INVIRCAT

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

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SESAR
JOINT UNDERTAKING

Founding Members
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At a Glance

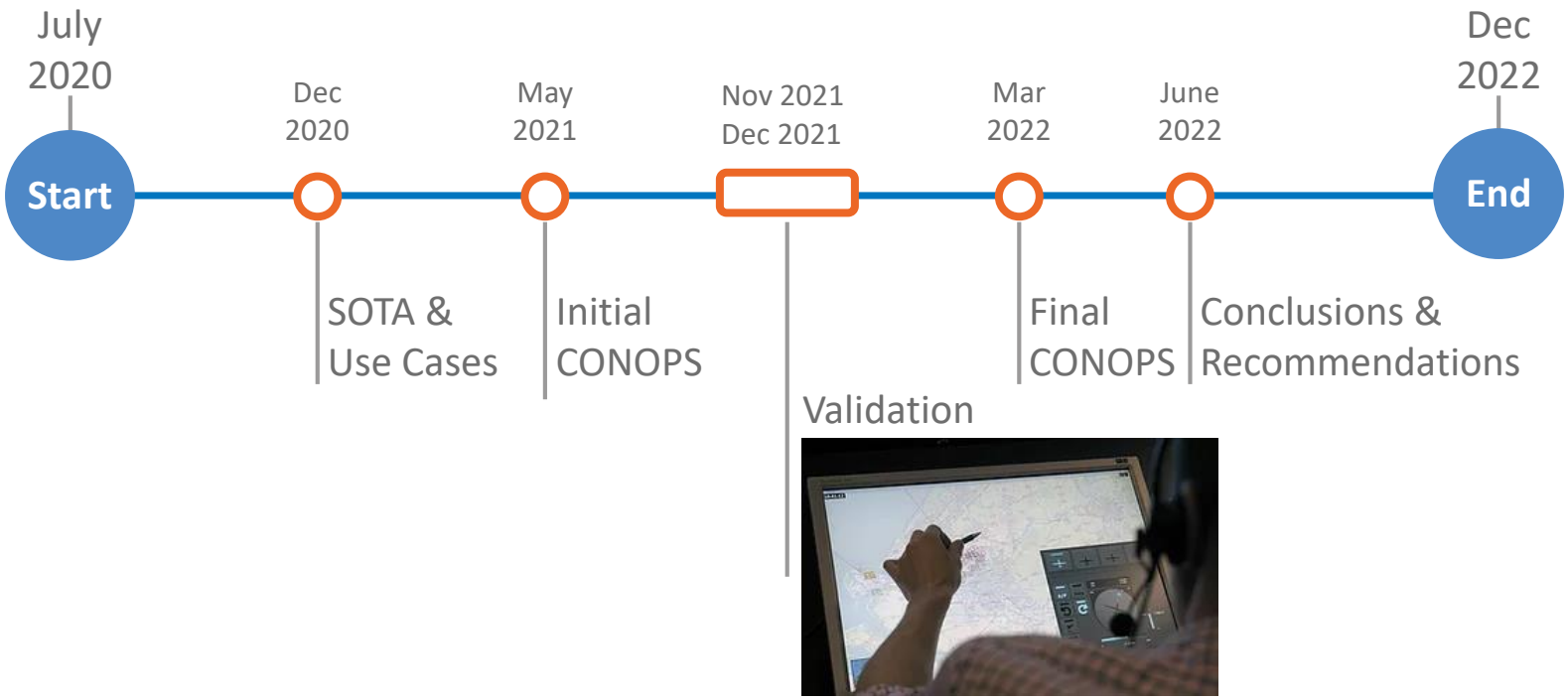
Duration: 30 months, July 2020 – December 2022

Consortium: 7 partners from 5 EU member states

Deliverables: 20 (10 public)

Milestones: 6

Schedule


July 2020
Start
Dec 2020
SOTA & Use Cases
May 2021
Initial CONOPS
Nov 2021
Dec 2021
Validation
Mar 2022
Final CONOPS
June 2022
Conclusions & Recommendations
Dec 2022
End

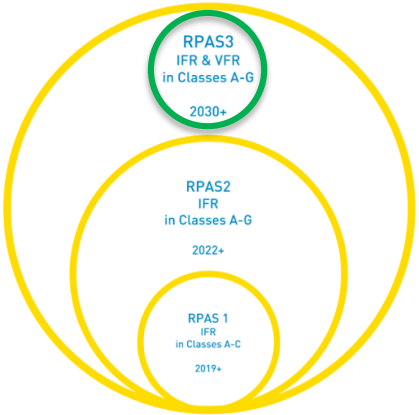
Project Scope

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

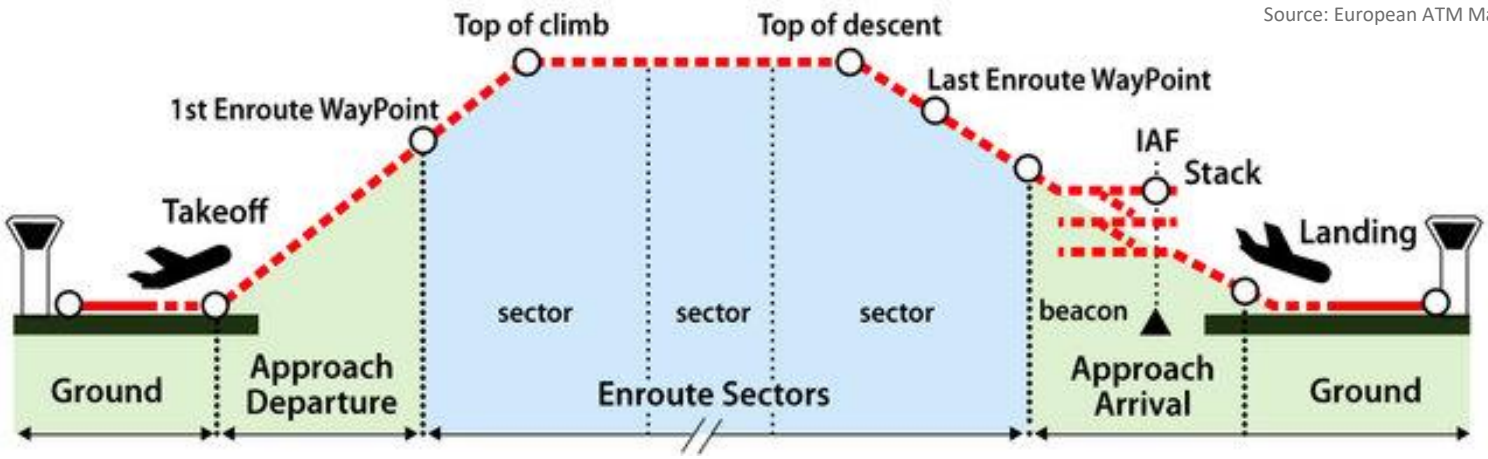
With special regards to

- 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: European ATM Masterplan



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

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

GA MQ-9A, Source: ga-asi.com

Boeing 737 cargo, Source: Airliners HD, Youtube

Source: EUROCONTROL, "RPAS ATM Concept of Operations Edition 4.0," 2017.

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

Dornier 228, Source : DLR

IAI Heron, Source: dronedj.com

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.

U-FLY RPS, Source: DLR

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)

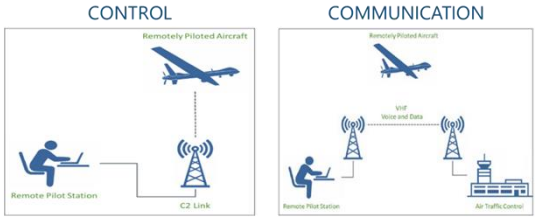
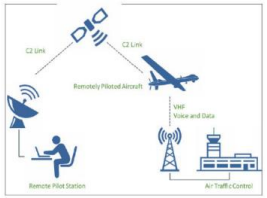
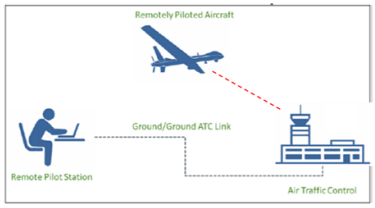
Aims to provide

- 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

	Pictogram	RPS location	Link	Technology	Estimated expected Latency*
RLOS		In RLOS of airport	Communication	Radio	290ms
			C2	Radio	1s
SATCOM		Remote	Communication	SATCOM	700ms
			C2	SATCOM	2s
Ground / RLOS via Gateway		Remote	Communication	Ground	150ms
			C2	Ground + Radio	1.5s

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

Source of graphics: ICAO Manual on RPAS, 2015

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

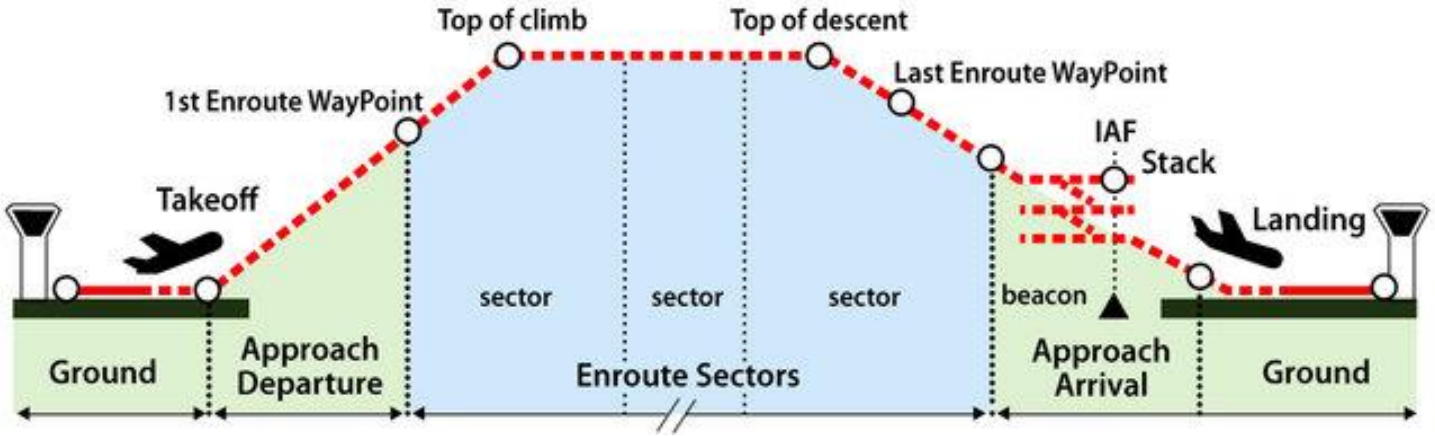
- Runway use and length requirements
- Fuel and maintenance requirements

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

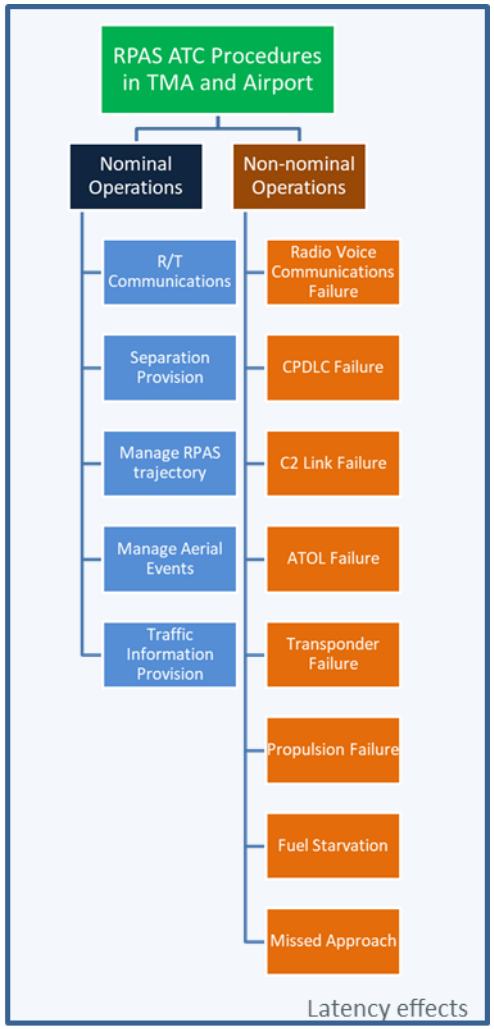
Operational Challenges

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)



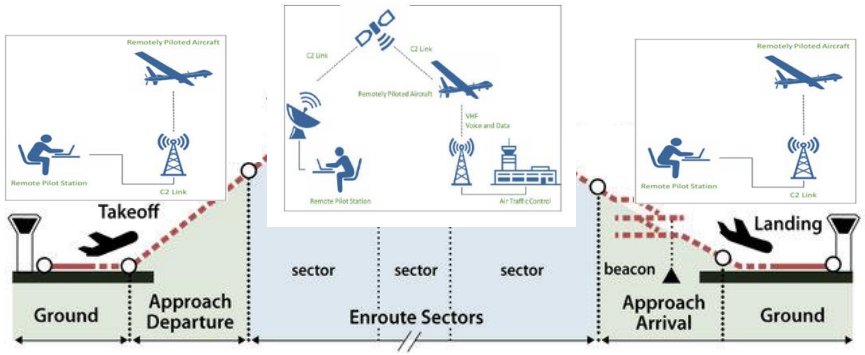
Handover RPS to RPS

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



Source of graphics: Letondal et. Al., Flights in my hands […], 2013; ICAO Manual on RPAS, 2015

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 RPILs and the ATCO
    - Nominal conditions

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INVIRCAT Project

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Investigate IFR RPAS Control in Airports and TMA
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