



Integrating RPAS into the arrival stream

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INVIRCAT – Integration of Remotely Piloted Aircraft Systems in the airport vicinity

- Remotely Piloted Aircraft Systems (RPAS) are a subset of the broader group of Unmanned Aircraft Systems (UAS)
- RPAS are unmanned aircraft which are piloted from a remote pilot station and:
 - **expected to be integrated into the air traffic management system equally as manned aircraft**
 - **real-time piloting control is provided by a licensed remote pilot**



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



Boeing 737 cargo, Source: Airlines HD, Youtube



Dornier 228, Source : DLR



IAI Heron, Source: dronedj.com

INVIRCAT – Integration of Remotely Pilot Aircraft Systems in the airport vicinity

- Why should RPAS be included in the arrival stream?
- Market for civil applications is growing
- Potential use cases
 - **Cargo transport**
 - **Crisis response, including involvement in search and rescue (SAR)**
 - **Communication and broadcast of information in remote areas**
 - **Monitoring of infrastructure**
 - **Atmospheric research**
- Dedicated airfields not always practicable

So what is the Difference?

How to get from
here



Source: General Atomics

to here?



Source: Royal Air Force/The Telegraph

Latency Aspects

- Different control station setups lead to different latency values
- With focus on airport vicinity, direct radio line of sight is most likely

	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

Source of graphics: ICAO Manual on RPAS, 2015

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

Integration Issues

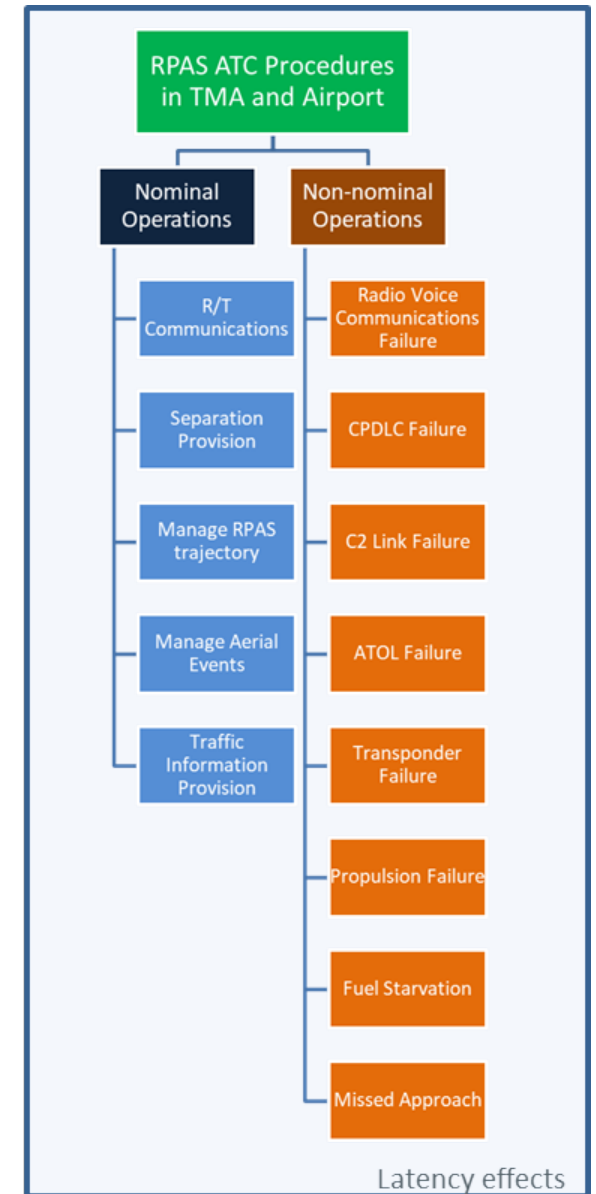
- Many different configurations for RPAS possible
- Different performances lead to different approach speeds
- Different designs lead to different susceptibility to wake turbulence
- Communication and control latency is one of the major aspects to be considered

Parameter	General Atomics MQ9A	IAI Heron	IAI Eitan (Heron TP)	Thales Watchkeeper WK450	BAE Systems Mantis	Euro MALE	Boeing 737-800 (optionally piloted)
Cruise Speed	169 kts	-	-	70 kts	200 kts	270 kts	455 kts
Max. Speed	260 kts	112 kts	220 kts	95 kts	300 kts	-	546 kts
Range	1,900 km	-	4,700 km	300 km	-	-	5436 km
Endurance	14 hours	52 hours	30+ hours	20 hours	30 hours	-	-
MTOW	4,763 kg	1,150 kg	5,400 kg	450 kg	9,000 kg	11,000 kg	79,016 kg
Ceiling	FL500	FL330	FL460	FL180	-	FL450	FL410
Powerplant	1 × Honeywell TPE331-10 turboprop, 900 hp	1 × Rotax 914 piston engine, 115 hp	1 × Pratt & Whitney Canada PT6-67A 1,200 hp	-	2 × Rolls-Royce M250B-17 turboprop, 380 hp each	2 x turboprop (unknown type)	2 x CFM56-7B24/26/27

Source: Wikipedia

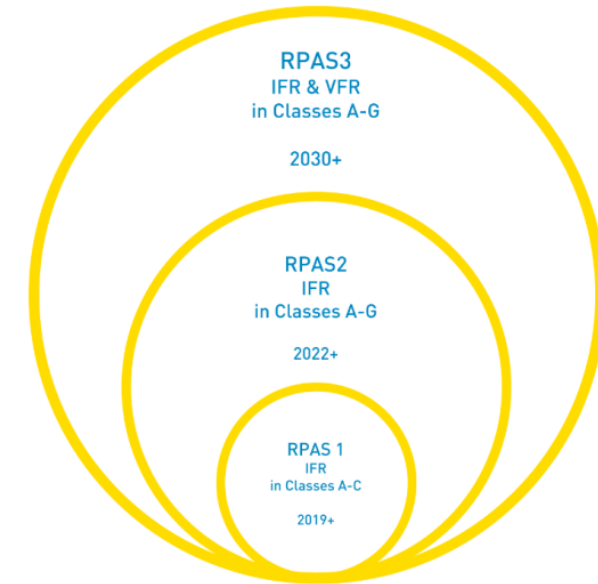
Operational Challenges

- **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 direct control during take-off and landing (to avoid pilot induced oscillation caused by signal latency)**
 - Reduced airspace capacity due to increased separation requirements (RPA performance figures, wake turbulence, etc.)
- **Non-Nominal Operations:**
 - Risk of RPAS specific contingencies (i.e. Communication and C2 link failure)

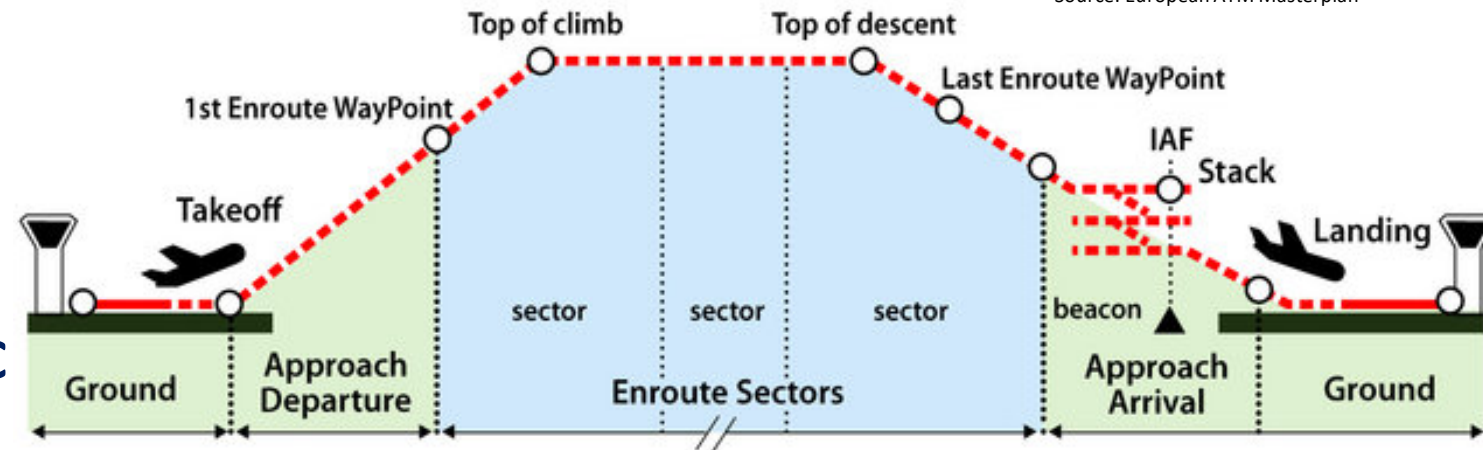


INVIRCAT – Scope

- INVIRCAT develops a CONOPS to integrate RPAS into the existing ATM environment and infrastructures within the TMA and airports under IFR
- With special focus on
 - 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

INVIRCAT – Assumptions

- **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**



INVIRCAT – Assumptions



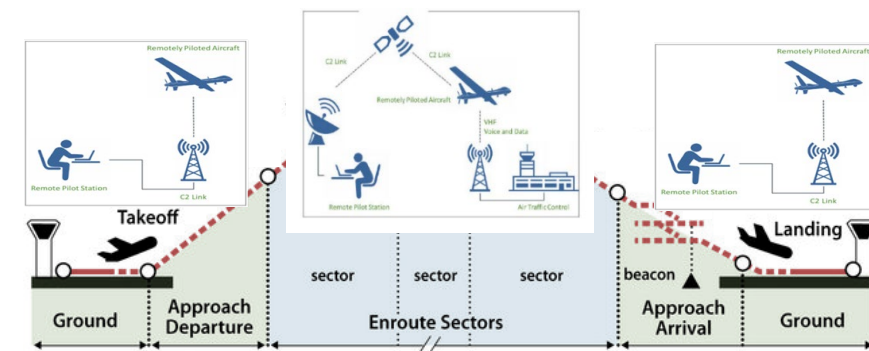
- In addition we assume the RPA to have
 - a fixed-wing structure (i.e. fly SIDs and STARs)
 - an airworthiness certificate and a type certificate
 - a certified Command and Control (C2) link
- and to be
 - equipped with a system that allows IFR landings without visual aid
 - equipped with an Automatic Take-Off and Landing System (ATOL)
 - able to conduct taxi operations on their own power

INVIRCAT – 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 Standard Instrument Departures (SID)
 - Arrival using Standard Arrival Routes (STAR), and holding
 - Approach and landing

Preliminary Findings

- RPAS Remote Pilot Station (RPS) handover
 - In order to always operate in radio line of sight in the airport vicinity, a handover from one RPS to another, located at or close to the airport, is likely to take place
- System requirements
 - Receiving RPS must be active and available
 - C2 link must be compatible and ATC communication must be ensured
 - Reliable voice communication link between the transferring and receiving remote pilot
- Operational considerations
 - Coordination between the respective remote pilots
 - 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

Preliminary Findings

- Definition of approx. 100 preliminary operational requirements derived from our initial concept of operations

- Examples include ATC

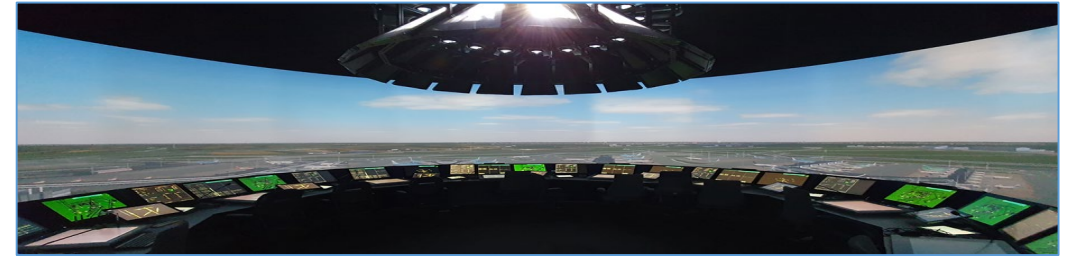
REQ-INVIRCAT-D2.5-0009	The RPIL shall be aware of and declare contingencies to the responsible ATCO when there is a contingency situation.
REQ-INVIRCAT-D2.5-0010	The RPIL shall command the RPA in contingency situations as agreed with the relevant authorities.
REQ-INVIRCAT-D2.5-0011	ATCOs shall be aware of which aircraft is remotely piloted.

- And the handover procedure

REQ-INVIRCAT-D2.5-0027	The RPIL in command shall inform the ATCO before the handover procedure is accomplished
REQ-INVIRCAT-D2.5-0028	The RPIL 1 shall brief information to RPIL 2 before handing over the RPA.
REQ-INVIRCAT-D2.5-0029	The RPIL 2 shall confirm the agreement with the briefing information to RPIL 1 before the handover is performed.

Real Time Simulations – Validation Focus

- Impact of latency on ATCO and remote pilot in different flight phases in the TMA
 - **Nominal conditions**
 - **Communication link failure**
 - **Transponder failure**
 - **Traffic conflict / traffic avoidance maneuver**
- Implications of ATOL system on take-off and landing operations
 - **Nominal conditions**
 - **ATOL occurrences**
 - **Conflict during runway operations or approach**
 - **C2 link failure**
- Implications of multiple RPAS at the same time in the approach phase
 - **Nominal conditions**
 - **C2 link failure**
 - **Coordination of handover between two remote pilots and the ATCO**
 - **Nominal conditions**



Further Reading

- <https://www.invircat.eu/> (all public deliverables available)
- <https://www.sesarju.eu/projects/invircat>
- <https://cordis.europa.eu/project/id/893375>
- <https://www.linkedin.com/company/invircat-project/>
- <https://twitter.com/InvircatProject>
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Investigate IFR RPAS Control
in Airports and TMA

INVIRCAT

INVIRCAT Project – Thank you for your attention



This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 893375

