Starvation

Use of voice communication via backup phone in case of
- Voice Communications Failure

Use of loiter waypoints in case of
- Transponder (Mode S) Failure
- Command and Control (C2) Link Failure

Controlled flight termination as ultima ratio in case of
- Command and Control (C2) Link Failure
Roles and Stakeholders

In general, the responsibilities of the stakeholders are comparable to manned aviation.

The most important additional responsibilities are:

**Remote Pilot (RPIL)**

- Monitor and configure C2 link systems
- In case of Communication loss contact ATC with any other available mean
- In case of C2 link loss contact and coordinate with ATC
- Terminate the flight, in the event such an action is deemed necessary

**ANSP/ ATC**

- Familiarize themselves with the necessary coordination with other ATCOs, aircraft, and the RPIL in RPAS contingency situations
Focus of Validation

• Impact of **latency** on ATCO and RPIL in different flight phases in the TMA
  • Nominal conditions
  • Communication link failure
  • Transponder failure
  • Conflict
• Implications of **ATOL system** on take-off and landing operations
  • Nominal conditions
  • ATOL occurrences (RTO, MA/GA)
  • Conflict (RTO, MA/GA)
  • C2 link failure
• Implications of **multiple RPAS** at a time in the approach phase
  • Nominal conditions
  • C2 link failure
• Coordination of **handover** between two RPIRs and the ATCO
  • Nominal conditions
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