

Validation Report

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Abstract

This report presents the results of the validation activities conducted within the HUCAN project for SESAR Solution 0445 – New holistic certification approach for novel ATM-related systems based on higher levels of automation. The validation was carried out remotely through the establishment and consultation of an Expert Group (EG), which provided feedback, comments, and suggestions regarding the validity, usefulness, and applicability of the proposed approach. The outcome of the validation was positive.

Overall, the experts acknowledged the value of promoting a certification-aware design approach for both system development and validation, as a means to support SESAR and non-SESAR projects in aligning with EASA's strategic objectives for AI certification in aviation. This approach is seen as instrumental in fostering consistency across SESAR projects, enabling a homogeneous application of certification principles throughout the development pipeline, and in enhancing synergies between

research and certification efforts. In particular, creating a continuum that spans from design to final certification, is expected to reduce the risks of gaps between innovation and compliance, thus contributing to speed up the innovation process.

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Author(s) of the document

Organisation name	Date
DBL	20.06.2025

Reviewed by

Organisation name	Date
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HUCAN

HOLISTIC UNIFIED CERTIFICATION APPROACH FOR NOVEL SYSTEMS BASED ON
ADVANCED AUTOMATION

HUCAN

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1 Executive summary

This document presents the validation results for SESAR Solution 0445 – *New holistic certification approach for novel ATM-related systems based on higher levels of automation*. This solution consists of a holistic and iterative certification-aware approach to design and validation that integrates strategic certification objectives from the early stages of ATM system development. The approach aligns with the building blocks identified in the EASA AI Roadmap 2.0, including human factors, accountability, responsibility, liability, safety, resilience, security, environmental sustainability, societal sustainability, and efficiency. By aligning design objectives with regulatory compliance from the outset, the solution facilitates efficient achievement of certification-readiness at the end of the development cycle. A dedicated toolbox complements the approach, collecting validation methods to support its application across R&I contexts.

The validation exercise, defined as TVAL.01.0[HUCAN]-[SOL.1]-TRL1, was conducted via a structured consultation involving an Expert Group (EG) and a Stakeholder Consultation Group (SCG). Targeting TRL2, the process combined the presentation of the HUCAN holistic approach with the collection of expert feedback—focusing on its validity, utility, and applicability.

The EG validated the approach, particularly its structured workflow, while recommending that the toolbox incorporate broader industry practices to enhance applicability beyond EU-funded R&I. The approach was recognised as a valuable mechanism to bridge the gap between research and certification, helping projects navigate regulatory expectations associated with automation and AI levels.

Based on expert feedback and project objectives, Solution 0445 is considered successfully validated. The EG gave either a positive or partially positive evaluation. Considering the TRL2 target, the validation outcome is deemed satisfactory.

2 Introduction

2.1 Purpose of the document

The HUCAN project proposes a novel approach for certification-aware design and validation of new ATM systems embedding higher levels of automation, including those based on AI and Machine Learning (ML). The proposed approach is intended to support both the approval/certification and the design phases of such technologies.

This document provides the validation report for **SESAR solution 0445 - New holistic certification approach for novel ATM related systems based on higher levels of automation**. It describes the results of the validation exercise defined in TVAL.01.0[HUCAN]-[SOL.1]-TRL1 and how it has been conducted, and provides a set of relevant conclusions and recommendations.

2.2 Intended readership

This document is addressed to the SESAR community, as well as to granting, regulatory, and certification bodies concerned with the scientific robustness of the proposed solutions. It aims to provide a contribution in promoting certification-aware design and validation approaches, thereby fostering future R&I in AI and high-level automation for aviation, and contributing to a more seamless transition from research to market deployment.

2.3 Background

SESAR Solution 0445 has drawn on the results previously developed within the project and documented in the following deliverables:

- D3.1 – *Certification methods and automation: benefits, issues and challenges*;
- D3.2 – *Innovative approaches to approval and certification*;
- D4.1 – *Case studies introduction: level of automation analysis and certification issues*; and
- D4.2 – *Performance-based requirements for advanced automation*.

2.4 Structure of the document

This document is structured into five sections. Following the introduction, readers will find an overview of the context of validation. This provides an overview of the SESAR solution 0445, as well as a brief description of the validation activities, and the deviations that have emerged. Next come the validation results and conclusions, complemented by a set of recommendations. A complete overview is available in the Executive Summary.

2.5 List of acronyms

Term	Definition
AA	Advanced Automation
AI	Artificial Intelligence
AMPLE3	SESAR3 ATM Master Planning and Monitoring
ANS	Air Navigation Service(s)
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
DES	Digital European Sky
DMP	Data Management Plan
EASA	European Union Aviation Safety Agency
EC	European Commission
ECTL	Eurocontrol
EG	Expert Group
ERP	Exploratory Research Plan
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment
GA	Grant agreement
HE	Horizon Europe
HF	Human Factor(s)
HRL	Human Readiness Level
HUCAN	Holistic Unified Certification Approach for Novel systems based on advanced automation
ID	Identifier
ISO	International Organization for Standardization
IT	Information Technologies

KPA	Key Performance Area
KPI	Key Performance Indicator
LOA	Level(s) of Automation
M	Month
ML	Machine Learning
MUAC	Maastricht Upper Area Control Centre
PEARL	Performance Estimation, Assessment, Reporting and simulation
PO	Project Officer
R&I	Research & Innovation
RMT	Rule Making Task
SESAR	Single European Sky ATM research
SESAR 3 JU	SESAR 3 Joint Undertaking
SRIA	Strategic Research and Innovation Agenda
TRL	Technology Readiness Level
VALP	Validation plan
VALR	Validation Report
WG	Working Group

Table 1. List of acronyms

3 Context of the validation

3.1 Preliminary remarks

The HUCAN project addresses the legal and regulatory challenges associated with increasing levels of automation in the ATM environment. This research initiative aligns with the Strategic Research and Innovation Agenda (SRIA) (SESAR JU, 2020), which highlights the need for new methodologies for the validation and certification of advanced automation (AA) that ensure transparency, address legal considerations, and guarantee robustness and stability under all conditions—particularly in operational ATM environments enabled by various Artificial Intelligence (AI)-based solutions. In response, the HUCAN project proposes a novel, holistic, and human-centred approach to the certification and approval of new ATM-related airborne and ground systems that incorporate higher levels of automation, including those based on AI and Machine Learning (ML).

From the beginning of the project, however, the legal framework on AI and advanced automation has considerably changed, especially in the European Union (EU). In particular, with the entrance into force of the EU AI Act (Reg. (EU) 2024/1689)², these evolutions have been affecting both the general audience as well as the aviation domain.

Accordingly, the project has read its objectives in light of these advancements, particularly focusing on the applicability of EASA strategic objectives for the certification of AI in aviation (EASA, 2023; EASA, 2024(a); EASA, 2024(b)) throughout the SESAR development pipeline.

This involved a review of the validation plan initially outlined in the Exploratory Research Plan (ERP – D1.2). In terms of substance, the strategy remains almost unchanged. However, it was necessary to slightly redefine the contents and the structure of the validation objectives, as well as the description of the exercises. All the occurred updates have been reported in the dedicated sections of this report.

In this regard, it is worth noting that HUCAN differs from other initiatives funded under the Capacity on Demand and Dynamic Airspace flagship. Rather than introducing a novel technical solution, the project builds on well-established methods and use cases to innovate the design and validation approach. This novel approach aims to support certification-aware design in R&D projects focusing on AI and advanced automation in aviation. In line with the initial agreement with the Project Officer (PO), the activities to validate the novel approach did not involve the use of SESAR enablers or the SESAR architectural framework. Given that achieving the expected level of maturity in HUCAN primarily relies on desk research and expert consultation, the Expert Group (EG) appeared to be the most suitable technique for validating these outcomes and adequate for a solution that has to reach TRL2 by the end of the project. By collecting qualitative data—such as expert opinions, comments, and suggestions—the EG enables an impartial and objective evaluation of the quality of the work. Additionally, the

² Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act).

Stakeholder Consultation Group established within the project has also been consulted to ensure broader validation and alignment.

In line with the guidelines provided by the European Commission (EC) on Ethics and Data Protection in EU-funded research projects, and the HUCAN policy on data protection (as outlined in the DMP – D1.1), this document does not disclose the names of the experts involved in the validation activities, but rather reports the number of people involved, their roles and areas of expertise, in order to balance transparency with privacy. Their feedback and comments are presented in anonymous and aggregated form.

3.2 SESAR solution 0445: a summary

The solution 0445 consists of a holistic and iterative design approach that gradually incorporates strategic AI certification objectives and requirements from the early stages of the development of ATM systems based on higher levels of automation. This approach covers the key performance areas identified in the EASA AI Roadmap 2.0 (EASA, 2023) and encompasses human factors, accountability, responsibility, liability, safety, resilience, security, environmental sustainability, societal sustainability, and efficiency. Aligning design objectives with compliance goals from the outset, the approach ensures that regulatory and safety standards are contextualized and met efficiently by the end of the development cycle. The solution is further complemented by a toolbox collecting the useful validation methods that can support the application of the proposed design approach.

The solution aims to reduce the gap between the research and the time to market by supporting the innovations throughout the concept development pipeline, promoting a consistent methodological approach across projects and leveraging the complementarities between research activities and certification processes.

The process workflow is represented by the figure below (Figure 1), where the following main elements can be discerned:

- **System Design.** System design is the start- and endpoint of the cycle by providing the basis for the assessment, as well as the updated design given the feedback from the assessment. In this context, the system is the overall AI-based sociotechnical system, meaning that it describes the functioning and interface of the AI-based system(s), the functioning and interaction with other technical systems, the roles, tasks and responsibilities of human operators, and the operational conditions for which the system is designed. The way that the design is changed is up to the design team and it is separated from the assessment of the design.
- **Assessment Compass.** This step sets the scene for the assessment by determining levels of automation, technology and human readiness levels (TRLs/TRLs), key performance areas, and certification objectives.
- **Holistic Assessment Cycle.** This cycle is the core of the framework by assessing multiple KPAs for critical scenarios of the sociotechnical system with (AI-based) advanced automation.
- **Feedback to Design.** Based on the combined KPA results from the holistic assessment cycle, this step identifies issues in the current design or it identifies/refines requirements or assurance levels towards a more mature design.

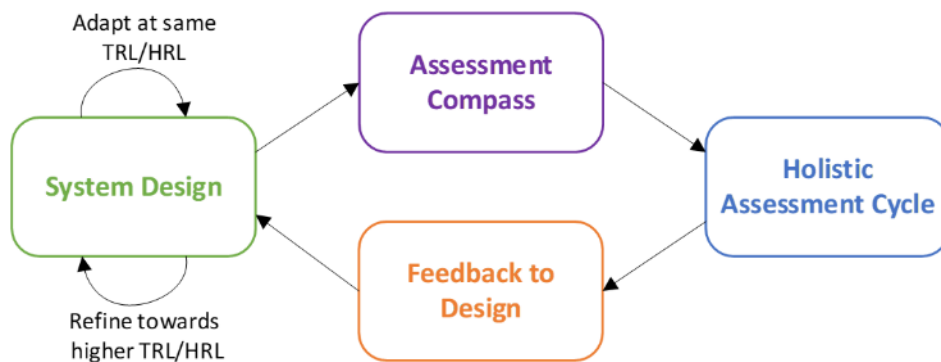


Figure 1. HUCAN holistic framework for certification-aware design.

The following figure (Figure 2) gives the overview of HUCAN approach in terms of the relations between system design and feedback to design from an holistic assessment cycle in support of transitioning to next technology/human readiness levels.

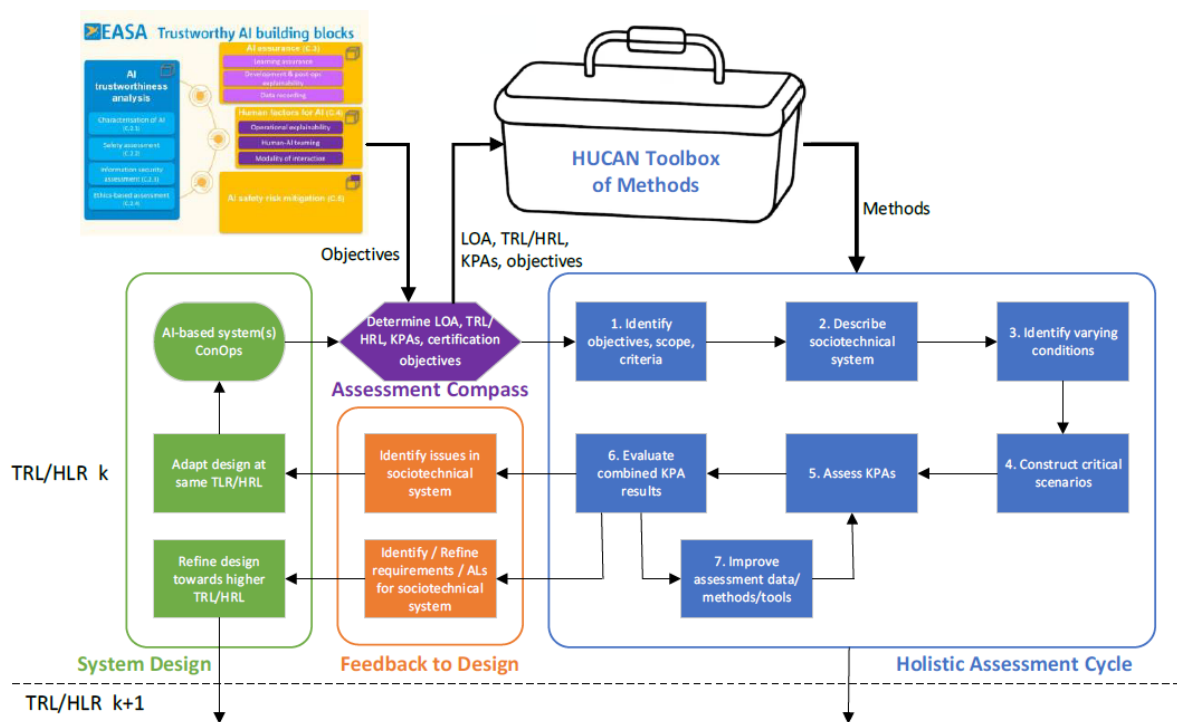


Figure 2. Steps in the HUCAN holistic framework for certification-aware design.

The support toolbox currently covers the following methods (Table 2).

Method	KPAs	TRL/HRL	LOA
ABMS (Agent-Based Modelling & Simulation)	Safety, Security, HF, Resilience	TRL 2-9 HRL 2-8	0 – 5

AI RMF (AI Risk Management Framework)	Accountability, Responsibility, HF, Safety, Security	TRL 4-9 HRL 4-9	0 – 5
BUSA (Bias, Uncertainty and Sensitivity Analysis)	All	TRL 2-9 HRL 2-9	0 – 5
Environmental Assessment of AI Ecosystem	Environmental sustainability	TRL 3-9	0 – 5
FMEA (Failure Modes and Effects Analysis)	Safety	TRL 3-6	0 – 5
FRAIA (Fundamental Rights and Algorithms Impact Assessment)	Societal sustainability	TRL 4-9 HRL 4-9	0 – 5
HAZOP (Hazard and Operability study)	HF, Safety	TRL 3-6 HRL 3-6	0 – 5
Heuristic Evaluations	HF, Safety, Efficiency	HRL 3-6	0 – 4
HITL (Human-In-The-Loop) Simulations & Wizard of Oz	HF, Safety, Efficiency	HRL 5-9	0 – 4
HTA (Hierarchical Task Analysis)	HF, Efficiency	HRL 3-6	0 – 4
NSV-4 diagram (System Functionality and Flow model)	Safety	TRL 2-6	0 – 5
Responsibility & Liability Analysis	Liability, Responsibility, Accountability	TRL 4-9 HRL 4-9	0 – 5
Safety Scanning and Security Scanning	Safety, Security	TRL 1-6 HRL 1-6	0 – 5
SecRAM (Security Risk Assessment Methodology)	Security	TRL 2-6	0 – 5
Usability Testing	HF, Safety, Efficiency	HRL 3-6	0 – 4

Table 2. List of validation methods in the toolbox and associated KPAs, TRL/HRL, LOA.

Further details on the process and the associated toolbox can be found in Deliverable D4.4 – *Holistic Approach to the Approval and Certification of Automated Systems*.

3.3 Summary of the validation plan

3.3.1 Validation plan purpose

For the validation of this solution, and in line with the selected validation technique, HUCAN organised a series of meetings and interviews with qualified experts to gather feedback, comments, and suggestions on the utility and applicability of the proposed approach, as well as on the supporting toolbox outlining useful validation methods to support its practical implementation.

These activities were conducted online, through both synchronous and asynchronous modes, and took place between M20 (April 2025) and M22 (June 2025), involving the following experts (Table 3) according to the validation plan as scheduled below (**Errore. L'origine riferimento non è stata trovata.**).

Organisation	Role	Expertise
EASA	ATM/ANS Expert	ATM/ANS
EASA	WG on EASA AI Roadmap	Software
EASA	WG on EASA AI Roadmap	ATM/ANS
EASA	WG on EASA AI Roadmap	HF
EASA	WG on EASA AI Roadmap	HF
ECTL-MUAC	Head of ATM Development	ATM/ANS
ECTL-MUAC	Cognitive Ergonomist	HF
Deep Blue	Head of Area	HF
Deep Blue	Head of Area	HF
Deep Blue	Head of Area	Environment

Table 3. Experts involved in validation activities.

Organisation	Activity	Purpose	Iterations
EASA	Online feedback collection meetings	Collecting feedback and comments from the regulatory bodies regarding the validity and utility of the HUCAN approach	2
ECTL-MUAC	Online feedback collection meetings	Collecting feedback and comments from developers and deployers regarding the	2

		validity and utility of the HUCAN approach	
ECTL-MUAC	Review of documents	Collecting feedback and comments from developers and deployers regarding the general utility and applicability of the HUCAN approach	1
Deep Blue	Online feedback collection meetings	Collecting feedback and comments from R&I experts on the validity and utility of the HUCAN approach, in relation to the specific needs of SESAR projects	3

Table 4. Validation plan and scheduling.

3.3.2 Summary of validation objectives and success criteria

Considering the evolving legal and regulatory framework throughout the HUCAN project, as well as the refinement of the project's initial positioning, the scope and description of the dedicated validation exercise have been revised from what was originally outlined in the ERP. As a result, the objective initially identified as TVAL.01.01—focusing on the general validation of the HUCAN approach to certification—has been divided into two distinct sub-objectives. The first, designated as OBJ-HUCAN-TRL2-TVAL.01.01, aims to assess the validity and utility of the approach with respect to certification needs in the aviation domain concerning AI and advanced automation. The second, OBJ-HUCAN-TRL2-TVAL.01.02, evaluates the broader utility and applicability of the approach within research and innovation (R&I) initiatives.

The table below (Table 5) provides the updated description of the validation objective TVAL.01.0 as currently structured and success criteria associated with the SESAR solution 0445.

Validation objective(s) ID	Validation objective(s)	Success criteria
OBJ-HUCAN-TRL2-TVAL.01.01	Assess the validity and utility of the HUCAN approach in light of the specific AI and AA certification needs and expectations in the aviation domain.	The EG provides positive feedback on the validity and utility of the HUCAN approach, in light of the specific AI and AA certification needs and expectations in the aviation domain
OBJ-HUCAN-TRL2-TVAL.01.02	Assess the general utility and applicability of the HUCAN approach into R&I initiatives, in general and within the SESAR framework	The EG provides positive feedback on general utility and applicability of the HUCAN approach into R&I initiatives, in general and within the SESAR framework

Table 5. HUCAN validation objectives and success criteria.

3.3.3 Validation assumptions

The HUCAN project is based on initial and intermediate assumptions which first emerged from a study of the state of the art, and were subsequently refined based on feedback collected with the support of the Stakeholder Consultation Group (SCG). The main assumptions that form the basis of the certification-aware approach to design and validation can be summarised as follows:

1. Future R&I projects focusing on AA and AI will increasingly be required to consider certification constraints and objectives from the earliest stages of system design. What is currently being observed is a growing awareness across the aviation research and innovation ecosystem that certification will no longer be an end-of-pipeline concern for solutions with a high maturity level, but rather an integral part of design planning, affecting strategic decisions throughout the development lifecycle.
2. Well-established certification processes are proving inadequate in the face of the challenges posed by highly automated solutions, particularly those based on AI. As documented by regulatory entities and granting authorities' initiatives, there is a growing need for adaptable, context-aware certification pathways that can be tailored to operational scenarios, technology maturity levels and automation profiles.
3. As certification becomes a strategic consideration from the outset, R&I actors will need to develop internal capabilities—not only in terms of technical expertise, but also regulatory literacy, particularly given the rapid evolution of regulatory ecosystems related to AI. Cross-functional collaboration (e.g., engineering, human factors, legal, ethics) will be essential to navigate this complexity.
4. The certification of solutions involving human-machine interaction in operational environments—particularly those with high levels of automation—requires novel design and validation approaches. These approaches should take into account the medium- and long-term implications of technology deployment, considering their impacts on the operational context, modes of use, ethical aspects of interaction, and the human operator's capacity to maintain or regain control when necessary.

Due to the maturity level of SESAR-SOL.0445, it was not possible to apply the method directly. As previously mentioned, the EG was therefore engaged to help investigate the project's contribution in relation to these assumptions, as part of a feedback collection exercise.

3.3.4 Validation exercises list

Considering the evolution of the legal and regulatory framework over the course of the HUCAN project, as well as the refinement of its initial positioning and objectives, the scope and description of the dedicated validation exercise have been revised compared to what was initially outlined in the ERP. The updated description is provided below (Table 6). The deviations with respect to the ERP follow in § 3.4.2.

Identifier	TVAL.01.0[HUCAN]-[SOL.1]-TRL1
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Title	Validation of the workflow of the certification-aware design and validation approach and the related methodological toolbox (D4.4).
Description	The feedback collection involves regulatory bodies, developers and deployers and SESAR R&I experts. The exercise is structured in two phases: • presentation of the HUCAN approach (process and toolbox) • collection of feedback, comments and suggestions
KPA/TA addressed	Human factors, accountability, responsibility, liability, safety, resilience, security, environmental sustainability, societal sustainability, and efficiency.
Addressed expected performance contribution(s)	The expected contribution(s) aim(s) to: • Assess the validity of the new approach • Assess the general utility of the new approach in R&I • Assess the applicability of the approach in R&I • Refine the approach, if needed
Maturity level	TRL2
Use cases	UC4
Validation technique	Expert group
Validation platform	N/A
Validation location	Online
Start date	M18
End date	M22
Validation coordinator	DBL
Status	<closed>
Dependencies	N/A

Table 6. Exercise SOL.1#

Linked Element Type	TVAL.01.0
<SESAR Solution>	TVAL.01.0
<Project>	HUCAN

<Sub-Operating Environment>	N/A
<Validation Objective>	OBJ-HUCAN-TRL2-TVAL-001

Table 7. Exercise SOL.1# Trace.

3.4 Deviations

3.4.1 Deviations with respect to the SESAR 3 JU project handbook

In line with the project objectives and research methodology as outlined in the proposal and approved in the GA, the Consortium has worked with the PO to proceed as described above. This approach, while deviating from the validation strategies conventionally adopted for concepts and technical solutions, has been mutually agreed.

3.4.2 Deviations with respect to the Exploratory Research Plan (ERP)

The deviation from the ERP can be summarised as follows:

- The UCs addressed by the project (D4.1) were utilised for the development of the certification-aware approach. Consequently, using only these scenarios for validating the approach would have compromised the substance and reliability of the final results.
- The scope of the first validation exercise (TVAL.01.0[HUCAN]-[SOL.1]-TRL1) was limited to UC4 – *Dynamic Allocation of Traffic between ATCO and System* – as this solution includes various dynamic automation modes, some of which are enabled by non-AI-based systems.
- The direct involvement of regulatory bodies, along with R&I experts familiar with the SESAR validation framework, offers more relevant and insightful information regarding the validity and usability of the approach for both its intended application and potential future use.

4 SESAR solution 0445 validation results

4.1 Summary of SESAR solution 0445 validation results

The table below (Table 8) summarizes the results of the validation exercise, with reference to the two sub-objectives of OBJ-HUCAN-TRL2-TVAL.01.0, as originally defined in D1.2 and subsequently updated and restructured in the present document (Table 6).

Due to the specific nature of the HUCAN project and the adopted validation strategy, the layout differs slightly from the template versions. In particular, the columns dedicated to SESAR solution validation objective title and SESAR solution success criterion ID were removed, since not applicable.

SESAR solution validation objective ID	SESAR solution success criterion	SESAR solution validation results	SESAR solution validation objective status
OBJ-HUCAN-TRL2-TVAL.01.01	The EG provides positive feedback on the validity and utility of the HUCAN approach, in light of the specific AI and AA certification needs and expectations in the aviation domain	The EG provided positive feedback	OK
OBJ-HUCAN-TRL2-TVAL.01.02	The EG provides positive feedback on general utility and applicability of the HUCAN approach into R&I initiatives, in general and within the SESAR framework	The EG generally provided positive feedback on the overall utility of the HUCAN approach. However, developers and deployers recommended adapting the toolbox to better align with current industrial validation practices, particularly to ensure its applicability in future R&I initiatives beyond the SESAR framework.	OK

Table 8. Summary of validation exercises results.

4.2 Detailed analysis of SESAR solution validation results per validation objective

4.2.1 OBJ-HUCAN-TRL2-TVAL.01.0 results

Overall, the EG provided positive feedback on the validity and utility of the HUCAN approach, particularly with regard to its process workflow. From a practical standpoint, developers and deployers offered suggestions to enhance the methodological toolbox. They noted that the current version of the toolbox may primarily reflect design and validation methodologies that are more familiar to the SESAR community but may not be fully aligned with other industry practices. However, industrial validation practices and standards may differ. Therefore, with a view to the potential evolution and consolidation of the HUCAN approach, they recommended taking these alternative references³ into account, in order to support the applicability of the solution beyond EU-funded research initiatives.

The following two tables summarise the key feedback from EG members, structured by validation sub-objectives and grouped according to their respective affiliations (Table 9).

OBJ-HUCAN-TRL2-TVAL.01.01		
Organisation	Feedback	Comment(s)/Suggestion(s)
EASA	Positive	The early integration of certification alignment into the initial development phases of solutions was perceived positively. This approach was considered potentially promising in fostering greater consistency across institutional guidance on AI within the R&I domain.
ECTL-MUAC	Positive	The approach was generally perceived as positive, particularly because it introduces a dedicated stage for considering emerging certification objectives related to AI. This allows for the identification and mapping of potential gaps within internal procedures and standards that may need to be addressed to meet those objectives.
Deep Blue	Positive	The themes of certification alignment and certification-aware solution design had not yet emerged as key concerns, but they contribute to raising awareness both in the application of the guidance provided by the EASA AI

³ For example, it was asked how the HUCAN approach could be used when, at the organizational level, structured and cohesive Safety Cases, IT Security Assessments, and Human Factors Assessments are required—also in compliance with Quality, Safety, and Security Management System standards.

OBJ-HUCAN-TRL2-TVAL.01.01		
Organisation	Feedback	Comment(s)/Suggestion(s)
		Roadmap within R&I initiatives and in supporting exploitation efforts within the SESAR framework.
OBJ-HUCAN-TRL2-TVAL.01.02		
Organisation	Feedback	Comment(s)
EASA	Positive	Overall, positive feedback was received during presentations and discussions regarding the general validity and usefulness of the approach. In particular, the project's efforts to clarify the points of alignment between EASA AI levels and automation levels were appreciated. Additionally, its contribution to facilitating certification-aware design throughout the entire design and development process was positively received.
ECTL-MUAC	Positive	Developers and deployers generally acknowledged the value and usefulness of the approach, as well as its potential to raise awareness of certification aspects and speed up the development pipeline. However, as they do not have specific expertise in this area, they also reported some difficulties in handling the outlined process and workflow for applying the new approach, and suggested complementing it with dedicated operative guidelines. With the same purpose of smoothing the integration of this approach, they also suggested refining the toolbox to better reflect current industrial validation practices and enhance its applicability in future R&I initiatives (e.g. Safety Case, IT Security Assessment and HF Assessment).
Deep Blue	Positive	There was general appreciation for the integration of certification considerations within the existing Key Performance Areas (KPs) typically used for solution design and validation in aviation. This approach was valued for building on existing expertise rather than requiring entirely new specialisations.

Table 9. OBJ-HUCAN-TRL2-TVAL.01.0 Results - Detailed overview

4.3 Confidence in validation results

4.3.1 Limitations of validation results

The HUCAN validation results offer valuable insights into the feasibility and potential benefits of supporting certification alignment in R&I initiatives since the early stages of development. However, some limitations restrict the generalisation of these findings:

- **Limited number of participants and interactions:** Due to scheduling and availability constraints, the number of experts directly consulted for validation, as well as opportunities for discussion, were limited.
- **Conditions affecting applicability:** Given the current maturity level and the availability of case studies, only a preliminary examination of challenges that may arise in the practical application of the method within R&I initiatives—both industrial and SESAR-related—was possible.

Overall, the validation confirms the feasibility of the HUCAN approach. Importantly, the limitations described above do not negatively impact the maturity assessment of the concept, given its current low maturity level—TRL2.

4.3.1.1 Quality of validation results

Validation results are primarily based on qualitative data and expert judgement opinions. This includes the feedback, comments and suggestions collected over the course of online meetings, review of documents and e-mail exchanges that occurred in the interaction with the members of the EG.

Considering the role of the organisations involved in the EG, the expertise of the individuals participating, and their experience with the topics addressed, the results collected can be assessed as **good** – reliable and relevant in relation to the project’s objectives and its final TRL.

4.3.1.2 Significance of validation results

Given the validation technique employed and the structure of the exercise, it is not possible to estimate the statistical significance of the collected data. Consequently, the considerations outlined in the previous paragraphs remain applicable.

5 Conclusions and recommendations

5.1 Conclusions

For the sake of clarity, this section consolidates the overall results obtained from the validation activities. Compared to the original SESAR template, this entails only minor deviations. Specifically, the findings related to Conclusions on SESAR solution maturity (5.1.1) and Conclusions on concept clarification (5.1.2) are presented in aggregated form within the general-level conclusions. As for the Conclusions on technical feasibility (5.1.3), within the scope of HUCAN these can only be outlined in preliminary terms and are summarised here in terms of applicability. The Conclusions on performance assessments (5.1.4) are not applicable.

Based on this and in light of the specific characteristics of the HUCAN project and the outcomes of the exchanges with the EG, it can be concluded that Solution 0445 – New holistic certification approach for novel ATM-related systems based on higher levels of automation has been successfully validated. This conclusion is supported by the fact that, with respect to validation objective OBJ-HUCAN-TRL2-TVAL.01, later restructured into sub-objectives OBJ-HUCAN-TRL2-TVAL.01.01 and OBJ-HUCAN-TRL2-TVAL.01.02, all consulted experts expressed either a positive (OK) or partially positive (partially OK) opinion.

As a general remark, there was a broad endorsement of the certification-aware design approach, recognising its potential not only to shorten the research and development timelines toward market readiness, but also to support a more informed approach to the implications stemming from the classification of automation and AI levels for the future certification of research outcomes.

Considering the nature of the solution and the targeted maturity level (TRL2), the validation is considered to have yielded an overall positive outcome.

Regarding the significance of these results in clarifying the concept, their main value lies in demonstrating the applicability of the methodology in R&I contexts, also beyond the SESAR framework. In this regard, it is recommended that the methods included in the toolbox be considered for broader adoption in industrial settings to support the implementation of certification-aware design strategies.

5.2 Recommendations

The following sections outline the key recommendations for further developing the certification-aware approach that was created within the HUCAN project.

5.2.1 Recommendations for next phase

For the next phase, it is recommended that the certification-aware approach and the related application process are complemented with dedicated operative guidelines. To further strengthen the applicability of the proposed approach, it is advisable to include more systematic integrations of the supporting methods within the toolbox, thereby enhancing its practical implementation in industrial settings. This should include identifying specific tools, processes or frameworks that can operationalise

the certification-aware design approach in various R&I contexts, both within and beyond the SESAR framework. Providing clear guidance on how these methodologies contribute to the validation pathway would enhance the approach's replicability, scalability, and broader adoption.

5.2.2 Recommendations on regulation and standardisation initiatives

It is recommended to closely monitor the evolution and consolidation of new elements introduced through the implementation of the guidance proposed by EASA, as well as by the EC, particularly in light of the ongoing work promoted under the Rule Making Task: RMT.0742 – *Artificial Intelligence Trustworthiness*. These developments are expected to play a key role in shaping the regulatory and certification landscape for AI-based systems in aviation.

In addition, it is advised to consider the contribution that international standardisation efforts, particularly those led by EUROCAE and ISO, can offer in supporting the achievement of certification objectives. Special attention should be paid to the ongoing work of EUROCAE WG-114, notably the upcoming **ED-324 – Process Standard for Development and Certification Approval of Aeronautical Products Implementing AI** (currently in draft, with a publication target date of 31/12/2025). Likewise, several ISO/IEC JTC 1/SC 42-related standards are of strategic relevance, including:

- **ISO/IEC 42001:2023 – AI Management System**
- **ISO/IEC 23894:2023 – Guidance on AI Risk Management**
- **ISO/IEC 23053:2022 – Framework for AI Systems Using Machine Learning**
- **ISO/IEC 42005:2025 – AI System Impact Assessment**

These emerging regulatory and standardisation frameworks can contribute significantly to further clarifying the references, objectives, and requirements necessary to support a certification-aware approach to design and validation. Maintaining alignment with such developments will help ensure that the approach remains robust, future-proof, and anchored in legal certainty and standardisation best practices.

From an internal perspective, SESAR has already launched a revision process of its validation methodologies, also in response to the specific challenges posed by AI-related features. In this regard, clear synergies can be identified between the work carried out within HUCAN and that developed under projects such as **AMPLE3 – SESAR3 ATM Master Planning and Monitoring** (GA ID 101114738) and **PEARL – Performance Estimation, Assessment, Reporting and Simulation** (GA ID 101114676). Monitoring the outcomes of these projects can help reinforce and further consolidate the approach developed by HUCAN. Conversely, the solutions and methods elaborated within HUCAN may provide valuable input for the operationalisation of results emerging from other initiatives, particularly in the context of promoting a certification-aware approach within SESAR.

5.2.3 Recommendations for future R&I activities

In view of the potential further development of HUCAN Solution 0445 within other R&I initiatives, it is recommended that the approach be applied to practical use cases and that lessons learned be collected in future activities.

6 References

6.1 Applicable documents

This VALR complies with the requirements set out in the following documents:

[Performance management](#)

- [1] SESAR 3 JU, Project Handbook, Edition 02.00, 19 December 2024

[Validation](#)

- [2] SESAR 3 JU, Project Handbook, Edition 02.00, 19 December 2024

[Programme management](#)

- [3] 101114762, HUCAN, Grant Agreement, 17.05.2023
- [4] SESAR 3 JU, Project Handbook, Edition 02.00, 19 December 2024

6.2 Reference documents

- [5] EC, Ethics and data protection (Guidance note), 5 July 2021
- [6] EASA, Artificial Intelligence Roadmap 2.0 – Human-centric approach to AI in aviation, Version 2.0, March 2023
- [7] EASA, EASA Concept Paper: Guidance for Level 1 & 2 machine learning applications. A deliverable of the EASA AI Roadmap, Issue 02, March 2024 [EASA 2024(a)]
- [8] EASA, EASA AI Days – High level conference, Cologne, Germany, 2nd and 3rd July 2024 (Day 1 Presentations) [EASA, 2024(b)]
- [9] HUCAN, Deliverable 1.1 – Data management plan, Edition 01.00, 30 November 2023
- [10] HUCAN, Deliverable 1.2 – Exploratory research plan, Edition 02.00, 29 February 2024
- [11] HUCAN, Deliverable 4.4 - Holistic approach to approval and certification of automated systems, Edition 01.00, 30 June 2025
- [12] SESAR JU, Strategic Research and Innovation Agenda – Digital European Sky, Luxembourg, September 2020.