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INVIRCAT

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Abstract

This document represents deliverable D2.5 of the INVIRCAT project and it is titled INVIRCAT Preliminary requirements definition. This deliverable includes the requirements applicable to the INVIRCAT reference architecture for the integration of Remotely Piloted Aircraft Systems (RPAS) into Terminal Manoeuvring Area (TMA) and airports under Instrumental Flight Rules (IFR). This deliverable will be updated in INVIRCAT WP4 with the final requirements once the results of simulations are available.

The requirements derived in this document are of two types: operational, which are those that specify the operation and procedures of RPAS in every flight phase in the TMA and airport environments, and functional, which are those that specify what the systems (RPAS, remote pilot, Air Traffic Controllers, etc.) have to do to conduct the operation and meet the procedures defined. The operation is addressed in the INVIRCAT Concept of Operations and Use Cases have been defined to validate the concept. Deriving requirements is important in INVIRCAT, because they will serve to define the reference architecture to be validated according to the concept and use cases defined.



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1 Executive summary

This document represents deliverable D2.5 of the INVIRCAT project and is titled "Preliminary requirements definition".¹ The deliverable lists the preliminary operational and functional requirements derived for the integration of Remotely Piloted Aircraft Systems (RPAS) into the existing Air Traffic Control (ATC) procedures and infrastructures within Terminal Manoeuvring Areas (TMA) and at airports under Instrument Flight Rules (IFR).

The document is based on D2.2 Use Cases Definition and Concept Outline [1] and D2.3 Initial CONOPS "RPAS in the TMA" [2], which in turn relies on the needs and assessment of the CONOPS of the project's Advisory Board.

The preliminary requirements are structured in three main chapters. The first main chapter contains the baseline requirements, i.e., those requirements stating what the RPAS, the remote pilot (RPIL) or the corresponding ATCO have to comply with as Standard Operating Procedure. The operational requirements considered as the specific operational aspects that are required for the integration of RPAS within the TMA and airports, in nominal and contingency situations as defined in INVIRCAT, are included in the second main chapter. Finally, the third main chapter derives the functional requirements, or in other words, it describes what functions are required to enable the integration.

All these requirements are traced with the validation objectives to allow the analysis of their fulfilment with the results of the simulations.

Thus, the goal of this document is to set the basis for stating what is initially required to comply with the objective of the INVIRCAT CONOPS and, after the simulations are completed and the results assessed, to update these requirements in order to have a final and complete set of valid requirements for the integration of IFR RPAS into the existing ATC procedures and infrastructures within TMA and at airports.

¹ The opinions expressed herein reflect the author's view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

2 Introduction

2.1 Purpose and structure of the document

This document derives the operational and functional requirements that will serve to define the reference architecture to be implemented in the validation infrastructure.

The requirements are structured to address the specific challenges in nominal conditions and contingencies as presented in INVIRCAT D2.2 Use Case Definition and Concept Outline [1], so that the validation objectives can be easily traceable to the operational and functional requirements and assessed, after the simulations performed in WP3, changing their status from defined to validated, modified or, even, deleted and the reason why.

The document structure is as follows:

Chapters 0 and 1 introduce the deliverable and the expected results in the form of an executive summary and an introduction.

Chapter 0 provides the purpose of the derivation of operational and functional requirements in INVIRCAT and a template for writing requirements in a harmonised manner throughout the document, as well as a summary of the validation objectives due to the relationship established between requirements and validation. It also includes a summary of the derived requirements.

Chapter 4 presents the baseline requirements that state what the RPAS, the RPIL or the corresponding ATCO have to comply with as Standard Operating Procedure regardless of whether the aircraft is manned or unmanned.

Chapter 5 includes the operational requirements for nominal and contingency situations.

Chapter 6 is similar to chapter 5 but, in this case, the requirements included are those related to the functional characteristics.

Chapter 7 summarises the results of the document in terms of conclusions and explains the next steps.

Finally, Appendices A, B and C list the references, acronyms and terms used for the elaboration of this document.

2.2 Scope of preliminary requirements

Preliminary requirements are derived to establish the reference architecture used for simulations in INVIRCAT.

This document covers two types of requirements: operational and functional. Operational requirements establish how the system operates, i.e., the operational activities that have to be executed by all actors (RPAS, remote pilot, ATC, etc.) to successfully conduct the nominal and contingency situations. Functional requirements represent what the system has to do to (i.e., be capable of communicating, monitoring, etc.) to conduct the nominal and contingency situations as well.



It has to be noted that non-functional requirements, i.e., those that explain how well the system has to perform (e.g., latency, safety, performance, etc.) are not part of this document as they will be derived from the simulation results as part of WP3 and will be included in D4.2 Final Operational and Technical Requirements. These non-functional requirements will be qualitative, and in certain cases quantitative when the information is available, so that the effects of the requirements on the INVIRCAT architecture can be evaluated.

2.3 Relationship with other documents

This document is based on all the previous INVIRCAT WP2 deliverables such as D2.1 Current State-of-the-Art and regulatory basis [3], D2.2 Use Cases Definition and Concept Outline [1] as well as D2.3 Initial CONOPS “RPAS in the TMA” [2]. Furthermore, it is related to D3.1 Validation Plan [4], as it will serve to check whether the requirements are validated in relation to validation objectives as well as to D3.3 Use Cases Simulation Plan [5] because these use cases will be the ones that will provide the validation of the reference architecture.

Moreover, D3.4, the Exploratory Research Validation Report, will be used to analyse the exploratory research results, which will feed the results of D4.2, the Final Operational and Technical Requirements Definition, where the requirements included in this document will be updated and conclusively defined on the basis of the validation result.

3 Requirements in INVIRCAT

3.1 Purpose

The main purpose of deriving requirements in INVIRCAT is to set the basis for the project's reference architecture to be used in the simulations.

INVIRCAT focuses on the integration of RPAS in airports and TMA. This objective conveys explicitly the addition of a new participant in airport and TMA operations: the RPAS.

RPAS are not only the system itself (Remotely Piloted Aircraft RPA, Remote Pilot Station RPS, C2 link and other related equipment such as Automatic Take-off and Landing (ATOL) systems), but also the RPIL as a new role. The fact that RPAS have to fly following instrumental flight rules implies that they, as well as the RPIL, have to comply with the same set of standard rules and practices as manned IFR aircraft. In this sense, ATCOs will have to manage RPAS operations in the same manner as they do with IFR aircraft.

However, RPAS have some specificities that derive from the fact that the pilot is not on board and that have to be considered explicitly. These specificities also impact specific activities or actions that ATCOs have to execute. ATCO actions, in nominal operations and with regard to the type of RPAS considered in this project, generally do not differ from those that are currently being executed for manned aircraft. However, in RPAS contingency situations, RPAS will behave differently and both ATCOs and RPILs have to maintain close communication about the new actions and situations expected.

This rationale is why, in the context of D2.5, requirements are explicitly derived for both nominal and contingency situations in different phases of the flight inside the TMA and at airports.

The derivation of operational and functional requirements is based on the initial concept of operations as well as on the use cases defined for the nominal and non-nominal operations. This approach resembles the one used in [6] as the concept of operations and use cases can be identified as states (e.g. nominal, non-nominal), activities (e.g. communicate, command), blocks (e.g. data link architecture, ATOL system), and messages exchanges (e.g. the remote pilot informs ATCO about a situation). Therefore, the set of requirements derived can be considered complete for the purpose of establishing the reference architecture.

3.2 Requirements writing

Requirements are the foundation of any engineering effort and are statements that identify a product or process in terms of operations, functions or design characteristics.

Requirements have to be written in a way that serves their purpose. For this reason, some guidelines on how to write good and appropriate requirements are stated below [7] [8]:

- Needed: Requirements represent demands or constraints on a system which have an impact on performance or cost. It is important to ensure that every requirement is needed and avoid the mistake of requesting things that are not needed.



- Atomic: It implies that only one property or functionality has to be stated per requirement. This is because of the fact that considering more than one property or functionality would/could cause causes complexity issues in the verification or validation of the system.
- Unique: Each property or functionality has to be stated only once in a single requirement. If repetition occurs, a change in wording could lead to a different meaning and a conflict between requirements could be the result.
- Positive: Requirements have to express what is needed and not what is not needed.
- Objective: Requirements do not have to be open for interpretation.
- Understandable: Requirements are not for the people who write them but for the ones who will use them.
- Concise: Requirements have to state what is needed, avoiding superfluous details and unnecessary information.
- Traceable: It is necessary to know who is the author of each requirement in case clarifications are needed.
- Prioritizable: Not all requirements have the same relevance or importance. In case conflicts between requirements appear, it is necessary to prioritize them.
- Feasible: They have to be achievable. If they are not, it is not worth the effort to write them.
- Modifiable: This is important in INVIRCAT as requirements will be used for the design of the reference architecture used for simulations. If the result of simulations implies that a requirement needs to be modified, the requirement has to allow it.

3.3 Requirements template

This is the template that will be used to define all requirements.

Table 1: Requirements template

Identifier	REQ-INVIRCAT-D2.5-XXXX
Requirement	<i>Requirement statement</i>
Status	<Defined><Validated><Modified><Deleted>
Rationale	<i>Why requirement is stated</i>
Category	<Operational><Functional>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	<i>Identifier of the validation objective that covers it in D3.1</i>

Identifier	REQ-INVIRCAT-D2.5-XXXX
Additional Comment	<i>For example: This requirement also applies to flight phase X nominal/contingency</i>

3.4 Requirements and Validation Objectives for INVIRCAT

The INVIRCAT Validation Plan document (D3.1) [4] is a high-level plan for the different validation activities described in the INVIRCAT Use Cases Simulation Plan (D3.3) [5]. It specifies a set of common validation objectives addressed by the INVIRCAT project. Requirements have to be traced with validation objectives to identify whether the requirements can be validated, modified or deleted.

Not all requirements are specific for RPAS or strictly RPAS related. Some of them have been collected because the introduction of RPAS in the TMA impact the way ATC units and manned aviation interact with each other.

The following table summarises the validation objectives that are applicable to operational and functional requirements to provide the reader with a quick reference and to help the reader understand what validation objectives are assigned to each requirement.

Table 2: Summarised list of validation objectives

Identifier	Assessment Objective
OBJ-INV-001	Acceptability of IFR RPAS Integration in TMA/Airport under Nominal Conditions.
OBJ-INV-002	Acceptability of IFR RPAS Integration in TMA/Airport in Contingency Situations.
OBJ-INV-003	Acceptable Safety Levels under Nominal Conditions.
OBJ-INV-004	Acceptable Safety Levels in Contingency Situations.
OBJ-INV-005	Acceptable ATOL Procedures under Nominal Conditions.
OBJ-INV-006	Acceptable ATOL Procedures in Contingency Situations.
OBJ-INV-007	Acceptable Latency in C2-Link and R/T Voice Communication.
OBJ-INV-008	Acceptable Safety Levels during RPA Handover.
OBJ-INV-009	Adequate Phraseology under Nominal Conditions.
OBJ-INV-010	Adequate Phraseology in Contingency Situations.
OBJ-INV-011	Adequate Information Provision for RPIL and ATCO under Nominal Conditions.
OBJ-INV-012	Adequate Information Provision for RPIL and ATCO in Contingency Situations.
OBJ-INV-013	Adequate Requested Human Contribution under Nominal Conditions.
OBJ-INV-014	Adequate Requested Human Contribution in Contingency Situations.
OBJ-INV-015	Acceptable Workload Levels for ATCO under Nominal Conditions.
OBJ-INV-016	Acceptable Workload Levels for ATCO in Contingency Situations.

3.5 Summary of requirements

This section presents a summary of all the requirements contained in this deliverable to allow the reader to have an overview of the INVIRCAT preliminary operational and functional requirements. This summary includes the requirement ID and title and it is linked to the detailed requirements table below so that the reader can navigate directly through the requirements.

Table 3: Summary of requirements

Requirement ID	Requirement Description
REQ-INVIRCAT-D2.5-0001	RPILs shall fly the RPAS following SOP as an on-board pilot would do at any moment and phase of the flight.
REQ-INVIRCAT-D2.5-0002	RPILs shall navigate the RPAS following SOP as an on-board pilot would do at any moment of the flight.
REQ-INVIRCAT-D2.5-0003	RPILs shall carry out SOP communications with ATCOs at any moment of the flight.
REQ-INVIRCAT-D2.5-0004	ATCOs shall carry out SOP communications with RPILs at any moment of the flight.
REQ-INVIRCAT-D2.5-0005	ATCOs shall manage RPAS as any on-board piloted aircraft with the same level of air traffic services at any moment of the flight.
REQ-INVIRCAT-D2.5-0006	Specific RPAS contingency procedures shall be published in the same way as they are published for manned aircraft.
REQ-INVIRCAT-D2.5-0007	The RPIL shall verify that all RPAS systems are fully functional during all phases of flight.
REQ-INVIRCAT-D2.5-0008	The RPIL shall verify that flight parameters are set correctly during all phases of flight.
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.
REQ-INVIRCAT-D2.5-0012	The RPIL shall resume the flight after a contingency is resolved and continue the flight in accordance with the approved flight plan and ATC clearance.
REQ-INVIRCAT-D2.5-0013	The RPIL shall command the RPA according to clearances issued by the ATCO.
REQ-INVIRCAT-D2.5-0014	The RPIL shall adhere to segmented standard taxiways, when available.
REQ-INVIRCAT-D2.5-0015	Upon ATC holding instructions, RPAS shall stop taxiing.
REQ-INVIRCAT-D2.5-0016	The RPIL shall park the RPA at the apron position instructed by ATCO.

Requirement ID	Requirement Description
REQ-INVIRCAT-D2.5-0017	The RPIL shall engage the ATOL system upon ATC clearance for take-off.
REQ-INVIRCAT-D2.5-0018	The RPIL shall supervise the take-off procedure while the ATOL system is activated.
REQ-INVIRCAT-D2.5-0019	The RPIL shall disengage the ATOL when the take-off phase has finished.
REQ-INVIRCAT-D2.5-0020	The RPIL shall follow the published and cleared SID procedure, in accordance with ATCO instructions.
REQ-INVIRCAT-D2.5-0021REQ-INVIRCAT-D2.5-0020	The RPIL shall follow the published and cleared STAR procedure.
REQ-INVIRCAT-D2.5-0022	The RPIL shall follow the cleared and instructed holding pattern.
REQ-INVIRCAT-D2.5-0023	The RPIL shall engage the ATOL system when established on the ILS.
REQ-INVIRCAT-D2.5-0024	The RPIL shall follow the instructed approach in order to land.
REQ-INVIRCAT-D2.5-0025	The APP Exe. ATCO shall integrate the RPA into the landing sequence.
REQ-INVIRCAT-D2.5-0026	The RPIL shall follow the cleared and instructed landing procedure.
REQ-INVIRCAT-D2.5-0027	The RPIL shall disengage the ATOL system when the RPA is ready to exit the runway.
REQ-INVIRCAT-D2.5-0028	The RPIL in command shall inform the ATCO before the handover procedure is accomplished
REQ-INVIRCAT-D2.5-0029	The RPIL 1 shall brief information to RPIL 2 before handing over the RPA.
REQ-INVIRCAT-D2.5-0030REQ-INVIRCAT-D2.5-00	The RPIL 2 shall confirm the agreement with the briefing information to RPIL 1 before the handover is performed.
REQ-INVIRCAT-D2.5-0031	The RPIL 1 shall handover the RPA C2 to RPIL 2.
REQ-INVIRCAT-D2.5-0032	The RPIL 1 shall keep active command over the RPA until the handover procedure has been accomplished.
REQ-INVIRCAT-D2.5-0033	The RPIL 2 shall keep active command over the RPA after the handover procedure has been accomplished.
REQ-INVIRCAT-D2.5-0034	The RPIL in command shall adhere to new clearances from the ATCO after the handover procedure.
REQ-INVIRCAT-D2.5-0035	The RPIL shall actively give the RTO command to the RPA after a single engine RPA failure or a multi-engine RPA partial/total failure that occurs before VR.
REQ-INVIRCAT-D2.5-0036	The RPIL shall communicate to the TWR ATCO that the RPA is stopped after a single engine RPA failure or a multi-engine RPA partial failure leading to an RTO.

Requirement ID	Requirement Description
REQ-INVIRCAT-D2.5-0037	The RPIL shall inform the TWR ATCO about the intended contingency procedure when a single engine RPA failure or a multi-engine RPA partial/total failure occurs after VR.
REQ-INVIRCAT-D2.5-0038	The RPIL shall inform the TWR ATCO about diversion options after a multi-engine RPA partial failure before VR with actual take-off.
REQ-INVIRCAT-D2.5-0039	The TWR ATCO shall coordinate actions with the APP Exe. ATCO after a multi-engine RPA partial failure before VR with actual take-off.
REQ-INVIRCAT-D2.5-0040	The RPIL shall inform the APP Exe. ATCO about the planned procedure when there is a single engine RPA failure or a multi-engine RPA partial/total failure.
REQ-INVIRCAT-D2.5-0041	In case of actual take-off after a partial failure of a multi-engine RPA occurs, the RPIL shall initiate a diversion procedure to another airport
REQ-INVIRCAT-D2.5-0042	In case of actual take-off after a partial failure of a multi-engine RPA occurs, the RPIL shall coordinate such diversion procedure with the APP Exe. ATCO.
REQ-INVIRCAT-D2.5-0043	When there is an engine failure and the RPIL communicates so the APP Exe. ATCO shall assist the RPIL
REQ-INVIRCAT-D2.5-0044	The RPIL shall continue the take-off procedure manually when an ATOL failure occurred after V1.
REQ-INVIRCAT-D2.5-0045	The RPIL shall report to the TWR ATCO the detected ATOL failure during take-off after V1.
REQ-INVIRCAT-D2.5-0046	The RPIL shall request instructions/clearance from the TWR ATCO in order to perform an RTB manoeuvre when an ATOL failure during take-off after V1 has occurred.
REQ-INVIRCAT-D2.5-0047	When an ATOL failure occurs after V1, TWR ATCO shall give instructions/clearance to the RPIL in order to perform an RTB operation.
REQ-INVIRCAT-D2.5-0048 Table 51: REQ-INVIRCAT-D2.5-004	When an ATOL failure occurs during approach (above Alert Height (AH)) either the RPIL shall recognize the need to execute the MA/GA procedure or the ATOL system itself shall detect the ATOL occurrence and shall recognize the need to execute the MA/GA procedure.
REQ-INVIRCAT-D2.5-0049	After a C2 link failure, the RPIL shall communicate to the APP Exe. ATCO that the RPA will fly automatically to the nearest or cleared waypoint.
REQ-INVIRCAT-D2.5-0050	After a C2 link failure the App pln. ATCO shall coordinate the activation of termination areas with the TWR ATCO.

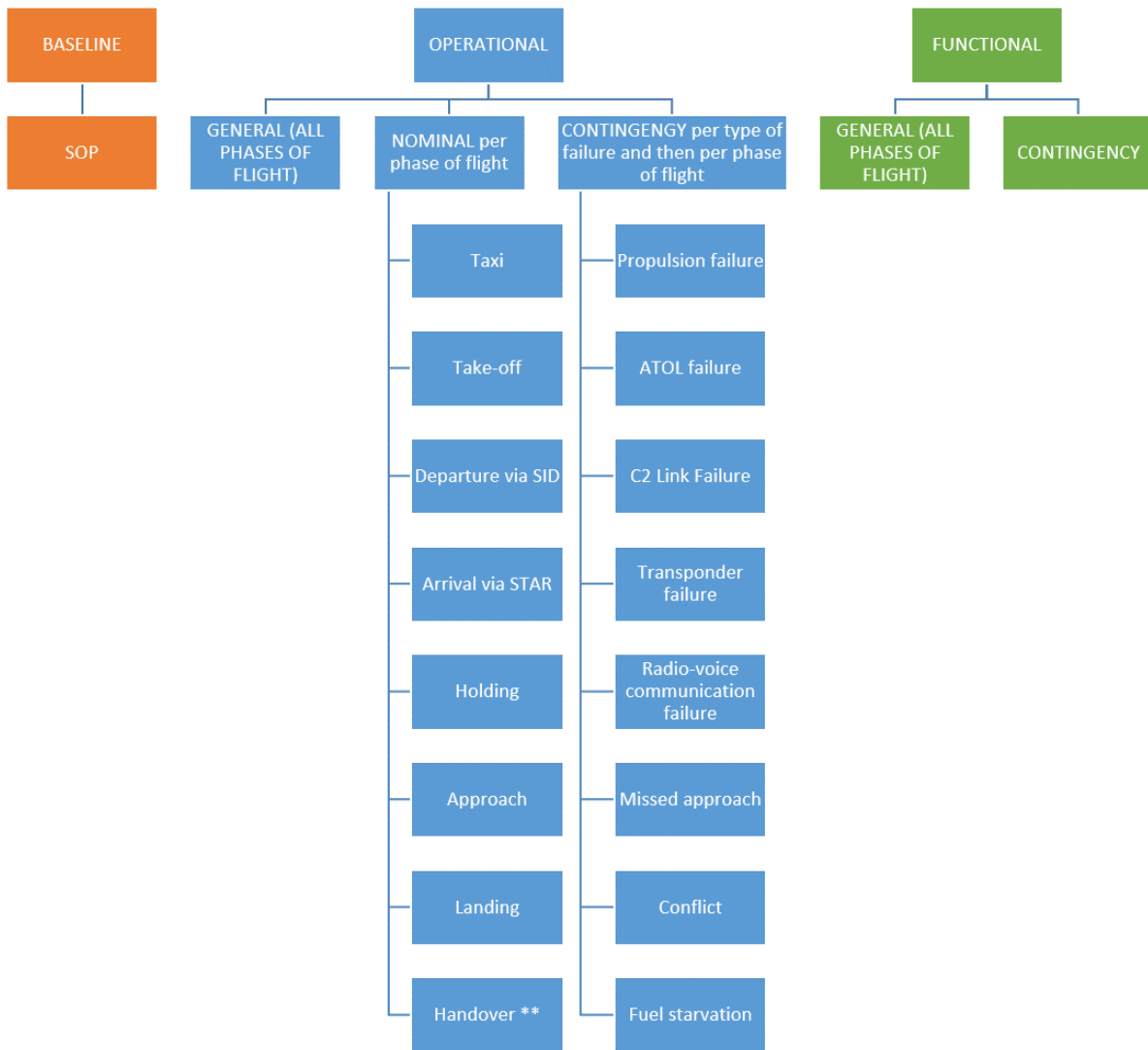
Requirement ID	Requirement Description
REQ-INVIRCAT-D2.5-0051	The RPIL shall have planned, in the flight plan, the contingency loiter waypoints, the termination flight procedure and the termination points for C2 link loss events.
REQ-INVIRCAT-D2.5-0052	In case of C2 link loss event, the RPIL shall communicate the C2 link reestablishment to the APP Exe. ATCO and APP pln. ATCO.
REQ-INVIRCAT-D2.5-0053	As soon as the APP Exe. ATCO notices a transponder failure, he/she shall contact the RPIL via voice communications.
REQ-INVIRCAT-D2.5-0054	When a transponder failure occurs and after being informed by the APP Exe. ATCO, the RPIL shall help the APP Exe. ATCO to identify the RPAS.
REQ-INVIRCAT-D2.5-0055	When a transponder failure occurs the APP Exe. ATCO shall provide guidance to the RPIL.
REQ-INVIRCAT-D2.5-0056	When a transponder failure occurs and after being informed by the APP Exe. ATCO the RPIL shall perform a transponder recycle.
REQ-INVIRCAT-D2.5-0057	When a radio voice communication failure occurs, the RPIL shall change the squawk code to 7600.
REQ-INVIRCAT-D2.5-0058	In the event of a R/T failure the RPIL shall re-start the VHF radios.
REQ-INVIRCAT-D2.5-0059	In the event of a R/T failure and after re-starting the VHF radio system the RPIL shall test if the procedure has been successful by contacting the APP Exe. ATCO via R/T.
REQ-INVIRCAT-D2.5-0060	When a R/T failure occurs and after making sure that communications are working normally, the RPIL shall change the squawk code from 7600 to the original value.
REQ-INVIRCAT-D2.5-0061	When a R/T failure occurs and if the event that VHF radios cannot be re-started using alternate means of communication (such as landline telephone), the RPIL shall request vectors for landing.
REQ-INVIRCAT-D2.5-0062	During the approach or landing phase, the RPIL should perform a missed approach procedure when he/she detects that there is a runway incursion.
REQ-INVIRCAT-D2.5-0063	The TWR ATCO shall instruct the RPIL to perform a missed approach when he detects that the runway is not free of other aircraft, vehicles, obstacles, and in general fixed or moving objects.
REQ-INVIRCAT-D2.5-0064	The TWR ATCO shall notify the RPIL to perform a missed approach procedure when he/she detects that the RPA is unstable on final.
REQ-INVIRCAT-D2.5-0065	In the event of a missed approach procedure, the RPIL shall have the capability to disengage the ATOL system and manually control the RPA upon an ATC instruction to do so.
REQ-INVIRCAT-D2.5-0066	In case of a conflict that generates a missed approach, the RPIL shall inform the TWR ATCO that the RPA is above the decision height.

Requirement ID	Requirement Description
REQ-INVIRCAT-D2.5-0067	In case of a conflict that generates a missed approach the TWR ATCO should provide information about the missed approach procedure to the RPIL concerned.
REQ-INVIRCAT-D2.5-0068	The RPIL shall follow the TWR ATCO instructions for the missed approach procedure manually.
REQ-INVIRCAT-D2.5-0069REQ-INVIRCAT-D2.5-006	The RPIL shall actively command the ATOL system to follow the TWR ATCO instructions for the tailored missed approach or published procedure when the procedure is capable of being performed by the ATOL system.
REQ-INVIRCAT-D2.5-0070	The APP Exe. ATCO shall provide the RPIL with instructions to loiter at an RPAS specific loiter point before a second attempt to land.
REQ-INVIRCAT-D2.5-0071	When the RPIL has been instructed to loiter by the APP Exe. ATCO before a second attempt to land, the RPIL shall inform the APP Exe. ATCO about the remaining time for loitering.
REQ-INVIRCAT-D2.5-0072	When the APP Exe. ATCO instructs the RPIL to re-join the landing sequence (after loitering before a second attempt to land) the RPIL shall command the RPAS manually in order to follow APP Exe. ATCO instructions
REQ-INVIRCAT-D2.5-0073	TWR ATCO or APP Exe. ATCO (depending of the exact flight phase of the RPA) shall identify any potential conflicts between the RPA and other aircraft.
REQ-INVIRCAT-D2.5-0074	As soon as TWR ATCO or APP Exe. ATCO (depending of the exact flight phase of the RPA) identify potential conflicts between the RPA and other aircraft, they shall instruct the RPIL and manned aircraft pilots to carry out the avoidance manoeuvre immediately.
REQ-INVIRCAT-D2.5-0075	When there is a fuel starvation situation, the APP Exe. ATCO shall give priority to the RPA to land as soon as the pilot declares the emergency.
REQ-INVIRCAT-D2.5-0076	The RPIL shall be able to select the dedicated channel to contact the ATSU responsible for the area where the RPA is flying.
REQ-INVIRCAT-D2.5-0077	The RPS shall provide the capability for the RPIL to manually, or semi-automatically steer the RPA and to enable its automated operations.
REQ-INVIRCAT-D2.5-0078	The camera on board the RPA shall allow the RPIL to detect relevant information from the surrounding environment during ground operations and make use of segmented taxiways.
REQ-INVIRCAT-D2.5-0079	The RPS shall provide the relevant information to the RPIL in order to monitor the RPA's current flight parameters, position, and system status and to supervise all automated operations.
REQ-INVIRCAT-D2.5-0080	The ATOL system shall allow the RPA to execute automatically the take-off, initial climb, approach and landing.

Requirement ID	Requirement Description
REQ-INVIRCAT-D2.5-0081	The RPAS shall comply with the equipment and CNS requirements applicable to the airspace it is operating in.
REQ-INVIRCAT-D2.5-0082	The RPA shall be equipped with DAA equipment that is compatible with existing ACAS and able to follow the DAA system's advice autonomously at any moment of the flight.
REQ-INVIRCAT-D2.5-0083	The RPS shall provide the capability to the RPIL to use all navigation procedures common under instrument flight rules (e.g. waypoints, SIDs & STARs, and vectors) at any moment of the flight.
REQ-INVIRCAT-D2.5-0084	During the handover procedure, the RPS shall provide voice and data communication between the RPILs participating in the procedure
REQ-INVIRCAT-D2.5-0085	During the handover procedure, the RPA systems shall provide flight information to both RPILs participating, the one handing over and the one receiving the RPA.
REQ-INVIRCAT-D2.5-0086	During a handover procedure, the RPS shall indicate the RPIL who is in command to both RPILs involved.
REQ-INVIRCAT-D2.5-0087	The RPA shall allow a handover of control from one RPS to another only upon the active command of both RPILs.
REQ-INVIRCAT-D2.5-0088	The RPS shall allow the RPIL to activate a Rejected Take-Off (RTO) procedure when required and as appropriate.
REQ-INVIRCAT-D2.5-0089	The RPAS shall automatically activate an RTO procedure when required and as appropriate and inform the RPIL.
REQ-INVIRCAT-D2.5-0090	The RPS shall allow the RPIL to activate a missed approach procedure when required and as appropriate.
REQ-INVIRCAT-D2.5-0091	The RPAS shall provide a function to the RPIL to activate a pre-programmed contingency manoeuvre, that automatically steers the aircraft to a safe waypoint, where it will loiter.
REQ-INVIRCAT-D2.5-0092	The RPA shall inform the RPIL and provide an automatically triggered, pre-programmed contingency manoeuvre, that in case of a C2 link loss steers the aircraft to a safe waypoint, where it will loiter.
REQ-INVIRCAT-D2.5-0093	The RPA shall inform the RPIL and provide an automatically triggered, pre-programmed termination procedure, that steers the aircraft to a safe termination point in case there is a C2 link loss and the RPA is running out of fuel.
REQ-INVIRCAT-D2.5-0094	The RPS shall in case of a C2 link loss provide an estimated position of the RPA to the RPIL, based on previous trajectory, flight plan information and any other available data.
REQ-INVIRCAT-D2.5-0095	The RPS shall provide a backup voice communication line to ATC for the case of a defective voice and data communication link.

See below a requirement classification used in this document at a glance.

Figure 1. Requirements classification



4 Baseline requirements

Baseline requirements are those that state what the RPAS, the RPIL or the corresponding ATCO have to comply with as a Standard Operating Procedure (SOP) as described in the Standardised Rules of the Air (SERA) regardless of whether the aircraft is manned or unmanned or if they fall under the operational or functional category. However, as the RPAS are a new actor in the airport and TMA, it is necessary to explicitly state the requirements to ensure that they are properly considered.

A few of them apply to Nominal or Contingency procedures only while the vast majority apply to both.

4.1 Normal Operations Baseline

Table 4: REQ-INVIRCAT-D2.5-0001

Identifier	REQ-INVIRCAT-D2.5-0001
Requirement	RPILs shall fly the RPAS following SOP as an on-board pilot would do at any moment and phase of the flight.
Status	<Defined>
Rationale	Standard operating procedures are applicable to RPILs when flying the RPAS.
Category	<Operational>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	This requirement is applicable also to contingency situations.

Table 5: REQ-INVIRCAT-D2.5-0002

Identifier	REQ-INVIRCAT-D2.5-0002
Requirement	RPILs shall navigate the RPAS following SOP as an on-board pilot would do at any moment of the flight.
Status	<Defined>
Rationale	Standard operating procedures are applicable to RPILs when navigating the RPAS.
Category	<Operational>



Identifier	REQ-INVIRCAT-D2.5-0002
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	This requirement is applicable also to contingency situations.

Table 6: REQ-INVIRCAT-D2.5-0003

Identifier	REQ-INVIRCAT-D2.5-0003
Requirement	RPILs shall carry out SOP communications with ATCOs at any moment of the flight.
Status	<Defined>
Rationale	Standard operating procedures are applicable to RPILs when communicating with ATCOs. This includes the request for instructions, read-back of any clearance of instruction provided by ATCOs, proper use of the dedicated communication channel and the knowledge of aeronautical phraseology.
Category	<Operational>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	This requirement is applicable also to contingency situations.

Table 7: REQ-INVIRCAT-D2.5-0004

Identifier	REQ-INVIRCAT-D2.5-0004
Requirement	ATCOs shall carry out SOP communications with RPILs at any moment of the flight.
Status	<Defined>

Identifier	REQ-INVIRCAT-D2.5-0004
Rationale	Standard operating procedures are applicable to ATCOs when communicating with RPILs. This includes the request for information, issue of instructions and clearances and acknowledgement of any RPIL communication.
Category	<Operational>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	This requirement is applicable also to contingency situations with regards to the acknowledgement of RPIL communications in such contingency situations, to let the RPIL know that the ATCO is aware of it.

Table 8: REQ-INVIRCAT-D2.5-0005

Identifier	REQ-INVIRCAT-D2.5-0005
Requirement	ATCOs shall manage RPAS as any on-board piloted aircraft with the same level of air traffic services at any moment of the flight.
Status	<Defined>
Rationale	Standard operating procedures are applicable to the management of RPAS by ATCOs as to any other aircraft. This includes providing separation from other aircraft when necessary as well as transferring the RPA control to other ATCOs depending on the flight phase.
Category	<Operational>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	This requirement is applicable also to contingency situations with regards to the separation in specific RPAS contingency situations as well as the transferring the RPA control to other ATCOs.

Table 9: REQ-INVIRCAT-D2.5-0006

Identifier	REQ-INVIRCAT-D2.5-0006
Requirement	Specific RPAS contingency procedures shall be published in the same way as they are published for manned aircraft.
Status	<Defined>
Rationale	RPAS have specific contingencies that have to be published and made available to all the relevant actors. Contingencies to be published include specific RPAS procedures, loiter points or dedicated termination areas.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	It may be necessary to declare the specific contingencies and procedures through a letter of agreement between the RPAS operators and the relevant authorities as well as publish them as SOP.

5 Operational requirements

This chapter presents the operational requirements that the INVIRCAT concept poses on IFR RPAS operations in the TMA.

The first paragraph contains the general operational requirements that are applicable to any situation. The second paragraph includes the operational requirements in nominal situations. Finally, the third paragraph considers the contingencies identified in INVIRCAT per type of failure² and derives the requirements applicable to them. Some contingencies only apply to specific phases of the flight in the TMA and at airports. Therefore, requirements associated to those contingencies are stated in such a manner that they are unique and only apply to the flight phases where the contingencies can occur.

5.1 General requirements

The following requirements are applicable to all flight phases of flight in the TMA, regardless of whether related to nominal or contingency situations.

Table 10: REQ-INVIRCAT-D2.5-0007

Identifier	REQ-INVIRCAT-D2.5-0007
Requirement	The RPIL shall verify that all RPAS systems are fully functional during all phases of flight.
Status	<Defined>
Rationale	The correct operation of all RPAS systems is necessary to ensure that the flight can be performed safely and to detect whether the flight changes from a nominal situation to a contingency situation. Systems include: engines, C2 link, transponder, ATOL, radio, and flight management system amongst others.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-007; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

² Failure types are those identified in D2.2 “Use Cases and Non-Nominal Conditions” Section 4.2 “Non-nominal use cases”

Table 11: REQ-INVIRCAT-D2.5-0008

Identifier	REQ-INVIRCAT-D2.5-0008
Requirement	The RPIL shall verify that flight parameters are set correctly during all phases of flight.
Status	<Defined>
Rationale	<p>The correct flight parameters confirm to the RPIL that the flight is being executed as expected. In addition, some systems provide relevant information to ensure the safety of the flight. Changes in these parameters may lead to a move from a nominal situation to a contingency situation.</p> <p>Parameters include flight speeds (e.g. V1 or VR during take-off), decision height, transponder codes or C2 link alerts.</p>
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 12: REQ-INVIRCAT-D2.5-0009

Identifier	REQ-INVIRCAT-D2.5-0009
Requirement	The RPIL shall be aware of and declare contingencies to the responsible ATCO when there is a contingency situation.
Status	<Defined>
Rationale	<p>Within the framework of INVIRCAT a contingency has to be declared when:</p> <ul style="list-style-type: none"> - There is a propulsion failure in a single engine RPAS. - There is partial propulsion failure in a multi engine RPAS. - There are ATOL system occurrences. - There is a command C2 link failure. - There is a transponder failure. - There is a radio voice communication failure. - There is a missed approach. - There is a conflict with another traffic. - The RPA is short of fuel.

Identifier	REQ-INVIRCAT-D2.5-0009
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006, OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	This requirement is applicable at any moment during the flight.

Table 13: REQ-INVIRCAT-D2.5-0010

Identifier	REQ-INVIRCAT-D2.5-0010
Requirement	The RPIL shall command the RPA in contingency situations as agreed with the relevant authorities.
Status	<Defined>
Rationale	<p>The intended contingency procedure has to be agreed before the RPAS are routinely introduced in airports and TMAs so that RPILs and ATCOs have a common understanding of the difference in contingencies for RPAS versus manned aircraft and the expected performance in their execution.</p> <p>The intended contingency procedure depends on the specific contingency (see REQ-INVIRCAT-D2.5-0009), but may include amongst other procedures the use of loiter waypoints, termination areas, conflict avoidance or alternative means to establish contact with ATCO in the event of a R/T failure.</p>
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 14: REQ-INVIRCAT-D2.5-0011

Identifier	REQ-INVIRCAT-D2.5-0011
Requirement	ATCOs shall be aware of which aircraft is remotely piloted.

Identifier	REQ-INVIRCAT-D2.5-0011
Status	<Defined>
Rationale	When issuing instructions or clearances, Ground, TWR, APP Exe. and APP Pln. ATCOS have to be aware of the type of aircraft they manage, as RPAS operations in airport and TMA will be slightly different from operations of on-board piloted aircraft.
Category	<Operational>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	N/A

Table 15: REQ-INVIRCAT-D2.5-0012

Identifier	REQ-INVIRCAT-D2.5-0012
Requirement	The RPIL shall resume the flight after a contingency is resolved and continue the flight in accordance with the approved flight plan and ATC clearance.
Status	<Defined>
Rationale	Once the contingency is finished, the RPIL has to resume the nominal flight conditions (regardless whether it is the original flight plan or an adapted flight plan as instructed by the responsible ATSU).
Category	<Operational>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 16: REQ-INVIRCAT-D2.5-0013

Identifier	REQ-INVIRCAT-D2.5-0013
Requirement	The RPIL shall command the RPA according to clearances issued by the ATCO.
Status	<Defined>
Rationale	The RPIL has to command the RPA in accordance with ATCO clearances to avoid potential collisions with other aircraft or generate delays.
Category	<Operational>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-005; OBJ-INV-006; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	N/A

5.2 Nominal requirements

Nominal operational requirements have been placed in this section, classified per phase of flight.

With regard to where to place handover related requirements, (handover is not a phase of flight, can occur at any phase of flight), but a procedure that could be included in general or nominal sections within this subchapter. Finally, it has been included at the very end of nominal section, after all phases of flight.

5.2.1 Taxi operations

The following requirements are applicable to taxi operations.

Table 17: REQ-INVIRCAT-D2.5-0014

Identifier	REQ-INVIRCAT-D2.5-0014
Requirement	The RPIL shall adhere to segmented standard taxiways, when available.
Status	<Defined>

Identifier	REQ-INVIRCAT-D2.5-0014
Rationale	Segmented standard taxiways are designed according to the one-way-principle where possible and implement mandatory holding points at taxiways hotspots or before crossing a runway. Segmented taxi ways are a new method to achieve fast-and-easy integration of RPAS in controlled aerodromes. Virtual stop bars, as addressed by SESAR W1 PJ03a, are also part of the holding points to take into account, if they are available.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 18: REQ-INVIRCAT-D2.5-0015

Identifier	REQ-INVIRCAT-D2.5-0015
Requirement	Upon ATC holding instructions, RPAS shall stop taxiing.
Status	<Defined>
Rationale	In order to move on the airport surface, the RPA may not move beyond the last position cleared by ATCO to avoid potential collisions with other aircraft.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 19: REQ-INVIRCAT-D2.5-0016

Identifier	REQ-INVIRCAT-D2.5-0016
Requirement	The RPIL shall park the RPA at the apron position instructed by ATCO.

Identifier	REQ-INVIRCAT-D2.5-0016
Status	<Defined>
Rationale	The RPIL cannot park the RPA at any position of the airport that may generate conflicts with other aircraft or block the airport operations.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

5.2.2 Take-off

The following requirements are applicable to take-off phase.

Table 20: REQ-INVIRCAT-D2.5-0017

Identifier	REQ-INVIRCAT-D2.5-0017
Requirement	The RPIL shall engage the ATOL system upon ATC clearance for take-off.
Status	<Defined>
Rationale	In the same manner as any RPA functionality, and take-off checklist is verified, ATOL system shall be verified too. The ATOL system feasibility checks is intended because, upon the clearance to take off, the RPIL has to ensure that the ATOL system is functioning correctly.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 21: REQ-INVIRCAT-D2.5-0018

Identifier	REQ-INVIRCAT-D2.5-0018
Requirement	The RPIL shall supervise the take-off procedure while the ATOL system is activated.
Status	<Defined>
Rationale	The ATOL system performs the take-off procedure under RPIL supervision.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	This requirement is also applicable for the landing procedure, as the ATOL system will land the RPA and reduce the speed after touchdown, (but still the procedure has to be supervised by the RPIL).

Table 22: REQ-INVIRCAT-D2.5-0019

Identifier	REQ-INVIRCAT-D2.5-0019
Requirement	The RPIL shall disengage the ATOL when the take-off phase has finished.
Status	<Defined>
Rationale	Once the RPA has finished the landing phase, the RPIL shall disengage the ATOL and continue with the flight.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	This requirement is not part of the use cases document.

5.2.3 Departure via SID

Founding Members

The following requirements are applicable to departure via SID phase.

Table 23: REQ-INVIRCAT-D2.5-0020

Identifier	REQ-INVIRCAT-D2.5-0020
Requirement	The RPIL shall follow the published and cleared SID procedure, in accordance with ATCO instructions.
Status	<Defined>
Rationale	The RPA may not move freely during its climb. It shall take into account the published restrictions in addition to ATCO instructions.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

5.2.4 Arrival via STAR

The following requirements are applicable to arrival via STAR phase.

Table 24: REQ-INVIRCAT-D2.5-0021

Identifier	REQ-INVIRCAT-D2.5-0021
Requirement	The RPIL shall follow the published and cleared STAR procedure.
Status	<Defined>
Rationale	When the RPA is en-route approaching the transition, the RPIL shall be able to follow the published STAR procedure while following the en-route ATCO instructions and clearances.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

5.2.5 Holding

Founding Members

The following requirements are applicable to holding phase.

Table 25: REQ-INVIRCAT-D2.5-0022

Identifier	REQ-INVIRCAT-D2.5-0022
Requirement	The RPIL shall follow the cleared and instructed holding pattern.
Status	<Defined>
Rationale	When the RPAS cannot proceed to complete the STAR due to congestion or to enhanced sequencing, APP Exe. ATCO shall communicate with the RPIL to proceed to a holding pattern. When the problem is solved, ATCO shall inform the RPIL to leave the holding pattern and give instructions accordingly.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

5.2.6 Approach

The following requirements are applicable to the approach phase.

Table 26: REQ-INVIRCAT-D2.5-0023

Identifier	REQ-INVIRCAT-D2.5-0023
Requirement	The RPIL shall engage the ATOL system when established on the ILS.
Status	<Defined>
Rationale	The ATOL system availability shall be supervised. As soon as the RPA is established on the ILS (or other precision approach means), the remote pilot shall activate the ATOL system.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 27: REQ-INVIRCAT-D2.5-0024

Identifier	REQ-INVIRCAT-D2.5-0024
Requirement	The RPIL shall follow the instructed approach in order to land.
Status	<Defined>
Rationale	Before landing, the RPIL shall follow ATCO clearances to continue with the approach phase.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 28: REQ-INVIRCAT-D2.5-0025

Identifier	REQ-INVIRCAT-D2.5-0025
Requirement	The APP Exe. ATCO shall integrate the RPA into the landing sequence.
Status	<Defined>
Rationale	Once the RPA is cleared to the IFR approach, the APP Exe. ATCO has to integrate the RPA in the landing sequence with other aircraft.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

5.2.7 Landing

The following requirements are applicable to the landing phase.

Table 29: REQ-INVIRCAT-D2.5-0026

Identifier	REQ-INVIRCAT-D2.5-0026
Requirement	The RPIL shall follow the cleared and instructed landing procedure.
Status	<Defined>
Rationale	The TWR ATCO cannot grant the landing clearance until the runway is free of other aircraft, vehicles, obstacles, and in general fixed or moving objects to avoid potential collisions. After vacating the runway, the RPA has to be steered towards the first taxi holding position to avoid potential collisions with other aircraft landing, while following Ground ATCO instructions.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 30: REQ-INVIRCAT-D2.5-0027

Identifier	REQ-INVIRCAT-D2.5-0027
Requirement	The RPIL shall disengage the ATOL system when the RPA is ready to exit the runway.
Status	<Defined>
Rationale	Once the RPA has landed and has reduced its speed, the RPIL has to take over the command of the RPA once it is close to the runway exit point and be able to steer it to the first taxi holding position. Therefore, exiting the runway is controlled by the RPIL not by the ATOL system.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-005; OBJ-INV-007; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

5.2.8 Handover

No operational use cases have been defined for the handover procedures. However, handover plays an important role in the INVIRCAT validation and a specific validation exercise has been defined. As a validation exercise, it has been assigned with validation objectives and, therefore, it is necessary to derive requirements to guarantee that they are subject to validation. Handover may apply to any phase of flight.

Table 31: REQ-INVIRCAT-D2.5-0028

Identifier	REQ-INVIRCAT-D2.5-0028
Requirement	The RPIL in command shall inform the ATCO before the handover procedure is accomplished.
Status	<Defined>
Rationale	The RPIL in command shall communicate with the ATCO before the handover procedure, declaring his/her intentions and the duration of the procedure.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	If the handover procedure is not completed the RPIL will inform ATCO.

Table 32: REQ-INVIRCAT-D2.5-0029

Identifier	REQ-INVIRCAT-D2.5-0029
Requirement	The RPIL 1 shall brief information to RPIL 2 before handing over the RPA.
Status	<Defined>

Identifier	REQ-INVIRCAT-D2.5-0029
Rationale	<p>The briefing information has to include, at least, the following items:</p> <ul style="list-style-type: none"> a) confirmation by the RPIL 2 that the RPAS is within the accepting RPS C2 link range; b) current state of the RPAS and location; c) faults/system failures with the RPAS; d) status of fuel/energy and other consumables; e) C2 link configuration; and f) changes or limitations to the intended flight or RPAS performance.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 33: REQ-INVIRCAT-D2.5-0030

Identifier	REQ-INVIRCAT-D2.5-0030
Requirement	The RPIL 2 shall confirm the agreement with the briefing information to RPIL 1 before the handover is performed.
Status	<Defined>
Rationale	The handover may not take place until RPIL 2 is satisfied with the information provided to ensure the safe continuance of the flight.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 34: REQ-INVIRCAT-D2.5-0031

Identifier	REQ-INVIRCAT-D2.5-0031
Requirement	The RPIL 1 shall handover the RPA C2 to RPIL 2.
Status	<Defined>
Rationale	In order to perform the handover, the RPIL 1 has to transfer the C2 of the RPA to the RPIL 2.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 35: REQ-INVIRCAT-D2.5-0032

Identifier	REQ-INVIRCAT-D2.5-0032
Requirement	The RPIL 1 shall keep active command over the RPA until the handover procedure has been accomplished.
Status	<Defined>
Rationale	During the handover procedure, the RPIL 1 is still the pilot in command.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 36: REQ-INVIRCAT-D2.5-0033

Identifier	REQ-INVIRCAT-D2.5-0033
Requirement	The RPIL 2 shall keep active command over the RPA after the handover procedure has been accomplished.

Identifier	REQ-INVIRCAT-D2.5-0033
Status	<Defined>
Rationale	When the handover procedure is completed, the RPIL 2 is the pilot in command.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 37: REQ-INVIRCAT-D2.5-0034

Identifier	REQ-INVIRCAT-D2.5-0034
Requirement	The RPIL in command shall adhere to new clearances from the ATCO after the handover procedure.
Status	<Defined>
Rationale	When the handover is completed successfully, the RPIL 2 is responsible for contacting the ATCO to continue the flight as he/she becomes the pilot in command.
Category	<Operational>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

5.3 Contingency requirements

5.3.1 Propulsion failures

Engine failure contingencies depend on the type of RPAS, whether it is single engine or multi-engine. They also depend on whether the failure is partial or total allowing to take off or not.

Engine failure requirements are divided into those occurring during the take-off phase and those occurring during another flight phase within the TMA or at the airport.

5.3.1.1 Propulsion failures during take-off

The following requirements are stated so that they applicable to engine failures during the take-off phase.

Table 38: REQ-INVIRCAT-D2.5-0035

Identifier	REQ-INVIRCAT-D2.5-0035
Requirement	The RPIL shall actively give the RTO command to the RPA after a single engine RPA failure or a multi-engine RPA partial/total failure that occurs before VR.
Status	<Defined>
Rationale	When a partial/total failure occurs before VR, regardless of whether a single engine RPAS failure or multi engine RPA partial/total failure the RPIL commands the RTO procedure.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 39: REQ-INVIRCAT-D2.5-0036

Identifier	REQ-INVIRCAT-D2.5-0036
Requirement	The RPIL shall communicate to the TWR ATCO that the RPA is stopped after a single engine RPA failure or a multi-engine RPA partial failure leading to an RTO.
Status	<Defined>
Rationale	The RTO will end with the RPA stopped on the runway.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.

Identifier	REQ-INVIRCAT-D2.5-0036
Additional Comment	N/A

Table 40: REQ-INVIRCAT-D2.5-0037

Identifier	REQ-INVIRCAT-D2.5-0037
Requirement	The RPIL shall inform the TWR ATCO about the intended contingency procedure when a single engine RPA failure or a multi-engine RPA partial/total failure occurs after VR.
Status	<Defined>
Rationale	The intended contingency procedure can be a landing operation at the same airport, a landing operation at a suitable site or a controlled flight into terrain.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 41: REQ-INVIRCAT-D2.5-0038

Identifier	REQ-INVIRCAT-D2.5-0038
Requirement	The RPIL shall inform the TWR ATCO about diversion options after a multi-engine RPA partial failure before VR with actual take-off.
Status	<Defined>
Rationale	For safety reasons, other aircraft under the control of the TWR ATCO which are close to the emergency RPA have to maintain separation with it and the TWR ATCO has to know the diversion options to plan the separation.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.

Identifier	REQ-INVIRCAT-D2.5-0038
Additional Comment	N/A

Table 42: REQ-INVIRCAT-D2.5-0039

Identifier	REQ-INVIRCAT-D2.5-0039
Requirement	The TWR ATCO shall coordinate actions with the APP Exe. ATCO after a multi-engine RPA partial failure before VR with actual take-off.
Status	<Defined>
Rationale	When the diversion planning includes entering into the sector of responsibility of the APP Exe. ATCO, both TWR and APP Exe. ATCOs have to coordinate the situation.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

5.3.1.2 Propulsion failures during flight within the TMA

These requirements are stated so that they are applicable to departure via SID, arrival via STAR, holding, approach and landing phases.

Table 43: REQ-INVIRCAT-D2.5-0040

Identifier	REQ-INVIRCAT-D2.5-0040
Requirement	The RPIL shall inform the APP Exe. ATCO about the planned procedure when there is a single engine RPA failure or a multi-engine RPA partial/total failure.
Status	<Defined>
Rationale	When there is a single engine RPA failure or multi-engine RPA partial/total failure, the pilot shall communicate, to the APP Exe. ATCO, the actions he/she will take to address the problem.
Category	<Operational>

Identifier	REQ-INVIRCAT-D2.5-0040
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 44: REQ-INVIRCAT-D2.5-0041

Identifier	REQ-INVIRCAT-D2.5-0041
Requirement	In case of actual take-off after a partial failure of a multi-engine RPA occurs, the RPIL shall initiate a diversion procedure to another airport
Status	<Defined>
Rationale	The diversion procedure implies departing from the planned route.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 45: REQ-INVIRCAT-D2.5-0042

Identifier	REQ-INVIRCAT-D2.5-0042
Requirement	In case of actual take-off after a partial failure of a multi-engine RPA occurs, the RPIL shall coordinate such diversion procedure with the APP Exe. ATCO.
Status	<Defined>
Rationale	The diversion procedure implies departing from the planned route and has to be coordinated with the APP Exe. ATCO.
Category	<Operational>
Situation	Contingency>

Identifier	REQ-INVIRCAT-D2.5-0042
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 46: REQ-INVIRCAT-D2.5-0043

Identifier	REQ-INVIRCAT-D2.5-0043
Requirement	When there is an engine failure and the RPIL communicates so the APP Exe. ATCO shall assist the RPIL.
Status	<Defined>
Rationale	Once the emergency is declared, the APP Exe. ATCO shall help the RPIL to manage the situation in order to avoid conflicts or collisions.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

5.3.2 Automatic Take-off and landing system (ATOL) occurrences

These requirements are stated so that they are applicable to take-off and landing phases.

Table 47: REQ-INVIRCAT-D2.5-0044

Identifier	REQ-INVIRCAT-D2.5-0044
Requirement	The RPIL shall continue the take-off procedure manually when an ATOL failure occurred after V1.
Status	<Defined>
Rationale	When there is an ATOL failure after V1, the take-off cannot be automatically executed by the ATOL system. Consequently, the RPIL has to manually continue the take-off.
Category	<Operational>
Situation	<Contingency>

Identifier	REQ-INVIRCAT-D2.5-0044
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 48: REQ-INVIRCAT-D2.5-0045

Identifier	REQ-INVIRCAT-D2.5-0045
Requirement	The RPIL shall report to the TWR ATCO the detected ATOL failure during take-off after V1.
Status	<Defined>
Rationale	Once the ATOL failure after V1 has been detected by the RPIL, he has to communicate the ATOL failure after V1 to the TWR ATCO.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 49: REQ-INVIRCAT-D2.5-0046

Identifier	REQ-INVIRCAT-D2.5-0046
Requirement	The RPIL shall request instructions/clearance from the TWR ATCO in order to perform an RTB manoeuvre when an ATOL failure during take-off after V1 has occurred.
Status	<Defined>
Rationale	Once the ATOL failure after V1 is declared, the RPIL has to request instructions/clearances from the TWR ATCO to continue with the RTB manoeuvre.
Category	<Operational>
Situation	<Contingency>

Identifier	REQ-INVIRCAT-D2.5-0046
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 50: REQ-INVIRCAT-D2.5-0047

Identifier	REQ-INVIRCAT-D2.5-0047
Requirement	When an ATOL failure occurs after V1, TWR ATCO shall give instructions/clearance to the RPIL in order to perform an RTB operation.
Status	<Defined>
Rationale	TWR ATCO shall give instructions/clearances to the RPIL in order to manage the situation and avoid potential collisions or generate delays. The RTB operation has to be defined and agreed in operation manuals.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 51: REQ-INVIRCAT-D2.5-0048

Identifier	REQ-INVIRCAT-D2.5-0048
Requirement	When an ATOL failure occurs during approach (above Alert Height (AH)) either the RPIL shall recognize the need to execute the MA/GA procedure or the ATOL system itself shall detect the ATOL occurrence and shall recognize the need to execute the MA/GA procedure.
Status	<Defined>

Identifier	REQ-INVIRCAT-D2.5-0048
Rationale	The RPIL monitors the status of the ATOL system constantly when engaged. When there is an ATOL occurrence, either the RPIL or the ATOL itself shall be able to detect it and activate the execution of the missed approach procedure.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

5.3.3 Command and Control (C2) link failure

These requirements are stated so that they are applicable to departure via SID, arrival via STAR, holding, approach and landing phases.

Table 52: REQ-INVIRCAT-D2.5-0049

Identifier	REQ-INVIRCAT-D2.5-0049
Requirement	After a C2 link failure, the RPIL shall communicate to the APP Exe. ATCO that the RPA will fly automatically to the nearest or cleared waypoint.
Status	<Defined>
Rationale	The APP Exe. ATCO is in charge of maintaining separation between the RPA and other aircraft.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 53: REQ-INVIRCAT-D2.5-0050

Identifier	REQ-INVIRCAT-D2.5-0050
Requirement	After a C2 link failure the App pln. ATCO shall coordinate the activation of termination areas with the TWR ATCO.
Status	<Defined>
Rationale	If the C2 is not recovered, the RPA will fly directly to a termination area that has to be cleared.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	The termination area has to be cleared of other aircraft and obstacles.

Table 54: REQ-INVIRCAT-D2.5-0051

Identifier	REQ-INVIRCAT-D2.5-0051
Requirement	The RPIL shall have planned, in the flight plan, the contingency loiter waypoints, the termination flight procedure and the termination points for C2 link loss events.
Status	<Defined>
Rationale	When the RPA reaches the last waypoint and the C2 link is not recovered, it has to fly automatically towards the loiter waypoint. These loiter waypoints have to be pre-programmed in the RPA FMS together with the instructions of flying clockwise with an established speed and altitude. If, after a determined period, the C2 link is not recovered, then the RPA flies directly to the termination point.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	The specific implementation of this requirement is made in PJ13 Sol 117 ERICA.

Table 55: REQ-INVIRCAT-D2.5-0052

Identifier	REQ-INVIRCAT-D2.5-0052
Requirement	In case of C2 link loss event, the RPIL shall communicate the C2 link reestablishment to the APP Exe. ATCO and APP pln. ATCO.
Status	<Defined>
Rationale	When the RPIL detects that the transponder has automatically stopped transmitting the 7400 code, the C2 link is re-established, and the RPIL notifies ATCOs to deactivate the termination area and resume the flight.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

5.3.4 Transponder failure

These requirements are stated so that they are applicable to departure via SID, arrival via STAR, holding and approach phases.

Table 56: REQ-INVIRCAT-D2.5-0053

Identifier	REQ-INVIRCAT-D2.5-0053
Requirement	As soon as the APP Exe. ATCO notices a transponder failure, he/she shall contact the RPIL via voice communications.
Status	<Defined>
Rationale	When the APP Exe. ATCO notices the loss of RPAS labels, he shall contact the RPAS pilot to inform him/her about the transponder failure.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.

Identifier	REQ-INVIRCAT-D2.5-0053
Additional Comment	N/A

Table 57: REQ-INVIRCAT-D2.5-0054

Identifier	REQ-INVIRCAT-D2.5-0054
Requirement	When a transponder failure occurs and after being informed by the APP Exe. ATCO, the RPIL shall help the APP Exe. ATCO to identify the RPAS.
Status	<Defined>
Rationale	The RPIL shall follow the instructions of the APP Exe. ATCO to help identify the RPAS when a transponder failure occurs.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 58: REQ-INVIRCAT-D2.5-0055

Identifier	REQ-INVIRCAT-D2.5-0055
Requirement	When a transponder failure occurs the APP Exe. ATCO shall provide guidance to the RPIL.
Status	<Defined>
Rationale	In order to avoid conflicts while transiting to the contingency loiter waypoint, the APP Exe. ATCO shall provide the RPIL with the guidance needed during the procedure.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 59: REQ-INVIRCAT-D2.5-0056

Identifier	REQ-INVIRCAT-D2.5-0056
Requirement	When a transponder failure occurs and after being informed by the APP Exe. ATCO the RPIL shall perform a transponder recycle.
Status	<Defined>
Rationale	In order to try to solve the transponder failure, the RPIL shall turn the transponder off and then on again.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

5.3.5 Radio voice communication failure

These requirements are stated so that they are applicable to departure via SID, arrival via STAR, holding and approach phases.

Table 60: REQ-INVIRCAT-D2.5-0057

Identifier	REQ-INVIRCAT-D2.5-0057
Requirement	When a radio voice communication failure occurs, the RPIL shall change the squawk code to 7600.
Status	<Defined>
Rationale	When the RPIL notices about the communications failure, the squawk code shall be changed to indicate communication failure to ATC.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 61: REQ-INVIRCAT-D2.5-0058

Identifier	REQ-INVIRCAT-D2.5-0058
Requirement	In the event of a R/T failure the RPIL shall re-start the VHF radios.
Status	<Defined>
Rationale	In order to try to solve the problem, the RPIL shall re-start the VHF radio by appropriate means.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 62: REQ-INVIRCAT-D2.5-0059

Identifier	REQ-INVIRCAT-D2.5-0059
Requirement	In the event of a R/T failure and after re-starting the VHF radio system the RPIL shall test if the procedure has been successful by contacting the APP Exe. ATCO via R/T.
Status	<Defined>
Rationale	The RPIL has to check that the radio connection is working again after a re-start contacting the APP Exe. ATCO via R/T.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 63: REQ-INVIRCAT-D2.5-0060

Identifier	REQ-INVIRCAT-D2.5-0060
Requirement	When a R/T failure occurs and after making sure that communications are working normally, the RPIL shall change the squawk code from 7600 to the original value.
Status	<Defined>
Rationale	If the connection is working normally, the RPIL shall change the squawk code to its original value, i.e. the value before the failure.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 64: REQ-INVIRCAT-D2.5-0061

Identifier	REQ-INVIRCAT-D2.5-0061
Requirement	When a R/T failure occurs and if the event that VHF radios cannot be re-started using alternate means of communication (such as landline telephone), the RPIL shall request vectors for landing.
Status	<Defined>
Rationale	If re-starting the RPAS VHF radios is unsuccessful, the RPIL shall request vectors for landing at base or the nearest alternate airport within the same TMA.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	The alternate airport has to be within the range of the RPA, remaining fuel and appropriate for its landing (e.g. runway length).

5.3.6 Missed approach

These requirements are stated so that they are applicable to approach and landing phases.

Table 65: REQ-INVIRCAT-D2.5-0062

Identifier	REQ-INVIRCAT-D2.5-0062
Requirement	During the approach or landing phase, the RPIL should perform a missed approach procedure when he/she detects that there is a runway incursion.
Status	<Defined>
Rationale	To avoid a potential collision with another aircraft that is occupying the runway and has not been identified by the ATCO, the RPIL has to declare a missed approach when he/she considers that the RPA cannot land safely.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 66: REQ-INVIRCAT-D2.5-0063

Identifier	REQ-INVIRCAT-D2.5-0063
Requirement	The TWR ATCO shall instruct the RPIL to perform a missed approach when he detects that the runway is not free of other aircraft, vehicles, obstacles, and in general fixed or moving objects.
Status	<Defined>
Rationale	To avoid a potential collision with other aircraft, vehicles, obstacles, and in general fixed or moving objects which may be occupying the runway before the RPA is on final, the ATCO has to instruct the RPIL to perform a missed approach procedure.
Category	<Operational>
Situation	<Contingency>

Identifier	REQ-INVIRCAT-D2.5-0063
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 67: REQ-INVIRCAT-D2.5-0064

Identifier	REQ-INVIRCAT-D2.5-0064
Requirement	The TWR ATCO shall notify the RPIL to perform a missed approach procedure when he/she detects that the RPA is unstable on final.
Status	<Defined>
Rationale	To avoid a potential collision with the runway or any other object, the ATCO has to notify the RPIL to perform a missed approach procedure when he detects the RPA is unstable.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 68: REQ-INVIRCAT-D2.5-0065

Identifier	REQ-INVIRCAT-D2.5-0065
Requirement	In the event of a missed approach procedure, the RPIL shall have the capability to disengage the ATOL system and manually control the RPA upon an ATC instruction to do so.
Status	<Defined>
Rationale	The ATOL system allows the RPA to land automatically and can also perform missed approaches and rejected take-off procedures. But in case the TWR ATCO commands the RPIL to perform a manual procedure (a manual missed approach), the RPIL has to be sure he can disengage the ATOL system and take full manual control of the RPAS
Category	<Operational>

Identifier	REQ-INVIRCAT-D2.5-0065
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 69: REQ-INVIRCAT-D2.5-0066

Identifier	REQ-INVIRCAT-D2.5-0066
Requirement	In case of a conflict that generates a missed approach, the RPIL shall inform the TWR ATCO that the RPA is above the decision height.
Status	<Defined>
Rationale	In case of a conflict that generates a missed approach, after the RPIL has verified the RPA is above the alert height, he/she has to inform the TWR ATCO and wait for instructions.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 70: REQ-INVIRCAT-D2.5-0067

Identifier	REQ-INVIRCAT-D2.5-0067
Requirement	In case of a conflict that generates a missed approach the TWR ATCO should provide information about the missed approach procedure to the RPIL concerned.
Status	<Defined>
Rationale	Each airport has specific missed approach procedures in terms of altitude, speed or heading published for manned aircraft. If the missed approach procedure is tailored for the RPA, it has to be published as well as per REQ-INVIRCAT-D2.5-0007.



Identifier	REQ-INVIRCAT-D2.5-0067
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 71: REQ-INVIRCAT-D2.5-0068

Identifier	REQ-INVIRCAT-D2.5-0068
Requirement	The RPIL shall follow the TWR ATCO instructions for the missed approach procedure manually.
Status	<Defined>
Rationale	If the ATOL system is disengaged, the RPIL manually commands the RPA in accordance with the published missed approach procedure or the tailored instructions given by the TWR ATCO.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 72: REQ-INVIRCAT-D2.5-0069

Identifier	REQ-INVIRCAT-D2.5-0069
Requirement	The RPIL shall actively command the ATOL system to follow the TWR ATCO instructions for the tailored missed approach or published procedure when the procedure is capable of being performed by the ATOL system.
Status	<Defined>
Rationale	The RPIL has to command the ATOL system actively to ensure that the missed approach procedure is executed correctly.

Identifier	REQ-INVIRCAT-D2.5-0069
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 73: REQ-INVIRCAT-D2.5-0070

Identifier	REQ-INVIRCAT-D2.5-0070
Requirement	The APP Exe. ATCO shall provide the RPIL with instructions to loiter at an RPAS specific loiter point before a second attempt to land.
Status	<Defined>
Rationale	If it is not possible to attempt a second landing immediately, the APP Exe. ATCO has to give a vector to the agreed RPAS loiter point and instruct the RPIL to loiter there until new instructions are provided and an opening in the landing sequence is available.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 74: REQ-INVIRCAT-D2.5-0071

Identifier	REQ-INVIRCAT-D2.5-0071
Requirement	When the RPIL has been instructed to loiter by the APP Exe. ATCO before a second attempt to land, the RPIL shall inform the APP Exe. ATCO about the remaining time for loitering.
Status	<Defined>
Rationale	The amount of fuel of the RPA limits the time that the RPIL can continue loitering at the loiter point defined by the ATCO.

Identifier	REQ-INVIRCAT-D2.5-0071
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 75: REQ-INVIRCAT-D2.5-0072

Identifier	REQ-INVIRCAT-D2.5-0072
Requirement	When the APP Exe. ATCO instructs the RPIL to re-join the landing sequence (after loitering before a second attempt to land), the RPIL shall command the RPAS manually in order to follow APP Exe. ATCO instructions
Status	<Defined>
Rationale	If it is possible to re-join the landing sequence, the vector provided by APP Exe. ATCO is commanded manually by the RPIL.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

5.3.7 Conflict

These requirements are stated so that they are applicable to take-off, departure via SID, arrival via STAR, holding and approach phases.

Table 76: REQ-INVIRCAT-D2.5-0073

Identifier	REQ-INVIRCAT-D2.5-0073
Requirement	TWR ATCO or APP Exe. ATCO (depending of the exact flight phase of the RPA) shall identify any potential conflicts between the RPA and other aircraft.
Status	<Defined>

Identifier	REQ-INVIRCAT-D2.5-0073
Rationale	When the RPAS receives permission to take-off, climb, descend, hold or approach ATCOs must be aware of any violation of separation minima and act immediately to avoid collisions.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 77: REQ-INVIRCAT-D2.5-0074

Identifier	REQ-INVIRCAT-D2.5-0074
Requirement	As soon as TWR ATCO or APP Exe. ATCO (depending of the exact flight phase of the RPA) identify potential conflicts between the RPA and other aircraft, they shall instruct the RPIL and manned aircraft pilots to carry out the avoidance manoeuvre immediately.
Status	<Defined>
Rationale	When the distance to another aircraft falls below the well clear distance, APP Exe. ATCO shall issue a traffic avoidance manoeuvre.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

5.3.8 Fuel starvation

These requirements are stated so that they are applicable to take-off, departure via SID, arrival via STAR, holding and approach phases.

Table 78: REQ-INVIRCAT-D2.5-0075

Identifier	REQ-INVIRCAT-D2.5-0075
Requirement	When there is a fuel starvation situation, the APP Exe. ATCO shall give priority to the RPA to land as soon as the pilot declares the emergency.
Status	<Defined>
Rationale	When there is a fuel starvation and the pilot has declared the emergency, ATCO give it priority to land.
Category	<Operational>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

6 Functional requirements

Functional requirements are those related to what the system has to do. In order to derive the functional requirements, the same approach as for the operational requirements derivation has been followed. This chapter is split into two subchapters. In the first one, the general requirements applicable to all flight phases either in a nominal or contingency situation are stated. The second subchapter applies to contingency specific requirements (some of them applying to more than one contingency).

6.1 General Requirements

Table 79: REQ-INVIRCAT-D2.5-0076

Identifier	REQ-INVIRCAT-D2.5-0076
Requirement	The RPIL shall be able to select the dedicated channel to contact the ATSU responsible for the area where the RPA is flying.
Status	<Defined>
Rationale	As any other aircraft, the RPAS communication equipment has to allow the RPIL to select a dedicated channel to contact the responsible ATCO at any moment of the flight.
Category	<Functional>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	N/A

Table 80: REQ-INVIRCAT-D2.5-0077

Identifier	REQ-INVIRCAT-D2.5-0077
Requirement	The RPS shall provide the capability for the RPIL to manually, or semi-automatically steer the RPA and to enable its automated operations.
Status	<Defined>

Identifier	REQ-INVIRCAT-D2.5-0077
Rationale	The RPAS C2 system has to allow the RPIL to manually issue commands to the RPA, or semi-automatically, as well as receive control information at any moment of the flight.
Category	<Functional><Contingency>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-005; OBJ-INV-006; OBJ-INV-007; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	N/A

Table 81: REQ-INVIRCAT-D2.5-0078

Identifier	REQ-INVIRCAT-D2.5-0078
Requirement	The camera on board the RPA shall allow the RPIL to detect relevant information from the surrounding environment during ground operations and make use of segmented taxiways.
Status	<Defined>
Rationale	The camera has to allow the RPIL to be aware of other aircraft on ground, or about to land, and to detect markings and signs, and/or lights within the movement area and the apron. In addition, on-board cameras ensure a safe use of segmented taxiways when ground personnel are not able to check them.
Category	<Functional>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.

Table 82: REQ-INVIRCAT-D2.5-0079

Identifier	REQ-INVIRCAT-D2.5-0079
Requirement	The RPS shall provide the relevant information to the RPIL in order to monitor the RPA’s current flight parameters, position, and system status and to supervise all automated operations.

Identifier	REQ-INVIRCAT-D2.5-0079
Status	<Defined>
Rationale	The RPIL is responsible for the RPAS and should always be able to monitor and supervise the RPA.
Category	<Functional>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	This requirement also applies to any other flight phase and both for nominal and contingency situations, except for C2 link failure.

Table 83: REQ-INVIRCAT-D2.5-0080

Identifier	REQ-INVIRCAT-D2.5-0080
Requirement	The ATOL system shall allow the RPA to execute automatically the take-off, initial climb, approach and landing.
Status	<Defined>
Rationale	ATOL system has to be capable of working correctly during the moments of the flight where it is required.
Category	<Functional><Contingency>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-005; OBJ-INV-006; OBJ-INV-007; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	This requirement is also applicable in certain contingencies such as missed approach/go-around and rejected take-off.

Table 84: REQ-INVIRCAT-D2.5-0081

Identifier	REQ-INVIRCAT-D2.5-0081
Requirement	The RPAS shall comply with the equipment and CNS requirements applicable to the airspace it is operating in.
Status	<Defined>
Rationale	All aircraft have to comply with the equipment and CNS requirements of the respective airspace classes.
Category	<Functional>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-010; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	This requirement also applies to any flight phase at the airport or TMA operations.

Table 85: REQ-INVIRCAT-D2.5-0082

Identifier	REQ-INVIRCAT-D2.5-0082
Requirement	The RPA shall be equipped with DAA equipment that is compatible with the existing ACAS and able to follow the DAA system's advice autonomously at any moment of the flight.
Status	<Defined>
Rationale	DAA functionality has to be at least comparable to manned aviation, i.e. it has to work in nominal and contingency situations like the C2 link loss.
Category	<Functional>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-007; OBJ-INV-008; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	N/A

Table 86: REQ-INVIRCAT-D2.5-0083

Identifier	REQ-INVIRCAT-D2.5-0083
Requirement	The RPS shall provide the capability to the RPIL to use all navigation procedures common under instrument flight rules (e.g. waypoints, SIDs & STARs, and vectors) at any moment of the flight.
Status	<Defined>
Rationale	The RPA navigation performance shall be within the same navigation performance margins as other IFR aircraft.
Category	<Functional>
Situation	<Nominal><Contingency>
Traceability to Validation Objective	INV-001; OBJ-INV-002; OBJ-INV-003; OBJ-INV-004; OBJ-INV-005; OBJ-INV-006; OBJ-INV-007; OBJ-INV-008; OBJ-INV-011; OBJ-INV-012; OBJ-INV-013; OBJ-INV-014; OBJ-INV-015; OBJ-INV-016.
Additional Comment	N/A

Table 87: REQ-INVIRCAT-D2.5-0084

Identifier	REQ-INVIRCAT-D2.5-0084
Requirement	During the handover procedure, the RPS shall provide voice and data communication between the RPILs participating the in the procedure
Status	<Defined>
Rationale	The handover procedure requires communication between the two RPILs involved to ensure a safe handover.
Category	<Functional>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 88: REQ-INVIRCAT-D2.5-0085

Identifier	REQ-INVIRCAT-D2.5-0085
Requirement	During the handover procedure, the RPA systems shall provide flight information to both RPILs participating, the one handing over and the one receiving the RPA.
Status	<Defined>
Rationale	Both pilots need to be aware of all information (at least RPA position, altitude, speed, heading, system status, and flight plan) necessary to safely conduct the flight operation.
Category	<Functional>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 89: REQ-INVIRCAT-D2.5-0086

Identifier	REQ-INVIRCAT-D2.5-0086
Requirement	During a handover procedure, the RPS shall indicate the RPIL who is in command to both RPILs involved.
Status	<Defined>
Rationale	The pilot who is in command must be aware of his/her responsibility in order to react to any contingency situation that may arise.
Category	<Functional>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	N/A

Table 90: REQ-INVIRCAT-D2.5-0087

Identifier	REQ-INVIRCAT-D2.5-0087
Requirement	The RPA shall allow a handover of control from one RPS to another only upon the active command of both RPILs.
Status	<Defined>
Rationale	In order to guarantee that the RPA is never uncontrolled, the receiving RPIL must be able to indicate his readiness to control the RPA before the RPIL in control can discharge from his command.
Category	<Functional>
Situation	<Nominal>
Traceability to Validation Objective	OBJ-INV-001; OBJ-INV-003; OBJ-INV-007; OBJ-INV-008; OBJ-INV-009; OBJ-INV-011; OBJ-INV-013; OBJ-INV-015.
Additional Comment	For clarification, RPAS are understood as a set of an RPA with a number of RPS (at least one) and a number of RPIL (at least one).

6.2 Contingency specific requirements

Table 91: REQ-INVIRCAT-D2.5-0088

Identifier	REQ-INVIRCAT-D2.5-0088
Requirement	The RPS shall allow the RPIL to activate a Rejected Take-Off (RTO) procedure when required and as appropriate.
Status	<Defined>
Rationale	The RPIL shall be able to activate contingency procedures.
Category	<Functional>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 92: REQ-INVIRCAT-D2.5-0089

Identifier	REQ-INVIRCAT-D2.5-0089
Requirement	The RPAS shall automatically activate an RTO procedure when required and as appropriate and inform the RPIL.
Status	<Defined>
Rationale	The RPAS shall be able to perform contingency procedures automatically.
Category	<Functional>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 93: REQ-INVIRCAT-D2.5-0090

Identifier	REQ-INVIRCAT-D2.5-0090
Requirement	The RPS shall allow the RPIL to activate a missed approach procedure when required and as appropriate.
Status	<Defined>
Rationale	The RPIL shall be able to activate a missed approach procedure in case of contingency or when required and as appropriate.
Category	<Functional>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-006; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 94: REQ-INVIRCAT-D2.5-0091

Identifier	REQ-INVIRCAT-D2.5-0091
Requirement	The RPAS shall provide a function to the RPIL to activate a pre-programmed contingency manoeuvre, that automatically steers the aircraft to a safe waypoint, where it will loiter.
Status	<Defined>
Rationale	The introduction of loiter waypoints in safe distance to regular flight routes allows ATC and the RPIL sufficient time to react to contingencies.
Category	<Functional>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	The safe distance has to be defined through dedicated safety assessments.

Table 95: REQ-INVIRCAT-D2.5-0092

Identifier	REQ-INVIRCAT-D2.5-0092
Requirement	The RPA shall inform the RPIL and provide an automatically triggered, pre-programmed contingency manoeuvre, that in case of a C2 link loss steers the aircraft to a safe waypoint, where it will loiter.
Status	<Defined>
Rationale	The introduction of loiter waypoints in safe distance to regular flight routes allows ATC and the RPIL sufficient time to react to a C2 link loss, which will be trying to be re-established until the end of the flight phase is reached (e.g. the end of the SID or STAR).
Category	<Functional>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 96: REQ-INVIRCAT-D2.5-0093

Identifier	REQ-INVIRCAT-D2.5-0093
Requirement	The RPA shall inform the RPIL and provide an automatically triggered, pre-programmed termination procedure, that steers the aircraft to a safe termination point in case there is a C2 link loss and the RPA is running out of fuel.
Status	<Defined>
Rationale	In the worst-case scenario of a C2 link loss combined with low energy reserves, a controlled flight into terrain at a safe termination point imposes the least air and ground risk.
Category	<Functional>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 97: REQ-INVIRCAT-D2.5-0094

Identifier	REQ-INVIRCAT-D2.5-0094
Requirement	The RPS shall, in case of a C2 link loss, provide an estimated position of the RPA to the RPIL, based on previous trajectory, flight plan information and any other available data.
Status	<Defined>
Rationale	During C2 link loss the RPIL needs to be aware where the RPA is in order to work on mitigation procedures and reconnection.
Category	<Functional>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

Table 98: REQ-INVIRCAT-D2.5-0095

Identifier	REQ-INVIRCAT-D2.5-0095
Requirement	The RPS shall provide a backup voice communication line to ATC for the case of a defective voice and data communication link.
Status	<Defined>
Rationale	In order to maintain control and safe separation, there needs to be a communication link between ATC and the pilots to transfer commands and clearances. Due to the time criticality in the TMA, CPDLC is not deemed usable.
Category	<Functional>
Situation	<Contingency>
Traceability to Validation Objective	OBJ-INV-002; OBJ-INV-004; OBJ-INV-010; OBJ-INV-012; OBJ-INV-014; OBJ-INV-016.
Additional Comment	N/A

7 Conclusions and next steps

Nearly one hundred requirements have been derived, operational and functional ones, to allow the integration of IFR RPAS in airports and TMAs within the context of INVIRCAT.

These requirements are intended to set the basis for the integration of RPAS in such environment taking into account their particularities in nominal and contingency situations. Requirements do not only apply to RPAS and their related equipment, but also to the actions that the RPILs and ATCOs have to execute in order to perform a safe, orderly and expeditious operation of RPAS.

The particularities of RPAS account for the fact that requirements are applicable, on the one hand, to different moments of flight, such as departure or handover and, on the other hand, to particular moments of flight only.

The requirements contained in this document are traced to the validation objectives defined within the INVIRCAT validation plan so that, after the simulations take place and validation objectives are assessed to be met totally or partially, the requirements can be changed with respect to their status from defined to validated or modified, if necessary.

The update of requirements with regards to the results of the simulations will be reflected in INVIRCAT deliverable “D4.2 Final Operational and Technical Requirements” where, in addition to the requirements update, new non-functional requirements concerning performance, latency and safety will be derived.



Appendix A References

- [1] INVIRCAT Consortium, "D2.2 Use Case Definition and Concept Outline," 2021.
- [2] INVIRCAT Consortium, "D2.3 Initial CONOPS "RPAS in the TMA"," 2021.
- [3] INVIRCAT Consortium, "D2.1 Current State-of-the-Art and regulatory basis," 2020.
- [4] INVIRCAT Consortium, "D3.1 Validation Plan," 2021.
- [5] INVIRCAT Consortium, "D3.3 Use Cases Simulation Plan," 2021.
- [6] A. Salado and P. Wach, Constructing True Model-Based Requirements in SysML, 2019.
- [7] A. Salado, "A systems-theoretic articulation of stakeholder needs and system requirements," *Systems Engineering*, vol. 24, no. 2, pp. 83-99, 2021.
- [8] A. S. Rodríguez-Candela, *Systems Engineering: Theory and Practice*, Universidad Pontificia Comillas, 2014.

Appendix B Acronyms

Table 99: List of acronyms

Term	Definition
A-FUA	Advanced – Flexible Use of Airspace
ACAS	Airborne Collision Avoidance System
ACC	Area Control Centre
ACL	ATC Clearances Service
ACM	ATC Communications Management Service
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-C	Automatic dependent surveillance – Contract
AES	Aeronautical Earth Station
AH	Alert Height
AHRS	Attitude and Heading Reference System
AIP	Aeronautical Information Publication
AMC	Acceptable Means of Compliance
ANSP	Air Navigation Service Provider
AoR	Area of Responsibility
APP Exe. ATCO	Approach Executive Air Traffic Controller
APR	Approach
ASBU	Aviation System Block Upgrade
ASR	Air Surveillance Radar
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATCS	Air Traffic Control Service
ATFCM	Air Traffic Flow and Capacity Management

Term	Definition
ATM	Air Traffic Management
ATOL	Automatic Take-Off and Landing
ATS	Air Traffic Service
ATSU	Air Traffic Services Unit
AU	Airspace User
BADA	Base of Aircraft Data
BLOS	Beyond Line-of-Sight
BRLOS	Beyond Radio Line-of-Sight
BVLOS	Beyond Visual Line-of-Sight
C2	Command and Control
CA	Collision Avoidance
CAA	Civil Aviation Authority
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CIRA	Centro Italiano Ricerche Aerospaziali (Italian Aerospace Research Centre)
CFIT	Controlled Flight Into Terrain
CLS	Calculated Level of Safety
CNS	Communication, Navigation and Surveillance
CNPC	Control and Non-Payload Communication
CPDLC	Controller Pilot Data Link Communications
CONOPS	Concept of Operations
CWP	Controller Working Position
DA	Decision Altitude
DAA	Detect and Avoid

Term	Definition
DCL	Departure Clearance
DGPS	Differential Global Positioning System
DH	Decision Height
DLIC	Data Link Initiation Capability
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DLS	Data Link Services
DMA	Dynamic mobile area
DME	Distance Measuring Equipment
DMZ	De-Militarized Zone
DOF	Degrees of Freedom
DSC	Downstream Clearance Service
DTA	DAA Terminal Area
DWC	DAA Well Clear
EASA	European Aviation Safety Agency
EAT	Estimated Approach Time
ECAC	European Civil Aviation Conference
ECAM	Electronic Centralized Aircraft Monitoring
EGNOS	European Geostationary Navigation Overlay Service
EMI	Electromagnetic Interference
ESC	Electronic Speed Controller
EVLOS	Extended Visual Line of Sight
FCC	Flight Control Computer
FDPS	Flight Data Processing system
FIS	Flight information service

Term	Definition
FIS-B	Flight information service broadcast
FLARE	Flight Laboratory for Aeronautical Research
FMS	Flight management system
FPV	First-Person View
FSS	Fixed Satellite Service
FSTD	Flight Simulation Training Device
FTP	Flight Termination Points
GA	General Aviation
GAST	GBAS Approach Service Type
GAT	General Air Traffic
GBAS	Ground Based Augmentation System
GCS	Ground Control Station
GDPR	General Data Protection Regulation
GES	Ground Earth Station
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HD	High Definition
HIL	Human-in-the-Loop
HMI	Human Machine Interface
HP	Holding Pattern
HW	Hardware
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organization



Term	Definition
ICL	Initial Climb
ICT	Information and Communication Technology
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
IFF	Identification Friend or Foe
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INVIRCAT	Investigation of IFR RPAS Control at Airports and in the TMA
I/O	Input/Output
ISF	Integrated Simulation Facility
LIDAR	Light Detection and Ranging
LPV	Localizer Performance with Vertical guidance
MA	Missed Approach
MALE	Medium altitude long endurance
MAS	Managed Airspace
MCM	Maintenance Control Manual
METAR	METEorological Aerodrome Report
MFD	Multi-Function Display
MLS	Microwave Landing System
MOPS	Minimum Operational Performance Specifications
MTOW	Maximum Take-Off Weight
MUST	Multi UAV Simulated Testbed
NAA	National Aviation Authority
NARSIM	NLR ATC Research SIMulator

Term	Definition
NDB	Non-Directional Beacon
NLR	Nederlands Lucht- en Ruimtevaartcentrum (Netherlands Aerospace Centre)
NM	Network Manager
NOP	Network Operations Plan
NOTAM	Notice to Airmen
NPA	Notice of Proposed Amendment
OAT	Operational Air Traffic
OCD	Operational Concept Document
OSED	Operational Services and Environment Definitions
OTW	Out-the-Window
PA	Precision Approach
PAR	Precision Approach Radar
PBN	Performance Based Navigation
PFD	Primary Flight Display
PIC	Pilot in Command
PIO	Pilot-induced oscillation
PPS	Packets Per Second
PPS	Precise Positioning Service
PSR	Primary Surveillance Radar
R/T	Radio/Telephony
RAIM	Receiver Autonomous Integrity Monitoring
RCP	Required Communication Performance
RF	Radio Frequency
RLOS	Radio Line of Sight

Term	Definition
RNAV	Area navigation
RNP	Required Navigation Performance
ROC	RPAS Operator Certificate
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft System
RPIL	Remote Pilot
RPS	Remote Pilot Station
RTB	Return to Base
RTO	Rejected take-off
RTS	Real Time Simulation
RWC	Remain Well Clear
SAA	Sense And Avoid
SARP	Standard And Recommended Practice
SATCOM	Satellite Communication
SBAS	Satellite Based Augmentation System
SCB	Stakeholder Consultation Body
SERA	Standardised European Rules of the Air
SESAR	Single European Sky ATM Research Programme
ShMem	Shared Memory
SID	Standard Instrument Departure
SIP	Structural Integrity Program
SiS	Signal in Space
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SMR	Surface Movement Radars

Term	Definition
SMS	Safety Management System
SOP	Standard Operating Procedure
SPR	Safety Performance Requirements
SPS	Standard Positioning Service
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
SVS	Synthetic Vision System
SW	Software
SWaP	Size, Weight, and Power
SWIM	System Wide Information Management
TAR	Terminal Approach Radar
TCAS	Traffic Alert and Collision Avoidance System
TCP	Transmission Control Protocol
TIS	Traffic Information System
TLS	Target Level of Safety
TMA	Terminal Manoeuvring Area
TRL	Technology Readiness Level
TSA	(Static) temporary restricted area
TWR	Tower
UAM	Urban Air Mobility
UAS	Unmanned Aircraft System
UHF	Ultra High Frequency
USP	U-Space/UTM Service Provider
UTC	Universal Time Coordinated

Term	Definition
UTM	Unmanned Traffic Management
V&V	Verification & Validation
V1	Take-off Decision Speed for Multi Engine Aircraft
VFR	Visual Flight Rules
VHF	Very high frequency
VLD	Very Large Demonstration
VLL/VHL	Very Low Level/Very High Level
VLOS	Visual Line-of-Sight
VOIP	Voice Over Internet Protocol
VOR	VHF Omnidirectional Range
VR	Rotation Speed
VTOL	Vertical Take-Off and Landing
WAGE	Wide Area GPS Enhancements
WP	Work Package
WRC-15	World Radiocommunication Conference 2015
XPDR	Transponder

Appendix C Glossary of terms

Table 100: Glossary of terms

Term	Definition	Source of the Definition
ADS-B	Automatic dependent surveillance — broadcast (ADS-B): A means by which aircraft, aerodrome vehicles and other objects can automatically transmit and/or receive data such as identification, position and additional data, as appropriate, in a broadcast mode via a data link.	ICAO Doc 4444 PANS-ATM
AH	The alert height (AH) is a specified radio height for CAT III operations, based on the characteristics of the aeroplane and its fail-operational landing system. In operational use, if a failure occurred above the alert height in one of the redundant operational parts of the landing system in the aeroplane or relevant ground equipment, the approach would be discontinued and a go-around executed unless reversion to a higher decision height is possible. If a failure in one of the required redundant operational systems occurred below the alert height, it would be ignored and the approach continued	N/A
AoR	Area of Responsibility: An airspace of defined dimensions within which an ATC unit provides air traffic services.	EUROCONTROL ATM Lexicon
ATS surveillance system	A generic term meaning variously, ADS-B, PSR, SSR or any comparable ground-based system that enables the identification of aircraft.	ICAO RPAS CONOPS for international IFR Operations
BVLOS operation	Beyond visual line-of-sight (BVLOS) operation. An operation in which the remote pilot or RPA observer does not use visual reference to the remotely piloted aircraft in the conduct of flight	ICAO RPAS CONOPS for international IFR Operations

Term	Definition	Source of the Definition
C2 Link	Command and Control Link: The datalink used for the purpose of command and control (C2) functions in an RPAS.	JARUS: RPAS Required C2 Performance (RLP) Concept
DAA	Detect and avoid (DAA): The capability to see, sense, or detect conflicting traffic or other hazards and take appropriate action.	ICAO RPAS CONOPS for international IFR Operations
Drone	Synonym for UAS. Any aircraft and related systems without a pilot on board, either remotely piloted or autonomous.	N/A
GCS	Ground Control Station: RPS are sometimes named Ground Control Stations (GCS).	JARUS: RPAS Required C2 Performance (RLP) Concept
Handover	The act of passing the control of an operation from a human operator to another. The handover could be executed between Air Traffic Control Officers (e.g. in the control transfer from one sector to another, or from ACC to APP controllers). Namely for RPAS operations, the handover refers to passing piloting control from one remote pilot station to another.	N/A
PA	A precision approach (PA) is an instrument approach and landing using precision lateral and vertical guidance with minima as determined by the category of operation, namely CAT I, CAT II, CAT III operations, each related to progressively reducing decision minima.	ICAO Annex 6: Operation of Aircraft, extended
RPA	Remotely Piloted Aircraft: An unmanned aircraft which is piloted from a remote pilot station.	ICAO Annex 2: Rules of the Air ICAO Doc 10019: Manual on Remotely Piloted Aircraft Systems (RPAS)
RPAS	Remotely Piloted Aircraft System: A set of configurable elements consisting of a remotely-piloted aircraft, its associated remote pilot station(s), the required command and control links and any other system elements as may be required, at any point during flight operation.	ICAO Cir 328

Term	Definition	Source of the Definition
	RPAS are understood as a set of an RPA with a number of RPS (at least one) and a number of RPIL (at least one).	
RPIL	Remote Pilot: A person charged by the operator with duties essential to the operation of a remotely piloted aircraft and who manipulates the flight controls, as appropriate, during flight time.	ICAO Doc 10019: Manual on Remotely Piloted Aircraft Systems (RPAS) JARUS: RPAS Required C2 Performance (RLP) Concept
RPS	Remote Pilot Station: The component of the remotely piloted aircraft system containing the equipment used to pilot the remotely piloted aircraft.	ICAO Doc 10019: Manual on Remotely Piloted Aircraft Systems (RPAS)
Segregated airspace	Airspace of specified dimensions allocated for exclusive use to a specific user(s).	ICAO RPAS CONOPS for international IFR Operations
TMA	Terminal Manoeuvring Area (TMA): Controlled airspace around an airport.	N/A
UAS	Unmanned Aircraft System (UAS): Any aircraft and related systems without a pilot on board, either remotely piloted or autonomous.	N/A

