



ABOUT THE PROJECT

INVIRCAT (IFR RPAS Control in Airports and TMA) is a project funded by the SESAR Joint Undertaking as part of the SESAR 2020 Exploratory Research initiatives.

The main purpose of the project is to investigate innovative solutions for the safe and equal integration of remotely piloted aircraft systems in the terminal manoeuvring area and airport environments without entailing a significant impact on current airspace users. This process is guided by an innovation pipeline through which the European ATM community can explore new ideas, validate them with industrial partners and then demonstrate their viability for implementation.



TIMELINE

This timeline shows the progression of the project. The project has an overall duration of 30 months and is currently at month 25th. So far, 15 deliverables have been produced and approved by the SJU, out of the 20 deliverables to be released overall. Six of these deliverables are classified as public and available from the project website.

2020

Jul 2020

Project start



2022

M25

We are here

Dec 2022

Project end

Public deliverables available so far

see www.invircat.eu/deliverables

D2.1 Current State-of-the-Art and regulatory basis

This deliverable provides the project state-of-the-art focusing on three main aspects of RPAS integration: technologies, human aspects and applicable rules and standards. It also includes information about other past and present activities carried out in Europe, and more specifically within the SESAR framework.

D2.2 Use Cases Definition and Concept Outline

This deliverable describes the use cases and outlines the INVIRCAT concept for the integration of RPAS into the existing ATC procedures and infrastructures within TMAs and at airports under Instrument Flight Rules. It represents an initial step towards the creation of a Concept of Operations (CONOPS) for RPAS in the TMA and on airports.

D2.3 Initial Concept of Operations

The definition of the CONOPS serves as a basis to investigate the influence of the integration of RPAS on ATC and other aircraft in the defined use case scenarios. Based on the results of the simulations the final CONOPS and a set of high level operational and technical requirements will be defined.

D2.5 Preliminary Requirements Definition

This document sets 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.

D3.4 Exploratory Research Validation Report

This document summarises the validation context of the INVIRCAT project and presents the validation results of the simulation campaigns. It assesses the previously defined validation objectives qualitatively and quantitatively and summarises the results per identified key performance area in the project's scope. Finally, the expected quality and limitations of the results is discussed.

D4.1 Strategies on IFR RPAS Operations in the TMA: Alternatives, Requirements and Effects

This document summarises the key findings on alternatives and effects linked to IFR RPAS integration into the TMA in the course of the INVIRCAT project in the thematic topics of C2 link, communication link, ATOL systems, and taxi systems. An implementation recommendation is presented, based on timeframes from the SESAR Joint Undertaking ATM European Master Plan.

THIRD ADVISORY BOARD MEETING

The INVIRCAT consortium was delighted to welcome the members of the Advisory Board in the **INVIRCAT Third Advisory Board meeting**, which took place virtually, on May 16th, 2022.

The INVIRCAT Advisory Board consists of a large group of external experts and stakeholders with noteworthy and recognized expertise in the field of RPAS, RPAS integration, and standardization. It complements the expertise already included in the Consortium and acts as an independent consultation body.

Following a first meeting held in March 2021 in which the Advisory Board was involved in a series of activities intended to collect inputs for the production of the INVIRCAT Initial Concept of Operations, and a second meeting in September intended to present and discuss the initial CONOPS, the requirements defined at project level, and the validation strategy and approach, **the third Advisory Board meeting centred on presenting the consolidated CONOPS, based on the results of the simulation campaigns**. The meeting was structured as an **interactive workshop**.

After a brief recap of the INVIRCAT concept and objectives, a session followed dedicated to giving feedback back to the Advisory Board members. To this end, the **list of the cons, gaps, and suggestions** on the early concept of INVIRCAT collected during the 1st Advisory Board meeting **was shared to assess which of them were tackled by the project**. The exercise highlighted that of the gaps identified at the beginning of the project, many of them were indeed tackled by INVIRCAT, showing how the project took into consideration the initial contribution of the Advisory Board.

Then, the results of the simulation activities were introduced and presented with the help of a dedicated set of infographics. These illustrated the 5 Key Performance Areas (KPAs) identified as relevant for the project and the 18 associated validation objectives targeted (assessed both in nominal and contingency conditions, in most cases).

Finally, the consortium collected further gaps and research directions through a new collaborative exercise. Overall, the Advisory Board provided positive feedback on the presentation, considering the INVIRCAT results as very relevant.

Now, we are glad to share with all of you those same infographics that supported the presentation to the Advisory Board.

Keep reading: they will follow on the next pages.

More information on each Real Time Simulation scenario, complete with ATCO's feedback and suggestions, can be found on the INVIRCAT website:
<https://www.invircat.eu/dissemination-materials>

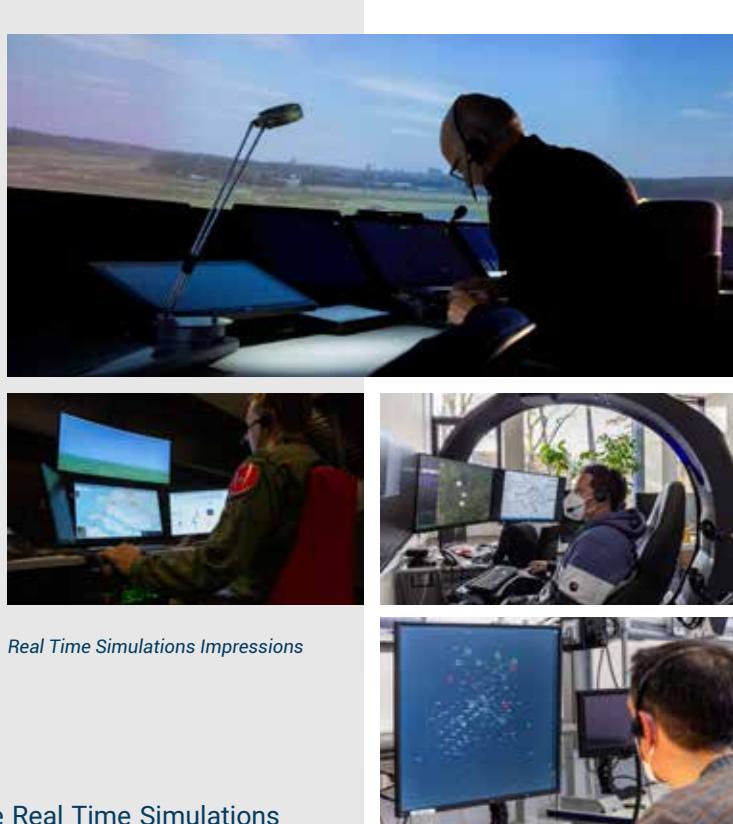


THE SIMULATION ACTIVITIES

In the last quarter of 2021, INVIRCAT carried out three real-time simulations to validate the proposed operational concept, procedures, and technological enablers.

One simulation was performed at **DLR**, in Germany, one at **Royal NLR** in the Netherlands, and one at **CIRA** in Italy. The concept was tested in three environments, each with numerous scenarios and a different focus, but with the common objective of evaluating the user acceptability, safety, and efficiency of the operations.

This allowed INVIRCAT to **broaden its validation activities**, a key strength for the project.



Real Time Simulations Impressions

VALIDATION PLAN

The INVIRCAT validation plan covers the three Real Time Simulations (RTS) and defines a set of Key Performance Areas (KPAs) and Validation Objectives to be consistently addressed during the entire simulation campaign.

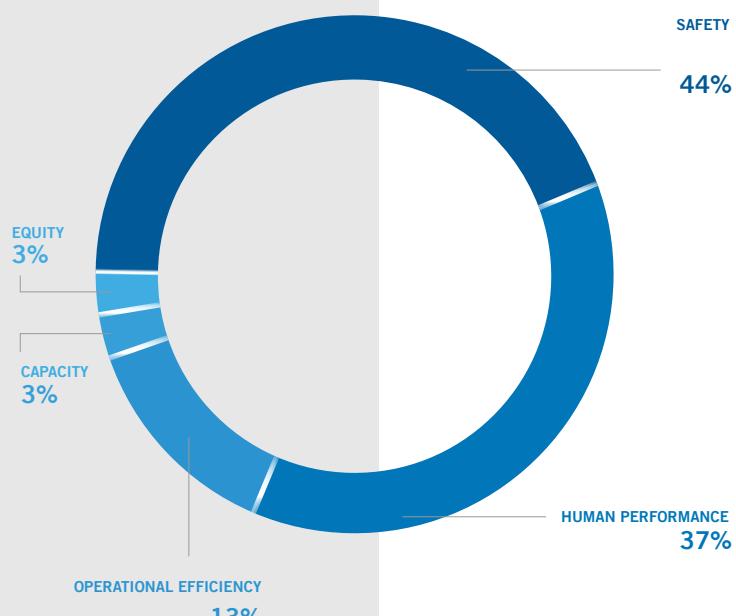
The validation plan is designed to study the impact of the INVIRCAT CONOPS on five KPAs. Eighteen validation objectives are identified (not all are listed below, because they were formulated both for nominal conditions and contingencies and mapped to the KPAs as represented in the graph (to be noticed that the association is not always univocal).

KPAs

- Human Performance
- Safety
- Equity
- Capacity
- Operational Efficiency

Validation Objectives

- Acceptability
- Safety levels
- ATOL procedures
- C2-Link and R/T voice latency
- RPA Handover
- Phraseology
- Adequacy of information provision
- Human contribution
- Air Traffic Controller (ATCO) Workload
- Impact on Runway Throughput
- Impact on TMA/Airport on Equity

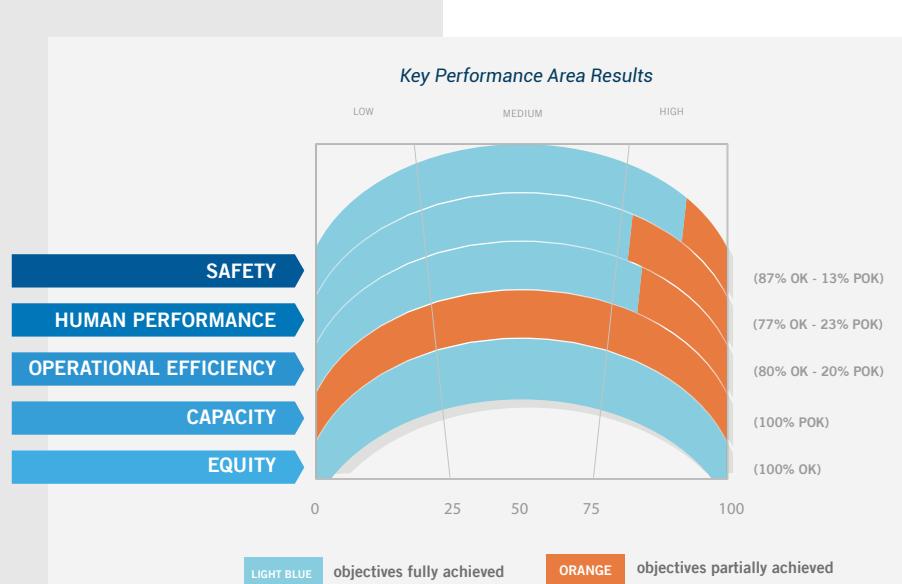


Mapping of the Validation Objectives to the KPAs

RESULTS OF SIMULATION ACTIVITIES

The graphical representation below shows the achievement level of the validation objectives associated with the KPAs and is based on the aggregated results of the three RTS.

For instance, as far as safety is concerned, it shows that the 87% of the associated validation objectives were considered fully achieved, while the remaining 13% are considered partially achieved. The next graphs will provide a detailed view of each KPA and the related validation objectives.



SUCCESS CRITERIA

-  POSITIVE FEEDBACK FROM ATCOS AND REMOTE PILOTS
-  NO AIRSPACE/COMMS FREQUENCY CAPACITY RESTRICTION DUE TO LATENCY
-  NO SIGNIFICANT DECREASE OF RUNWAY THROUGHPUT
-  EQUITABLE (AVERAGE) DELAY OF MANNED AND UNMANNED AIRCRAFT

ACHIEVEMENT LEVEL

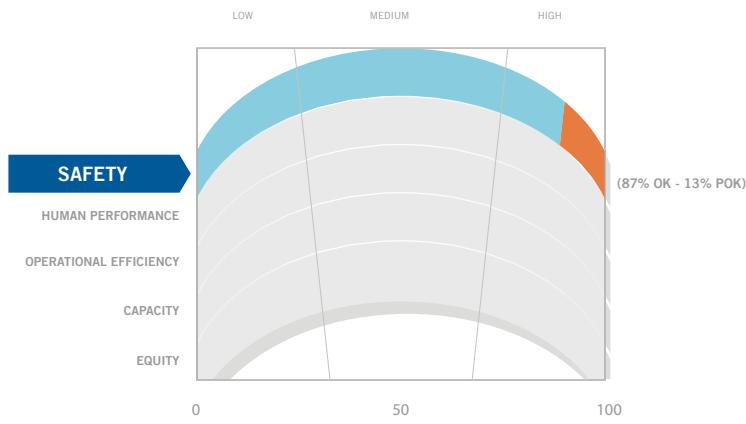
-  objectives fully achieved
-  objectives partially achieved

RESULTS OF SIMULATION ACTIVITIES: SAFETY

The graph below focuses on the results concerning the safety KPA; fifteen validation objectives were considered, including acceptability, overall safety levels, and ATOL procedures acceptability.

Most of the validation objectives were investigated both in nominal situation and in contingency. Overall, the simulations produced positive results and most of the validation objectives were fully achieved.

Two objectives were achieved partially: the safety in contingency objective, for which the ATCO and Remote Pilot (RPIL) suggested to follow manned Instrument Flight Rules (IFR), and recommended additional training; and the phraseology, with only one negative feedback collected from the RPIL.



ACCEPTABILITY		
IN NOMINAL CONDITIONS		
SAFETY LEVELS		
IN NOMINAL CONDITIONS		IN CONTINGENCIES
ATOL PROCEDURES ACCEPTABILITY		
IN NOMINAL CONDITIONS		IN CONTINGENCIES

C2-LINK AND R/T VOICE ACCEPTABLE LATENCY			
IN NOMINAL CONDITIONS			
ACCEPTABLE SAFETY LEVELS DURING RPA HANDOVER			
IN NOMINAL CONDITIONS			
PHRASEOLOGY ADEQUACY			
IN NOMINAL CONDITIONS			IN CONTINGENCIES

ADEQUACY OF INFORMATION PROVISION		
IN NOMINAL CONDITIONS		
IN CONTINGENCIES		
HUMAN CONTRIBUTION		
IN NOMINAL CONDITIONS		
IN CONTINGENCIES		
ATCO WORKLOAD		
IN NOMINAL CONDITIONS		
IN CONTINGENCIES		

SUCCESS CRITERIA

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ACHIEVEMENT LEVEL

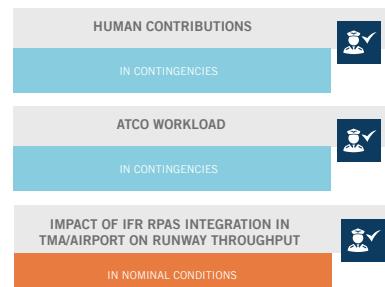
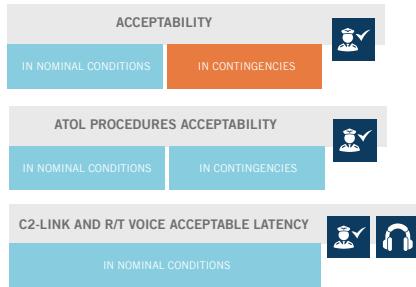
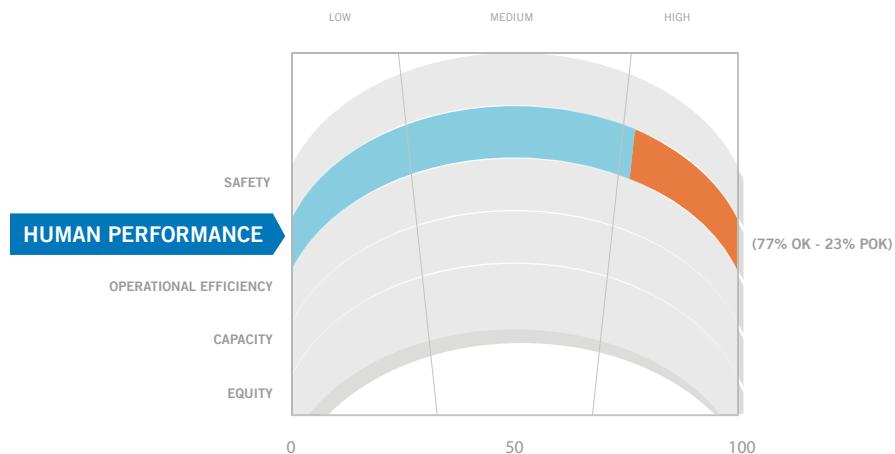
- | | |
|---|-------------------------------|
|  | objectives fully achieved |
|  | objectives partially achieved |

RESULTS OF SIMULATION ACTIVITIES: HUMAN PERFORMANCE

The next graph pertains the results of the human performance KPA and its thirteen validation objectives.

Again, many of the validation objectives were investigated in both nominal and contingency situations and overall, the simulations produced positive results, with most of the validation objectives fully achieved.

With regards to acceptability, the objective was partially achieved due to further research and investigation being necessary on the human-machine interface (HMI) of the Controller Working Position (CWP) especially in contingencies when a back-up communication line is used. As for phraseology, the need for additional RPAS specific phraseology in contingencies emerged, while for throughput the objective was achieved partially due to the RPAS performance differences to conventional/manned IFR traffic.



SUCCESS CRITERIA

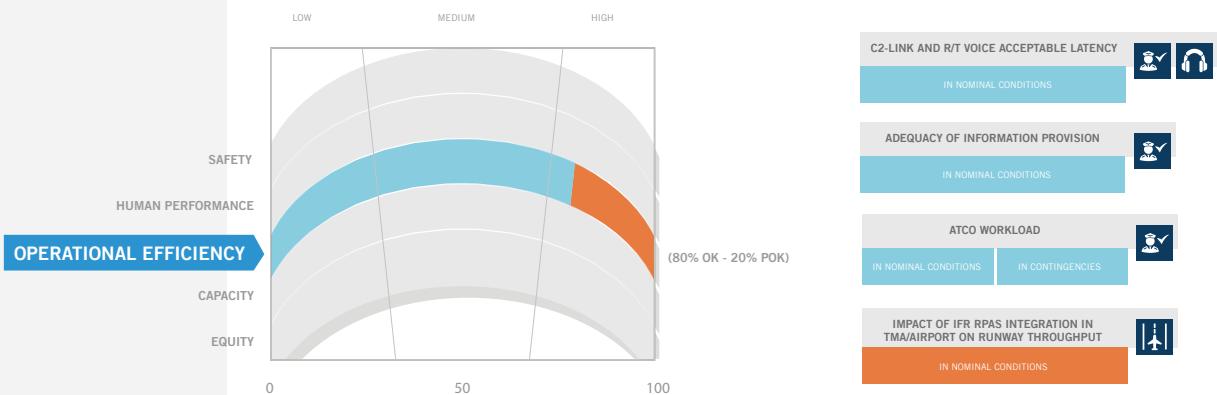
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ACHIEVEMENT LEVEL

- | | |
|--|-------------------------------|
|  LIGHT BLUE | objectives fully achieved |
|  ORANGE | objectives partially achieved |

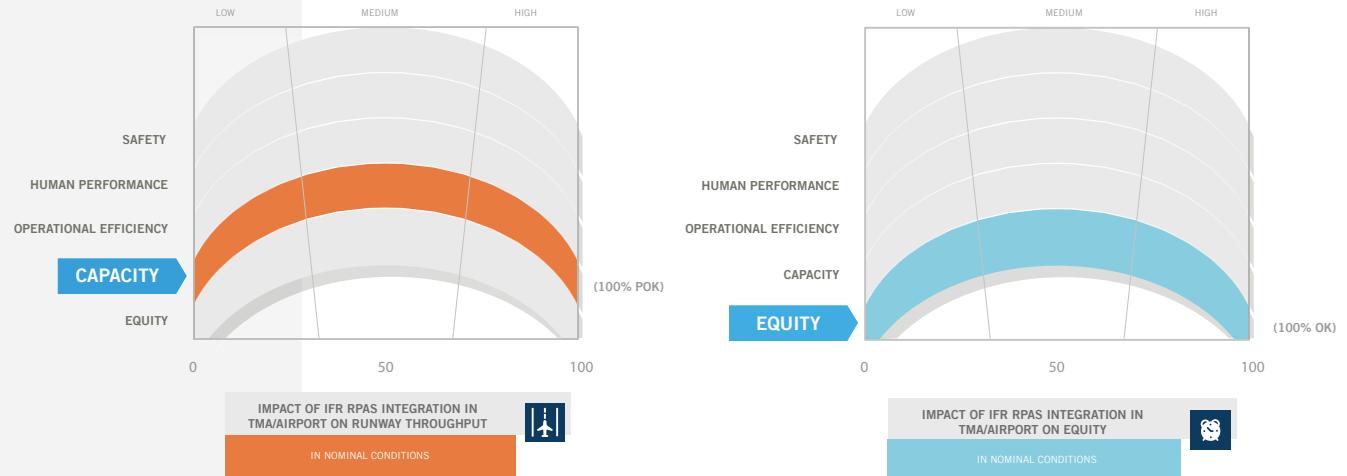
RESULTS OF SIMULATION ACTIVITIES: OPERATIONAL EFFICIENCY

Five validation objectives concern the operational efficiency KPA. Generally positive feedback was collected from pilots and ATCOs with regards to this KPA. In general, the runway throughput is maintained; despite the different performance between the simulated IFR RPAS and manned IFR traffic, ATCOs stated that in a situation of VFR and IFR mixed traffic the introduction of IFR RPAS does not represent an issue.



RESULTS OF SIMULATION ACTIVITIES: CAPACITY AND EQUITY

The capacity and equity KPAs were associated with one validation objective each. The impact of the integration of IFR RPAS on capacity was measured through runway throughput that was not negatively affected. ATCO feedback to the questionnaires reported differences in performance between the manned traffic and the considered RPAS; however, in a context where there is a mix of VFR and IFR traffic this should not represent an issue.



RESULTS OF SIMULATION ACTIVITIES PER SUCCESS CRITERIA

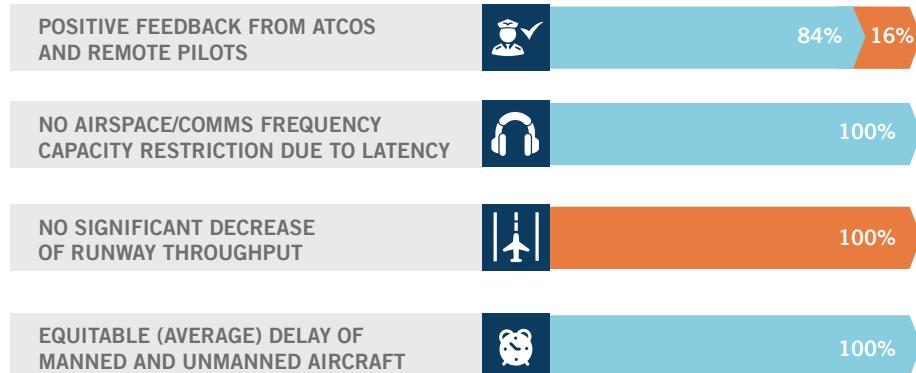
Finally, the results of the simulation activities are presented below aggregating the four success criteria used to assess the level of achievement of the validation objectives.

These criteria are transversal to KPAs, and their association with the validation objectives is shown in previous graphs.

Obviously, the achievement of success criteria reflects the results presented earlier. It is to be noticed that the last two success criteria are associated with one KPA each (capacity and equity respectively), and with one single specific validation objective.

ACHIEVEMENT LEVEL

LIGHT BLUE objectives fully achieved ORANGE objectives partially achieved



The INVIRCAT project will host its final public event next autumn in Rome, Italy.
Keep an eye on our website and social media to stay informed on the latest news about it.