



D3.2 Final workshop presentations of wave 2 catalyst-funded projects

Deliverable ID:	3.2
Dissemination Level:	PU
Project Acronym:	Engage
Grant:	783287
Call:	H2020-SESAR-2016-2
Topic:	SESAR-ER3-01-2016 Knowledge Transfer Network
Consortium Coordinator:	University of Westminster
Edition date:	29 January 2022
Edition:	01.00.00
Template Edition:	02.00.02

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N/A		

Document History

Edition	Date	Status	Author	Justification
01.00.00	29 January 2022	Release	Engage Consortium	New document for review by the SJU

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Engage

THE SESAR KNOWLEDGE TRANSFER NETWORK

This deliverable is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 783287 under European Union's Horizon 2020 research and innovation programme.



Abstract

This deliverable collates the final presentations of catalyst-funded wave 2 projects, given at Engage thematic challenge workshops and associated events.

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

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1 Introduction

1.1 Objectives of this document

The objective of this deliverable is to document the final presentations of catalyst-funded wave 2 projects, as presented at the Engage KTN's thematic challenge workshops and the 11th SESAR Innovation Days conference. The overall workshop planning, execution and results are described in the deliverable D2.7 [1], building on the planning and execution of the earlier series of workshops described in D2.6 [2].

Each catalyst-funded project has published a [final technical report](#) (i.e. a total of 18 reports over the two waves) and a consolidated view of these are presented in D3.6 [3] and the forthcoming D3.10 [4]. D3.6 highlights future research opportunities for ATM. The basic framework of this work is structured around three research pillars, namely: gap analysis, thematic challenges and horizon flagships – the consolidation of the catalyst-funded projects as one of these pillars is covered in detail by D3.6.

1.2 Catalyst funding wave 2 projects

Engage catalyst funding was used to support focused projects, where the focus was on maturing exploratory research further towards applications and operational contexts. These catalyst fund (CF) projects were chosen through the *second Call for catalyst funding*. Project proposals could address an Engage thematic challenge or be an 'open' topic. The choice of thematic challenges (TCs) is described in detail in deliverable D3.4 [5]. There are four thematic challenges:

- TC1: Vulnerabilities and global security of the CNS/ATM system,
- TC2: Data-driven trajectory prediction,
- TC3: Efficient provision and use of meteorological information in ATM,
- TC4: Novel and more effective allocation markets in ATM.

The TCs were further fine-tuned through the first series of workshops (described in deliverable D2.5 [6]), resulting in the TC descriptions that were included in the *first and second Calls for catalyst funding*. Proposals supporting a thematic challenge needed to clearly state with which challenge the proposal is aligned.

The second call documentation can be found [here](#). The call was open from 06 January 2020 to 06 April 2020, receiving 21 proposals. The evaluation process was carried out by the Awards Board and was concluded in May 2020, with notifications of the outcome sent to all proposers. Eight proposals were accepted to receive catalyst funding through the second wave, see Table 1. The projects' **abstracts**, **executive summaries** and **final technical reports** can be found here: engagektn.com/cf-summaries, under 'Second wave projects (2020-2021)'.

The following sections contain short descriptions of TC workshops, project summaries and the presentations. Final project presentations are available in PDF format and are attached to this report. The link to the Engage KTN website repository of TC workshop presentations, is also given.

Table 1. Catalyst-funding wave 2 projects, TC relation, end date and final presentation date

Project title	TC	End date	Workshop – final presentation
Proof-of-concept: practical, flexible, affordable pentesting platform for ATM/avionics cybersecurity ('ATM-cybersec')	1	30 June 2021	3 rd TC1 workshop 15 September 2021
Safe drone flight - assuring telemetry data integrity in U-Space scenarios ('SDF')	1	02 July 2021	
Collaborative cyber security management framework	1	31 May 2021	
Flight centric ATC with airstreams ('FC2A')	2	30 June 2021	11 th SESAR Innovation Days 07 December 2021
Probabilistic information Integration in Uncertain data processing for Trajectory Prediction ('PIU4TP')	2	30 June 2021	
Meteo Sensors In the Sky ('METSIS')	3	30 June 2021	
Weather impact prediction for ATFCM ('WIPA')	3	30 June 2021	
Role of Markets in AAS Deployment ('RoMiAD')	4	30 June 2021	3 rd TC4 workshop 21 June 2021

2 Thematic challenge 1 catalyst fund projects

The third TC1 workshop was held as a virtual event, on 15 September 2021. The TC1 objectives are: “CNS/ATM components (e.g., ADS-B, SWIM, datalink, Asterix) of the current and future air transport system present vulnerabilities that could be used to perform an ‘attack’. Further investigations are necessary to mitigate these vulnerabilities, moving towards a cyber-resilient system, fully characterising ATM data, its confidentiality, integrity and availability requirements. A better understanding of the safety-security trade-off is required. Additional security assessments for legacy systems are also needed to identify possible mitigating controls in order to improve cyber-resilience without having to replace and refit. Future systems security by design is essential: a new generation of systems architectures and applications should be explored to ensure confidentiality, cyber-resilience, fault tolerance, scalability, efficiency, flexibility and trust among data owners. Collaborative, security-related information exchange is essential to all actors in aviation. This is specially challenging in a multi-stakeholder, multi-system environment such as ATM, where confidentiality and trust are key.” All workshop presentations can be found, as a zipped file, here: <https://innaxis-comm.s3.eu-central-1.amazonaws.com/ENGAGE/Engage-TC1-workshop-3-presentations.zip>.

2.1 Proof-of-concept: practical, flexible, affordable pentesting platform for ATM/avionics cybersecurity ('ATM-cybersec')

Abstract: During the last decade, cybersecurity started to increasingly become an issue because many ATM/ATC/aviation stakeholders rely on electronic systems for critical parts of their operations, including safety-critical functions in avionics and related software/firmware. This project aims at closing this gap by developing a proof-of-concept practical, flexible, affordable pentesting platform for ATM/avionics cybersecurity. For this purpose we have developed from scratch a novel and unique end-to-end early stage (TRL3-4) platform as well as a comprehensive hardware/software testbed. With these, we have performed several hundreds of experimental iterations and developed four novel attacks while implementing altogether more than ten attacks. After pentesting more than 120 cumulative testbed configurations, we have discovered more than 40 vulnerabilities (e.g., Denial-of-Service, crashes, hangs) and a handful of logical and implementation bugs, all these posing imminent, realistic and dangerous cyber-physical threats to safe aviation/ATM/ATC. We also successfully repurposed our platform for defensive mechanisms, such as 'RSS-Distance' model for detecting fake/spoofed ADS-B messages. Our methodologies and results are thoroughly documented in three distinct research manuscripts that currently undergo academic peer-review.



“Proof of concept: practical, flexible, affordable pentesting platform for ATM/avionics cybersec”

Andrei Costin (ancostin@jyu.fi)
15.9.2021

15.9.2021

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Figure 1. ATM-cybersec – final presentation (click image to open the pdf file)

2.2 Safe drone flight - assuring telemetry data integrity in U-Space scenarios ('SDF')

Abstract: The Safe Drone Flight ('SDF') project was led by NATS in collaboration with The Open University (OU) and funded by the SESAR Engage Knowledge Transfer Network (KTN) catalyst. The project investigated the security of unmanned flight surveillance systems and, in particular, the drone telemetry data they transmit. Developing a safety assured and cyber secure surveillance system is an important step in enabling U-space services, supporting safe, efficient and secure access to airspace for large numbers of drones. This project matured a prototype blockchain-based drone surveillance system taking a U-space scenario-based approach to simulate several drone operations and validate the concept's suitability. Cyber security and safety assurance related research was conducted to determine data integrity-related design and performance requirements on the solution respectively.

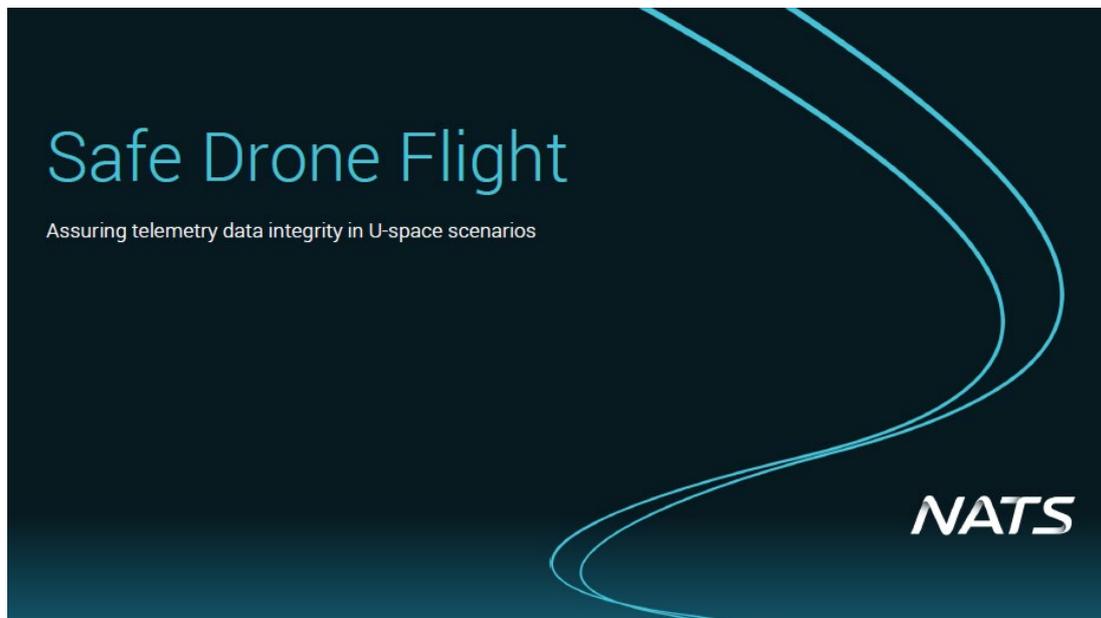


Figure 2. Safe Drone Flight – final presentation (click image to open the pdf file)

2.3 Collaborative cyber security management framework

Abstract: To support the safety of the ATM system, the future ATM architecture needs to deliver an exceptionally high level of cyber security. The objective of this project was therefore to advance cyber security management in several directions: (a) to develop a more collaborative approach to cyber security management; (b) to prototype these collaborative approaches; and (c) to adapt SESAR's existing risk assessment methodology, 'SecRAM', to more quantitative methods, from which Bayesian Network analysis could be applied. The outputs of the project were a concept of operations for collaborative security management, a basic prototype for collaborative security management, and an approach for the application of Bayesian Networks. The prototype was developed to support a risk assessment that could be done in collaboration between several partners, such as by the members of a SESAR Solution Project. The outcome of the project is a step forward in information sharing, productivity and methods of knowledge exchange in cyber security.



Collaborative cyber security management framework

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 783287

Figure 3. Collaborative cyber security management framework – final presentation (click image to open the pdf file)

3 Thematic challenge 2 catalyst fund projects

The fourth workshop was held on 03 September 2021 as a virtual event. The TC2 objectives are: “Accurate and reliable trajectory prediction (TP) is a fundamental requirement to support trajectory-based operations. Lack of advance information and the mismatch between planned and flown trajectories caused by operational uncertainties from airports, ATC interventions, and ‘hidden’ flight plan data (e.g., cost indexes, take-off weights) are important shortcomings of the present state of the art. New TP approaches, merging and analysing different sources of flight-relevant information, are expected to increase TP robustness and support a seamless transition between tools supporting ATFCM across the planning phases. The exploitation of historical data by means of machine learning, statistical signal processing and causal models could boost TP performance and enhance the TBO paradigm. Specific research domains include machine-learning techniques, the aggregation of probabilistic predictions, and the development of tools for the identification of flow-management ‘hotspots’. These could be integrated into network and trajectory planning tools, leading to enhanced TP.” To make room in the limited agenda for this virtual event, with a focus on specific themes, all CF project members were invited to participate in the workshop, whilst it was decided to showcase the CF work itself as part of the Engage presentation at the 11th SESAR Innovation Days conference on 07 December 2021. The conference presentation can be found here: <https://westminsterresearch.westminster.ac.uk/item/vqv0x/the-engage-ktn-achievements-lessons-and-legacy> (and [YouTube recording](#)).

3.1 Flight centric ATC with airstreams ('FC2A')

Abstract: The project addresses a challenging approach for an environmentally friendly and more agile ATM framework by combining a Flight Centric ATC (FCA) approach and the Airstream concept. The day-to-day adaptation of the Airstream network to the demand of the airspace users will provide a resilient and scalable system for supporting Dynamic Airspace Configuration (DAC). Driven by the digitalisation of ATM, autonomous management of aircraft inside the Airstream is promoted. A computational framework is implemented for the evaluation of the concept. New aggregation methodologies are proposed for extracting main traffic flows (aggregated flights) from the initial demand. A simple mechanism for building the tri-dimensional structure of the Airstream network and flight allocation is then applied using the aggregation results. New trajectories of the Airstream network traffic are ultimately produced. Finally, comparison of the various traffic samples (i.e. original versus airstream) is performed through complexity evaluation. The metrics used, based on geometric information approach, have been improved for large spherical areas.



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Figure 4. FC2A – final presentation (click image to open the pdf file)

3.2 Probabilistic information Integration in Uncertain data processing for Trajectory Prediction ('PIU4TP')

Abstract: The objective of the PIU4TP project is the development of a data-driven methodology for the trajectory prediction from long to short term before scheduled time of flight. Specifically, the methodology uses machine learning and data mining techniques to perform data analysis and to learn from past experience the aircraft future behaviour in terms of flight path selection. Therefore, it exploits historical data and uncertainties of current forecasts of some relevant mission and aircraft parameters to compute trajectory prediction outcomes enriched with associated probabilistic information. The project's final aim is to build a methodology that can support the Network Manager with air traffic flow and capacity management, allowing the optimisation of flight distribution among sectors and flight routes, the anticipation of air traffic flow requests and the identification in advance of potential conflicts.



PIU4TP

Probabilistic information Integration in Uncertain data
processing for Trajectory Prediction

- Funder: **SESAR Engage KTN – second Call for catalyst funding**
- Thematic challenge 2: **Data-driven trajectory prediction**
- Partner: **CIRA – Italian Aerospace Research Centre**
- Start Date: 01/07/2020
- End Date: 30/06/2021

The PIU4TP project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 783287.



Figure 5. PIU4TP – final presentation (click image to open the pdf file)

4 Thematic challenge 3 catalyst fund projects

The fourth workshop was held on 09 September 2021 as a virtual event. The TC3 objectives are: “The main objective of this challenge is to improve overall ATM system performance by providing better user-support tools based on improved meteorological (‘met’) products. The focus is on the synergy of several methods and techniques in order to better meet the needs of operational users and to support aviation safety (e.g., through creating early warning systems) and regulation-makers (e.g., moving from text-based to graphical information provision). All stakeholders may benefit from this synergy: ANSPs (e.g., sector reconfiguration and separation provision), airlines (e.g., storm avoidance), airport operators (e.g., airport management under disruptive events), and the Network Manager (e.g., demand-capacity balancing). The challenge is, therefore, to bring the following perspectives closer: (a) for meteorological/atmospheric science, the development of products tailored to ATM stakeholders’ needs, which are unambiguous and easy to interpret; (b) for stakeholders, the identification of the most suitable information available and its integration into planning and decision-making processes.” To make room in the limited agenda for this virtual event, with a focus on specific themes, all CF project members were invited to participate in the workshop, whilst it was decided to showcase the CF work itself as part of the Engage presentation at the 11th SESAR Innovation Days conference on 07 December 2021. The conference presentation can be found here: <https://westminsterresearch.westminster.ac.uk/item/vqv0x/the-engage-ktn-achievements-lessons-and-legacy> (and [YouTube recording](#)).

4.1 Meteo Sensors In the Sky ('METSIS')

Abstract: The Meteo Sensors in the Sky (METSIS) project explores the use of drones as a wind sensor network for U-space applications. The novel concept aims to provide accurate and low-cost wind nowcasts for drones using data collected by drones themselves, i.e., 'wind nowcasts for drones by drones'. A proof-of-concept flight-test experiment was performed using four drones to determine the feasibility of the METSIS concept at low altitudes. In the current incarnation, ultrasonic anemometers were mounted to each drone to measure local winds. The flight-tests evaluated the effect of obstacle-induced wind distortion, drone motion, measurement density, and measurement errors. Additionally, wind fields estimated during the flight-tests were published in real-time to the AirHub Drone Operations Center – a functional U-space Service Provider – to demonstrate the communication of these data to real end-users. The results indicate that the METSIS concept is a promising solution for wind nowcast component of the U-space weather information service. Future research should investigate the accuracy of the concept for a wider range of scenarios than considered here, and develop the technologies needed to increase the scalability of the concept.

METSIS
 METeo Sensors In the Sky

Investigating the use of drones as an aerial sensor network for low altitude hyper-local wind now-casting

Consortium
 nlr AirHub

Advisory Board
 TU Delft Koninklijk Nederlands Meteorologisch Instituut
 Ministerie van Infrastructuur en Waterstaat

11th SESAR Innovation Days
 SESAR JOINT UNDERTAKING Engage founding members

Figure 6. METSIS – final presentation (click image to open the pdf file)

4.2 Weather impact prediction for ATFCM ('WIPA')

Abstract: The WIPA – Weather Impact Prediction Tool for ATFCM initiative – has been launched by MetSafe and France Aviation Civile Services, in collaboration with Reims and Marseille Upper Area Control Centres. This one-year project addressed how the provision of weather hazards impact information on air traffic control sectors in intervals of one hour over the ATFCM horizon. To do so, WIPA considered the convection information as an input provided by the MET Enhanced ATFCM product (developed during the first catalyst wave), additional MET information (as real-time convection observation and SIGMET), and ATM information. The research approach focused on both technical and operational aspects, as needs identification, design of the tool and deployment via a SWIM webservice. Technical and operational validation trials showed that initial project objectives have been fulfilled: Reims and Marseille ATCOs and FMP operators highly improved their weather situational awareness and would likely have taken ATFCM measures based on received information.



July 1st, 2020 to July 30th, 2021

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Figure 7. WIPA – final presentation (click image to open the pdf file)

5 Thematic challenge 4 catalyst fund project

The third TC4 workshop was held as a virtual event, on 21 June 2021. The TC4 objectives are: “This research explores the design of new allocation markets in ATM, taking into account real stakeholder behaviours. It focuses on designs such as auctions and ‘smart’ contracts for slot and trajectory allocations. It seeks to better predict the actual behaviour of stakeholders, compared with behaviours predicted by normative models, taking into account that decisions are often made in the context of uncertainty. Which mechanisms are more robust against behavioural biases and likely to reach stable and efficient solutions, equitably building on existing SESAR practices? The research will address better modelling and measurement of these effects in ATM, taking account of ‘irrational’ agents such as airline ‘cultures’. A key objective is to contribute to the development of improved tools to better manage the allocation of resources such as slots and trajectories, and incentivising behaviour that benefits the network – for example by investigating the potential of centralised markets and ‘smart’ contract enablers.” All workshop presentations and material can be found, as a zipped file, here: <https://innaxis-comm.s3.eu-central-1.amazonaws.com/ENGAGE/Engage-TC4-workshop-3-material.zip>.

5.1 Role of Markets in AAS Deployment ('RoMiAD')

Abstract: Virtualisation provides a path for air navigation service providers (ANSPs) to address the implementation of the open architecture proposed by the Airspace Architecture Study (AAS). Project RoMiAD has developed an understanding of the high-level benefits of deploying the distributed architecture proposed by the AAS and potential mechanisms to incentivise the organisational reengineering necessary to achieve a Digital European Sky whilst ensuring national sovereignty over airspace. During the course of Project RoMiAD, it has become clear that if virtualisation had been adopted before 2018 across Europe – ATM costs could have been 30% cheaper and there would have been no significant en-route delay – only unremovable delay would have remained e.g. caused by weather. 75% of the benefits come from improvements in the air traffic services (ATS) layer – increasing Air Traffic Controller Officer (ATCO) productivity and capacity sharing – and are best enabled by the flexibility that the common data layer provides. The focus to achieve the benefits needs to be on building alliances and collaborations within the ATS layer to ensure that the common data layer can support those collaborations.

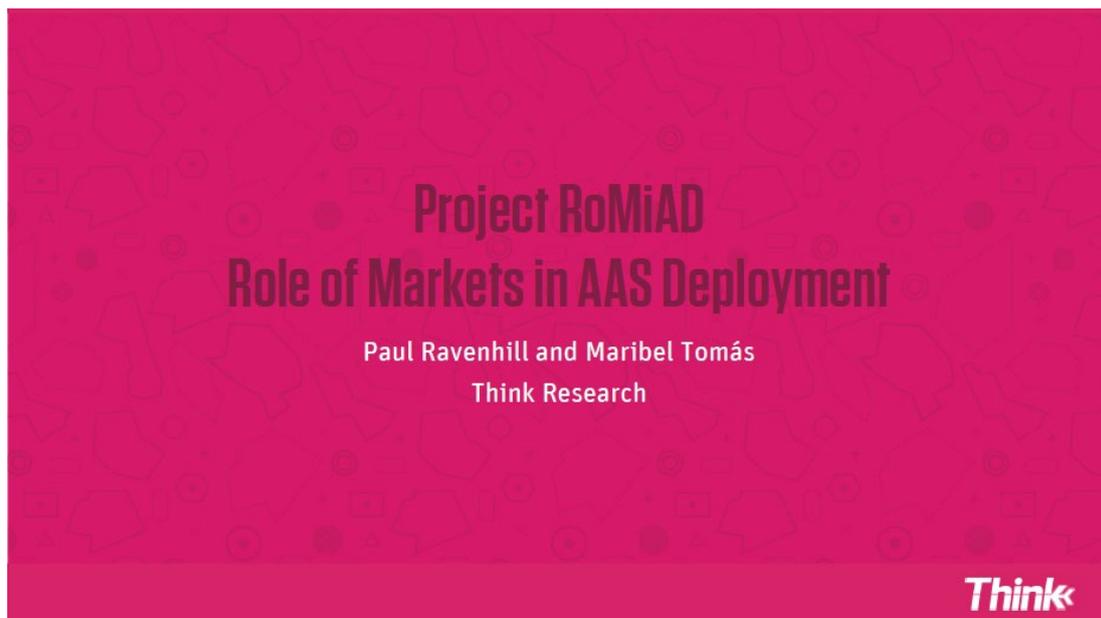


Figure 8. RoMiAD – final presentation (click image to open the pdf file)

6 Conclusions

This deliverable collates the final presentations of the eight CF wave 2 projects, whereas the wider lessons learned and research-focused conclusions are presented in D3.6 [3] and the forthcoming D3.10 [4].

As with the earlier wave 1 projects, final reports were assessed within the Engage KTN consortium and were of a high standard with few clarifications requested. As planned, final technical reports have been published on the Engage website after approval: engagektn.com/cf-summaries.

In addition to final reporting and final presentations at the Engage TC workshops and the SESAR Innovation Days conference, CF wave 2 project results have been presented at other workshops and various events such as the Amsterdam Drone Week and Meteorological Technology World Expo, with results positively received by the audiences.

Plans are in place for project results to be tested through industrial applications, such as NATS' *Safe Drone Flight* project. The France Aviation Civile Services-led CF wave 1 *MET Enhanced ATFCM* project results are being exploited by a SWIM webservice, and their follow-on wave 2 *WIPA* project's results have already been industrialised within *VigiAero* – an operational ATFCM weather-impact service, by consortium partner MetSafe.

Following the extension of CF wave 1 project results into a number of ER4 projects, such as *ALARM* and *SINOPTICA*, it is anticipated that CF wave 2 project results will also be extended into larger exploratory research projects, funded through future Calls. The setting up of specific fora in the [EngageWiki](#) that correspond to topics in such Calls, could be used to facilitate information exchange and the initial nurturing and scoping of proposal ideas.

7 References

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8 Acronyms

AAS	Airspace Architecture Study
ADS-B	Automatic Dependent Surveillance-Broadcast
ANSP	Air navigation service provider
ATC	Air traffic control
ATCO	Air Traffic Control Officer
ATFCM	Air traffic flow and capacity management
ATM	Air traffic management
ATS	Air Traffic Services
CF	Catalyst fund
CNS	Communication, navigation, surveillance
DAC	Dynamic Airspace Configuration
ER	Exploratory Research
FCA	Flight Centric ATC
FMP	Flow Management Position
KTN	Knowledge Transfer Network
MET	Aviation meteorology
SESAR	Single European Sky ATM research
SIGMET	Significant Meteorological information
SJU	SESAR Joint Undertaking
SWIM	System Wide Information Management
TBO	Trajectory-based operations
TC	Thematic challenge
TP	Trajectory prediction
TRL	Technology readiness level



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