D5.25 Engage 2 Open Science - Interim Report

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Abstract

This interim report presents the progress of Open Science implementation in the Engage 2 project (Task 5.6). In line with the Engage 2 Open Science Strategy (D5.24) and the H2020 OSCAR Code of Conduct, the consortium has advanced work across the seven core pillars of Open Science: open access, open data, open source, open methodology, open peer review, open educational resources, and citizen science. Key achievements include the launch of the Open Science tracking tool, the implementation of a stakeholder survey on open data, the expansion of the Engage Wiki as a central hub, and the publication of the first Diamond Open Access article. Awareness-raising activities during workshops have further supported community engagement, with strong interest in the planned Open Science Alliance (75% of survey respondents willing to join). While several practices remain at an early stage, the consortium has laid the foundations for broader adoption. This report also defines measurable targets and timelines for each pillar, providing clear direction for the next phase and supporting the overall aim of building a transparent, collaborative, and reproducible Air Traffic Management (ATM) research ecosystem.

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Copyright Statement

Engage 2

THE SESAR 3 KNOWLEDGE TRANSFER NETWORK

Engage 2

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List of Acronyms

Acronym	Description
AAT	Aeronautics and Air Transport
ADS- B	Automatic Dependent Surveillance–Broadcast
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management
BADA	Base of Aircraft Data
CC	Creative Commons
DDR2	Demand Data Repository 2
DOI	Digital Object Identifier
ECSA	European Citizen Science Association
ECTL	EUROCONTROL
EJTIR	European Journal of Transport and Infrastructure Research (EJTIR)
EOSC	European Open Science Cloud
ER	Exploratory Research
EU	European Union
FAIR	Findable, Accessible, Interoperable, and Reusable
H2020	Horizon 2020 research programme
JOAS	Journal of Open Aviation Science
NDA	Non-Disclosure Agreement
OA	Open Access
OS	Open Science
OSCAR	Open Science Aeronautics and Air Transport Research
PRC	Performance Review Commission

PRU	Performance Review Unit
R&D	Research and Development
S3JU	SESAR 3 Joint Undertaking
SESAR	Single European Sky ATM Research
SIDs	SESAR Innovation Days
SJC	SESAR Joint Coordination
SME	Small and Medium-sized Enterprise

Glossary of Terms

Term	Definition
Citizen Science	The active involvement of non-professional scientists or the wider public in aspects of research, fostering inclusiveness, outreach, and engagement.
Creative Commons (CC) Licence	A standard open licence (e.g., CC BY 4.0) that specifies how works such as publications or educational resources may be used, adapted, and redistributed.
Data Management Plan (DMP)	A structured document describing how research data are collected, stored, shared, licensed, and preserved during and after the project lifecycle.
Diamond Open Access	A model of Open Access publishing in which neither authors nor readers pay publication costs; expenses are covered by institutions, societies, or funders.
Digital Object Identifier (DOI)	A persistent identifier used to uniquely identify and provide a permanent link to digital research objects such as publications or datasets.
Engage Wiki	The Engage 2 project's online platform serving as a central repository for Open

	Access publications, datasets, Open Educational Resources, and other outputs supporting Open Science.
European Open Science Cloud (EOSC)	An EU initiative providing a federated environment for researchers to publish, find, and reuse data, services, and tools for Open Science.
FAIR Principles	A framework for data management ensuring that outputs are Findable, Accessible, Interoperable, and Reusable.
Green Open Access	Self-archiving of research outputs (e.g., accepted manuscripts) in repositories, sometimes after an embargo period.
Open Access (OA)	The practice of making research outputs freely available online without subscription or payment barriers, enabling broader dissemination and reuse. Covers different forms of Open Access, such as Green, Gold, and Diamond.
Open Data	Research data that are shared publicly in line with FAIR principles ("as open as possible, as closed as necessary"), allowing others to find, access, reuse, and build upon them.
Open Educational Resources (OER)	Teaching, training, and learning materials that are openly licensed (e.g., under Creative Commons), enabling free access, adaptation, and redistribution.
Open Methodology	Transparent sharing and documentation of research methods, designs, hypotheses, and processes to improve clarity, reproducibility, and trust.
Open Peer Review (OPR)	A peer review process where reports, reviewer identities, or editorial decisions are made openly accessible to increase transparency and accountability.

Open Research Europe	The European Commission's publishing platform for Horizon-funded research outputs, offering immediate Open Access without author fees.
Open Science (OS)	An overarching approach to research that promotes transparency, accessibility, collaboration, and reproducibility. It includes practices such as Open Access, Open Data, Open Source, Open Methodology, Open Peer Review, Open Educational Resources, and Citizen Science.
Open Science Alliance (for ATM)	A collaborative community initiative promoted in Engage 2 to support openness, reproducibility, and transparency in Air Traffic Management research.
Open Source	The practice of making software and code developed in research openly available under licences that allow use, modification, and redistribution.
OSCAR Code of Conduct	The "Open Science Aeronautics and Air Transport Research Code of Conduct," developed under H2020 OSCAR, which provides a framework for implementing Open Science in ATM research.
Zenodo	An open-access repository (operated by CERN and OpenAIRE) used for sharing datasets, software, and publications with Digital Object Identifiers (DOIs).

1 Introduction

This interim report presents the current status, progress achieved, challenges encountered, and key lessons learned in implementing Task 5.6: Implementation of Open Science under the Engage 2 project.

Task 5.6 supports Engage 2's overarching goal to bridge the gap between academia and industry, while fostering a future-ready Air Traffic Management (ATM) research ecosystem rooted in transparency, collaboration, and innovation.

Central to this task is the practical application and critical evaluation of the H2020 OSCAR Open Science Code of Conduct, a key framework developed to promote openness and reproducibility in European Aeronautics and Air Transport (AAT) research.

Since the start of the task, the Engage 2 consortium has undertaken structured activities aimed at operationalising the principles of Open Science within ATM research. These include assessing the applicability of the OSCAR guidelines in a real-world project context, identifying potential barriers and enablers to Open Science practices, and conducting stakeholder engagement activities through surveys and consultations.

This report synthesizes the findings and implementation to date, providing insights into how Open Science is currently practiced within the Engage 2 project, where the implementation gaps lie, and what practical steps can be taken to enhance adoption across the sector.

This document also serves as a foundational milestone in a phased implementation approach, whereby the strategy and practices established here will be refined and evolved throughout the life of the Engage 2 project. The findings and insights from this report will directly inform the preparation of the final deliverable, D5.6 (Engage 2 Open Science – Final Report, M54), supporting the formulation of well-founded, scalable, and actionable recommendations for advancing Open Science implementation in future ATM research.

Co-funded by the European Union

2 Engage 2 Open Science Strategy in a Nutshell

The Open Science Strategy (D5.24) presents in detail the open science practices that the Engage 2 consortium intends to implement, as much as possible, so as to support for the intended European ATM Performance gain.

Table 1 provides a summary of the Open Science practices that Engage 2 has planned in its strategy to immediately and easily implement using already existing platforms, repositories, and systems. The table provides a list of directly workable actions towards practicing Open Science.

The primary drawback to practicing open data has already been discussed within the consortium. A consensus was reached to pursue joint efforts through further research and systematic collection of information on the existing barriers to data accessibility, as well as on potential approaches to address them.

Moreover, in the effort to learn from prior experiences in practicing Open Science, the Engage 2 Consortium has considered contacting the projects that successfully applied Open Science in the previous SESAR calls to collect best practices. A dedicated questionnaire has been circulated to the projects' coordinators, for gathering valuable insights on their prior experience with implementing Open Science. Namely, Open Science best practices, perceptions and attitudes, lessons learned, potential gaps, barriers, and bottlenecks faced are addressed. Further details on this matter are provided in the following sections of this report.

The questionnaire results have been evaluated and are presented in this report in section 3.3. As stated in the Open Science Strategy (D5.24), the final results, conclusions and recommendations drawn and produced, will be subsequently widely shared and communicated with SESAR 3JU projects that are willing to collaborate with Engage 2, as well as other relevant stakeholders, organisations, and units. These include but are not limited to, EUROCONTROL's Performance Review Unit and the Performance Review Commission, etc., within the Open Science Alliance for ATM initiative. This should facilitate learning about the existing open science landscape, exchange on lessons learned, and improve future processes and methodologies, by further encouraging the development of innovative solutions for open science implementation, collaboratively and transparently, within ATM research.

Table 1 below provides an overview of the Open Science implementation actions within Engage 2, based on the initial Open Science strategy.

Practice	Action
Open Access	At least Green Open access[3] publications (also available on the wiki), aiming for Diamond Open Access[4]. Publication in EJTIR and JOAS journals will be encouraged, where appropriate. Open Research Europe open access publishing platform to be used for the publication of Engage 2 research outputs.
Open Data	Relevant data sets will be linked to data platforms compatible with OpenAIRE on the wiki in line with the Data Management Plan. Engage 2 wiki used as the entry step that takes users to the Open Aviation Data GitHub website, used as a comprehensive repository of aviation-related data initiatives, with a focus on open data sources and open tools. The access and the addition of sources is open to the wide ATM research community. European Open Science Cloud (EOSC), Zenodo and similar platforms will be used for hosting research data, white papers, presentations and notes hosting. Engage 2 survey on Open Data, for identifying main challenges, needs, gaps, and possible pathways towards promoting the practice of open data within the aviation research and education domain. Promotion of this practice to PhD students and catalyst funded projects. Report on usage and feedback.
Open Methodology	The methods and results obtained within catalyst funded project and PhD theses will be documented and published together, as open access publications. The methods, research designs and hypotheses, where applicable, will be described as explicitly, clearly, concretely and transparently as possible. Promotion of this practice to PhD students to introduce and encourage its use. Report on how many have used it and any barriers experienced.

[3] Green open access refers to self-archiving scientific work in repositories (e.g., arXiv.org [2021]) or on private websites without APCs (Sherpa Romeo, 2020); publishers may impose embargoes, though pre-review versions can often be shared immediately (open-access.net, 2020).

4 Diamond open access journals, funded by third parties or donations, charge neither authors nor readers; in ATM, these include the Journal of Open Aviation Science (open data/code required) and the European Journal of Transport and Infrastructure Research (SESAR Innovation Days 2023 Special Issue).

Open Peer review	Open peer review process is highly recommended for the project's publications. Promotion of this practice to PhD students to introduce and encourage its use. Report on how many have used it and any barriers experienced. Publication in JOAS will be encouraged.
OER	Creative commons license to be utilised for open access publishing and Open Educational Resources. Various development and learning resources like, training material, meta-source of research data, data on PhD and Master theses supported by the project, workshops, hackathons, and serious games will be available and accessible through the wiki
Open data, access, code, OER	Participation in and promotion of Open Science Alliance for ATM initiative, aiming at creating a research ecosystem increasing reproducibility of ATM research.
Citizen Science	Several platforms, such as Zooniverse, Citizen Science Association, European Citizen Science (ECSA) or EU-Citizen.Science, will be explored and exploited to build citizen science, i.e. carry out the project together with non-professional scientists to increase inclusiveness, integration, and engagement of the civil society in Engage 2. Also, publications available in open access regime will feed into citizen science as they will attract more media coverage through sharing information on social media and mainstream media outlets enabling not only better science communication, but also attracting the interest of industry and general public and eventually, supporting citizen science.

Table 1 Open Science implementation actions within Engage 2

3 Implementation Process

3.1. Open Science Implementation Collector Tool

To support the continuous monitoring and implementation of the Engage 2 Open Science (OS) Strategy, and to facilitate the preparation of the deliverable at hand, a dedicated Open Science tracking tool (Figure 1) has been developed and adopted by the task leader, EASN-TIS.

An Excel-based tracking sheet—accessible via Google Drive—has been prepared to ensure that all consortium members are informed and aligned on Open Science activities. The tool is intended to:

- **Provide an up-to-date overview of OS-related actions and activities undertaken across the consortium.**
- **Enable partners to add relevant activities already implemented.**
- **Serve as a reference to the practices and actions outlined in the original OS strategy.**
- **Help identify additional OS actions or practices that partners may still implement during the project**.

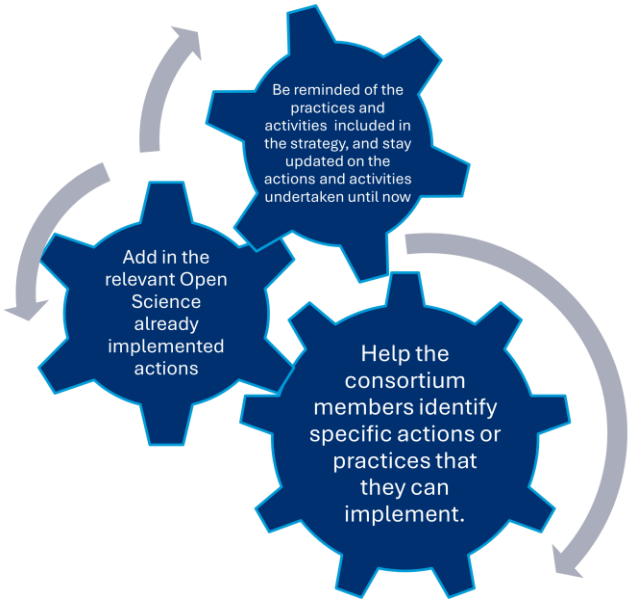


Figure 1 Role of the Open Science Tracking Tool

The Excel file includes three structured sheets:

- **Overall Open Science Practices and Principles**: A comprehensive list of the OS actions the Engage 2 consortium committed to, based on the agreed strategy. Furthermore, a specific list was compiled based on the Open Science strategy to facilitate the precise identification and categorization of the practices.

- **Promotion of OS Practices**: Tracking initiatives undertaken to raise awareness and promote OS within and beyond the consortium.
- **Open Data – Survey Focus**: keeping a close attention to data sharing practices as the main identified bottleneck during the setup of the Open Science Strategy. In the sheet, specific input is collected in relation to the Open Data survey run by the project, including the survey dissemination efforts and pathways, specific feedback and suggestions in relation to the survey implementation, results, and potential outcomes.

This tool will be used to continuously track progress toward implementing Open Science commitments throughout the project lifecycle.

3.2. Progress on Open Access

Under the Open Access strategy outlined in Deliverable D5.24 (*Engage 2 Open Science Strategy*), the Engage 2 consortium has taken tangible steps to implement Open Access practices across project activities. The progress made thus far is summarized below:

Implemented Actions

- **Green Open Access Publications**: Engage 2 supports Open Access by hosting a curated collection of 494 SESAR Innovation Days papers (2011–2024) and 438 USA/Europe ATM Research and Development Seminar papers (2011-2023) on its Wiki, thus ensuring access to relevant legacy research and complementing new Engage 2 publications. This ensures public availability of peer-reviewed research outputs and supports compliance with Article 17 of the Horizon Europe Grant Agreement.

- **Diamond Open Access Publication:** The publication of the *"Roadmap for a European Open Science Alliance for ATM Research"* in the *European Journal of Transport and Infrastructure Research (EJTIR)* demonstrates successful engagement with a Diamond Open Access platform, as encouraged in the strategy.

- **Engage 2 Wiki as a Dissemination Hub:** The Engage 2 Wiki serves as a central repository for project-related publications. It includes links to open-access materials with Digital Object Identifiers (DOIs), aligning with the strategy's goal of promoting FAIR (Findable, Accessible, Interoperable, and Reusable) research outputs.

The actions undertaken are in direct alignment with the objectives set out in the Engage 2 Open Science Strategy, and efforts will be made to continue the implementation of this practice, providing freely accessible and usable information and outputs to the scientific community and the wider general public.

Next Steps

The Engage 2 initiative will extend Green Open Access (OA) practices to all forthcoming publications, ensuring wider accessibility and compliance with open science standards. Project partners will be encouraged to prioritize Diamond or Gold Open Access journals where applicable, promoting equitable access to research findings. Additionally, the team will explore the use of Open Research Europe as a

publishing platform for eligible outputs. Efforts to monitor and document the application of Open Access principles will continue across other research strands within Engage 2, supporting transparency and alignment with best practices.

3.3. Progress on Addressing Open Data – Survey

Open Data are essential to fostering transparency, reproducibility, and collaboration in scientific research. In the context of Engage 2, the objective is to make research data "as open as possible, as closed as necessary", while ensuring compliance with FAIR (Findable, Accessible, Interoperable, and Reusable) principles.

Implemented Actions

- **Stakeholder Survey on Open Data Barriers and Opportunities:** A dedicated survey was developed and launched in **March 2024** to gather insights from the ATM research community regarding Open Data challenges, needs, and potential solutions. The survey targeted SESAR project participants and other stakeholders.
- **Engagement with Events and Wider Promotion:** The survey and Open Science Alliance was promoted at multiple events through a teaser campaign to stimulate interest in the **Open Science Alliance for ATM** and solicit participation from researchers willing to contribute to Open Data adoption and policy evolution.
- **Wiki Preparation for Open Data Hosting:** Although not yet fully populated, the Engage Wiki is being prepared as a hub for hosting and referencing open data sets, both from Engage 2 and external ATM research efforts.

Survey Implementation Process

The Open data and science for ATM survey aimed to capture how researchers, institutions, and industry actors within the ATM domain cope with data in general. The survey enquired from participants to describe open data requirements, reproducibility and to express their interest in participating in Open Science Alliance for ATM.

The following sections provide an overview of the survey's scope, structure, and results. These findings are a basis for extending the Open Science Alliance and contributing to a more transparent and collaborative ATM research landscape.

Objectives and scope of the survey

The Open Data and Open Science survey was designed with the primary objective of understanding the current state of Open Data practices within the ATM research community, with a particular focus on the experience and engagement of individuals involved in the ATM research in general. The survey

aimed to evaluate the open data requirements, the impact of reproducibility on ATM Solutions, and the willingness to participate in Open Science Alliance.

Methodology and Dissemination

The survey was designed and distributed using Google Forms in March 2024.

The dissemination process followed a multi-channel approach, anonymised[5]:

- Presentations at key events, including the Green Deal Flagship Meeting (June 2024) and Open Science Stakeholder Session (June 2024)
- Direct outreach to past coordinators of SESAR ER projects, from academia, industry, and regulatory bodies active in the ATM domain
- Prior to its final release, a teaser version of the questionnaire ('Open Science Alliance – Path to Expansion') was shared by the University of Westminster at the SESAR Innovation Days 2023 to gather early feedback and contact details for distribution
- Promotion was carried out via Engage 2's social media channels, the Airspace World 2024 event in Geneva, and targeted outreach to participants and coordinators of past and ongoing SESAR projects, including contacts from the SESAR Joint Coordination (SJC), EUROCONTROL (ECTL), the Performance Review Unit (PRU), and the Performance Review Commission (PRC)
- EASN contributed by emailing its members directly and including the survey in the EASN newsletter
- The University of Westminster also promoted the survey through a UK universities' transport mailing list

Results

We collected 20 responses, participants belonging to different organisation types. The distribution of responses can be seen in Figure 2. Most of the participants belong to research or higher education organisations, 4 responses from SMEs, and only 2 responses come from the industry (ANSP and Industry)[6].

The open science principles are quite important or highly important to roughly 70% of respondents, while only 10% state that those are not important, see Figure 3. Further, the participation in the open science activities by the respondents is depicted in Figure 4. A great majority already publishes articles as open access, which is to be expected, as it has been a requirement for EC funding for a while now. The next activity is publication of output data, which has also been a requirement from various funding bodies. The least number of participants publish the input data and code used to produce results. The

[5] As the channels used disseminate to a wide audience, but in an anonymised manner, it is impossible to know how many people it reached.

[6] Only one response was received from Engage 2 consortium members.

input data publication is often not possible due to various licensing or non-disclosure agreements linked to the data sourcing. Similarly, the authors of code are often hampered by the same problems, as often parts of the code are trained on the input data, and even those results either cannot be shared, or fall in the grey area, so the authors avoid publication due to uncertainty.

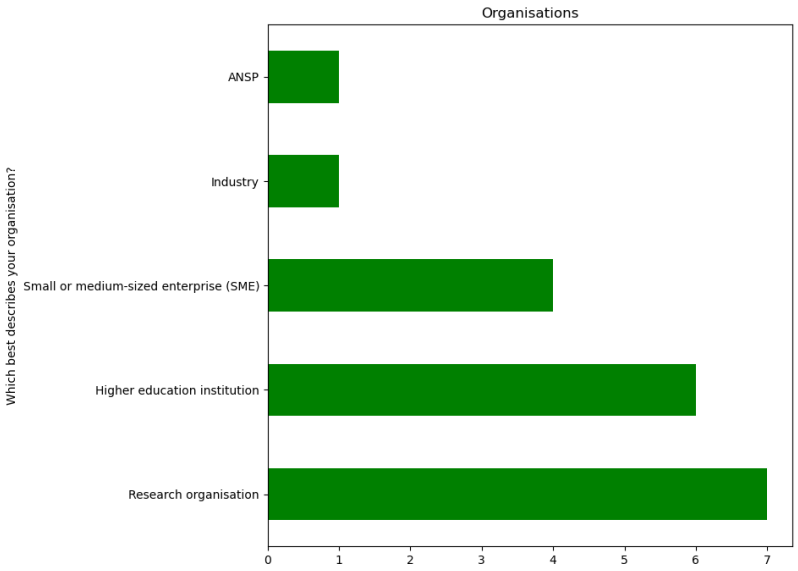


Figure 2 Distribution of participants across organisation types

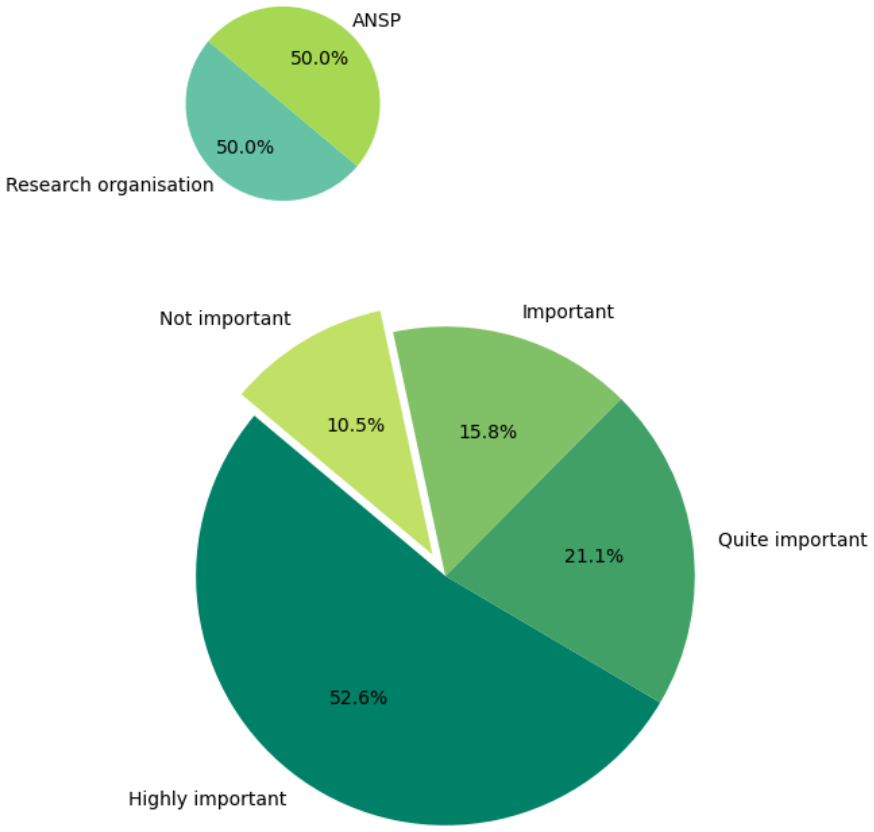


Figure 3 Importance of open science principles to survey respondents, with the organisation type for 'Not important' category

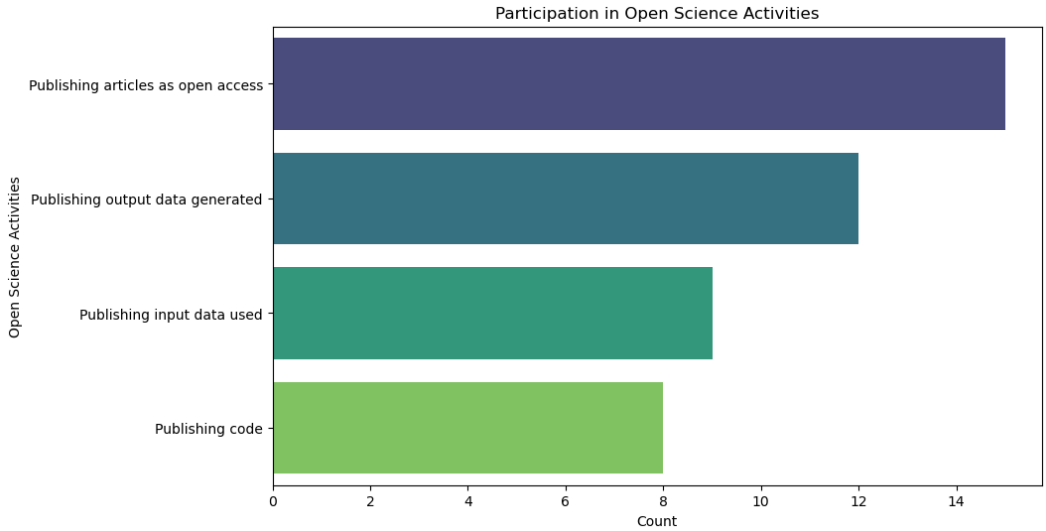


Figure 4 Participation in the open science activities

The respondents listed the free and accessible data sources they use in their research efforts:

- ADS-B - OpenSky Network and Flightradar24
- Weather and Copernicus
- EUROCONTROL R&D
- Bureau of Transport Statistics (US data only)
    - On-time – schedules
    - Passenger fares and itineraries
    - Financials

Under the paid, or not accessible, these data sources were listed:

- Premium access to Flightradar24
- Mobile network data
- Historical weather data
- European flight schedules
- Various multimodal data (e.g. rail capacities, cancellations, delays)
- (original) flight plans
- DDR2 - airspace configurations
- BADA

Furthermore, the respondents described the opportunities they see from open data. The open data for input, not only output data, would increase reproducibility and transparency, which could facilitate faster Solution[7] development. The use of Open data avoids time and money spent on data acquisition and cleaning and also gives better education possibilities for the new generation of aviation professionals.

It was acknowledged that there are not only cultural, but also very practical barriers to opening some data sources, like matters of confidentiality, sovereignty, or legal. There are also very real costs of data collection and maintenance. The lack of a common platform for ATM data was also cited.

Reproducibility is an important principle of the research process, as we can have more confidence in results that are confirmed through multiple findings, increasing the transparency of research. Full reproducibility in ATM research is hampered by limitations imposed regarding data sharing. The survey proposed that the openness, transparency and reproducibility of research under open science practices can enable faster innovation cycles of the ATM Solutions under development. About 85% of participants were of the opinion that ATM research reproducibility could speed up the time it takes to mature ideas.

Seventy-five percent of respondents expressed their interest in joining the Open Science Alliance, while the other respondents either declared that they do not want to join, or that they cannot decide

[7] ATM Solutions are new operational concepts, procedures and relevant technologies.

for their organisation The non response might have been linked with the anonymity, as those that stated the wish to join the Open Science Alliance needed to provide an email, at which point the survey answers lose the anonymity.

Next Steps

- Draft the terms of reference for Open Science Alliance and share it with interested respondents to the survey, to create a wider community.
- Implement Open Data section of the Engage Wiki, ensuring links to repositories like Zenodo and EOSC, which should point to the https://mode-s.org/atmdata/, which has been identified as the best candidate for the continuous update within ATM research community, well over the life-time of Engage 2 project.
- Promote successful examples and best practices in Open Data during Engage 2 workshops and summer schools, where related and possible.

3.4. Open Source

Open Source is a fundamental principle of Open Science that supports transparency, reproducibility, and innovation in research. Within Engage 2, the Open Source practice focuses on making *software* and *algorithms* developed under the project freely accessible, modifiable, and reusable by the wider ATM research community.

While no source code has been published to date, foundational planning is underway. The strategy has laid the foundation for future implementation, and PhD students and Catalyst Funded projects are encouraged to apply these principles as tools and scripts are developed.

Next Steps

The Engage 2 strategy sets out a comprehensive approach to promoting open-source practices and maximizing the impact of software outputs. It commits to identifying and documenting software and code components developed across all Engage 2 activities, particularly within catalyst-funded projects and PhD research. Eligible code will be published in open repositories such as *GitHub, GitLab, Bitbucket, or SourceForge*, using appropriate open-source licenses like the *MIT License* to ensure legal sharing and reuse. Dedicated sections will be created within the Engage Wiki to reference and link these code components, establishing a central hub for open-source outputs from Engage 2 and relevant SESAR-funded initiatives. Ongoing monitoring of code usage and feedback will support continuous improvement and inform reporting in Deliverable D5.6.

3.5. Open Methodology

Open Methodology refers to the practice of transparently documenting and sharing research methods, hypotheses, and study designs to enhance the clarity, reproducibility, and integrity of scientific

outputs. The Engage 2 project recognises this as an enabler for building trust and accelerating innovation within the ATM research domain.

No practical implementation or reported activities related to the Open Methodology practice are currently documented. However, the foundation for its integration is outlined, and awareness activities are planned as part of PhD support and training.

Next Steps

The catalyst funded projects and Engage 2 PhDs are required to explain and document the methodology used in their research. The catalyst funded project reports, and PhD theses will be published via the Engage 2 wiki, in addition to other publications.

3.6. Open Peer Review

Open Peer Review (OPR) is an emerging practice within Open Science that promotes transparency, accountability, and inclusiveness in the scientific publishing process.

Next Steps

Engage 2 is committed to promoting Open Peer Review (OPR) within its research community, where such review is possible. Note that there is only one open peer review journal for aviation topics, the Journal of Open Aviation Science (JOAS), which requires publication, data and code to be open for publication. Due to various licensing and NDAs linked to input data, this is often not possible for a wide variety of ATM research. The initiative will also track the adoption of OPR to assess its impact.

3.7. Progress on Open Educational Resources (OER)

The Engage 2 consortium recognises Open Educational Resources (OER) as a critical pillar of Open Science, aimed at promoting equal access to knowledge and training resources across the Air Traffic Management (ATM) research and education community.

Implemented Actions

- **Leverage of the Engage Wiki Platform:** The Engage Wiki, originally developed by the original Engage KTN, continues to serve as a central repository for ATM-related educational and research content. It is currently being updated to include Open Educational Resources accessible to both students and professionals.
- **Differentiated Access:** Preliminary efforts are underway to enable tailored access to educational resources on the Wiki based on user type (e.g., MSc/PhD students, educators, professionals).
- **Integration of Learning Materials:** The Wiki hosts a growing repository of training material, PhD and Master theses, and materials from workshops and summer schools. These resources support formal and informal learning and foster engagement with Open Science principles.

- **Licensing for Reuse:** All educational materials added to the Wiki are intended to be released under Creative Commons licenses (e.g., CC BY 4.0), ensuring legal clarity for reuse and redistribution.

Next Steps

Engage 2 is finalising the implementation of differentiated access functionality on the Wiki to better manage user permissions and content visibility. The project will complete the upload and indexing of current and future educational materials generated from various activities, including PhD research, summer schools, and workshops. To increase visibility and impact, these Open Educational Resources (OERs) will be actively promoted through Engage 2 events and the Open Science Alliance for ATM. Ongoing monitoring of user engagement and feedback will help refine both the content and access mechanisms, ensuring the resources remain relevant and user-friendly.

3.8. Progress on Citizen Science

Citizen Science represents an important facet of the Engage 2 Open Science agenda, promoting inclusivity, public engagement, and trust in research by involving non-professional scientists in various aspects of the scientific process.

Implemented Actions

- **Media-Based Public Engagement:** Engage 2 has actively used its website and LinkedIn profile to disseminate project outcomes and educational content, thereby increasing public visibility and engagement with ATM-related research.
- **Use of Online Channels for Outreach:** The project's online presence has been leveraged to make scientific knowledge accessible to the broader public, supporting awareness-building and informal citizen science participation.

The Open Science Strategy is publicly available online: The Engage 2 Open Science strategy[8] has been publicly made available and accessible to anyone visiting both the project website and the Wiki (Figure 5). A special mention has also been placed on the wiki's footer area on the homepage, highlighting that the project adheres to the Open Science Strategy, including the commitment to adhere to data/code sharing as openly as possible, respecting ethical and legal constraints; applying FAIR principles and using open licenses to encourage reuse, transparency and collaboration.

Next Steps

Engage 2 seeks to actively explore and implement opportunities for direct citizen science participation in its ongoing and future activities, such as public surveys and citizen-led data validation efforts. To support this, the project will engage with established citizen science platforms—like Zooniverse, EU-

[8] https://engagektn.eu/wp-content/uploads/2025/02/Engage-2_D5.24_V00.06_official.pdf

Citizen Science, and ECSA—as potential collaborators or sources of inspiration for piloting targeted activities aligned with ATM themes. The initiative also includes monitoring and documenting public interaction metrics across the website, Wiki, and social media channels to evaluate outreach effectiveness and identify areas for improvement. Additionally, qualitative feedback from stakeholders will be collected to assess perceptions of citizen involvement and to better understand the potential roles of non-scientific participants within Engage 2.

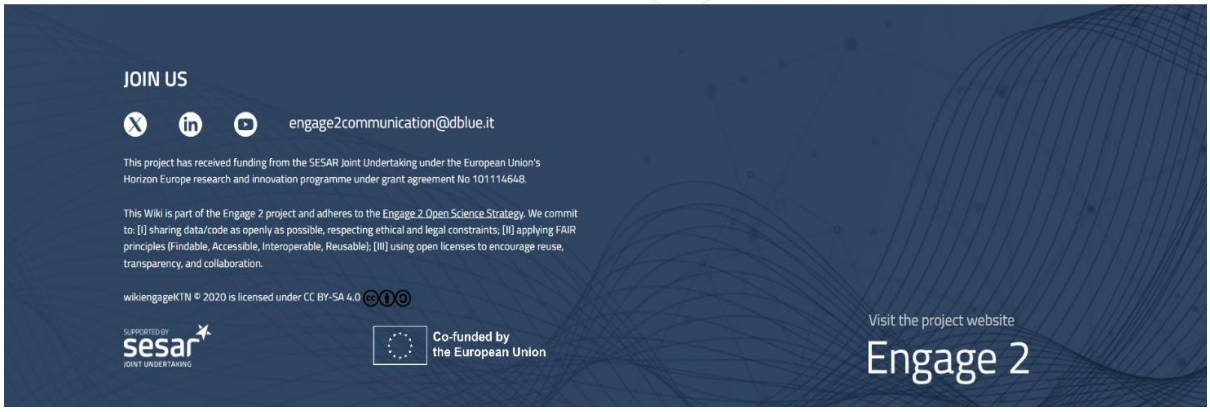


Figure 5 Screen Capture of Wiki Page's footer

3.9. Supplementary Open Science Promotional Activities

The Engage 2 consortium has actively promoted Open Science principles through targeted communication channels, training initiatives, and community outreach events (Table 2). These activities align closely with the strategic objectives outlined in D5.24, aiming to embed Open Science within the ATM research ecosystem and foster a collaborative research culture.

Activity Description	Mode	Event / Channel	Date	Notes
Promotion of the Open Science Alliance for ATM	Presentation	Green Deal EU flagship meeting	6 June 2024, Brussels	Aligns with strategic push for community building
Promotion of Open Science at a technical workshop	Presentation	Open Source Tools Workshop	7 June 2024, London	Includes best practices and tools for ATM research
Open Science tutorial and awareness at an academic training event	Presentation	Winter School #1 (Belgrade)	27–31 January 2025	Hands-on training session included
Promotion of OSCAR principles to Engage 2 students	Student engagement session	2nd Tangram Workshop (TU Delft)	3–4 April 2025	Student-targeted educational awareness

Table 2 Implemented Supplementary Open Science Promotional Activities

The promotion activities have effectively engaged a diverse range of stakeholder groups, including policy actors through events such as the Green Deal meeting, as well as researchers, PhD students, and internal project beneficiaries. These efforts show strong alignment with strategic goals related to awareness-raising and supplementary promotional activities that were highlighted in the initial strategy. The combined use of in-person and digital formats has proven valuable in addressing both high-level and grassroots engagement needs.

4 Reflections and Lessons Learned

The implementation of Open Science within the Engage 2 project has made meaningful strides, with several noteworthy achievements and valuable insights emerging along the way. Notable progress has been achieved in areas such as Open Access, stakeholder engagement through surveys, and the foundational development of support tools like the Open Science Implementation Collector Tool and the Engage 2 Wiki (Table 3). Key reflections include:

- **Early adoption and community engagement**: The Engage 2 consortium demonstrated proactive engagement through dissemination activities and a comprehensive Open Data survey. A notable outcome was that 75% of respondents expressed interest in joining the Open Science Alliance, underlining community readiness for collaborative action.
- **strategic use of platforms**: Leveraging existing infrastructures such as the Engage Wiki and OpenAIRE-compatible repositories has proven efficient for implementing Open Access and OER practices. The consortium's ability to centralize resources and track progress using collaborative tools laid a solid groundwork for future developments.
- **Survey insights**: The Open Data survey highlighted strong support for Open Science in principle (70% rated it quite important or very important).
- **Implementation gaps**: While foundational strategies are in place for Open Methodology, Open Source, and Citizen Science, actual implementation remains limited in these areas. This signals a need for further operational guidance, training, and incentivization to turn intent into action.
- **Cultural, legal and financial challenges**: The project identified a combination of cultural reluctance, legal complexity, financial burden and the absence of standardised platforms as persistent hurdles to data openness. The Engage 2 and Open Science Alliance are looking into finding ways of sharing the data in an open and accessible way, the beginning of which is now published in Engage 2 wiki, under Repository and open data part of the wiki. The intent is to have the open data for ATM lists and repositories be a live community resources, to live beyond Engage 2 (the Open data part is continuously updated by the community members that express interest).

Open Science Practice	Key Progress Highlights	Current Status
Open Access	SIDs 2023 and 2024 papers published via Green OA; 1 Diamond OA paper in EJTIR; Wiki actively used ATM Seminar (USA/Europe ATM Research and Development Seminar) papers available on the Wiki	In progress
Open Data	Stakeholder survey launched (March 2024); Wiki space prepared; collaboration started	In progress
Open Source	Strategy defined for code licensing and hosting; implementation pending	Planned
Open Methodology	Strategic guidelines established; integration with PhD work planned	In progress
Open Peer Review	Target journals identified; awareness and adoption by catalyst-funded projects and PhDs advised	In progress
Open Educational Resources (OER)	Wiki updated with some materials; content licensing and structured access planned	In progress
Citizen Science	Public engagement via website and social media; platform partnerships under consideration	Awareness and engagement initiated

Table 3 Summary of Progress Across Open Science Practices

5 Recommendations and Next Steps

This interim assessment presents a consolidated overview of the progress made in the implementation of Open Science practices within the Engage 2 project under Task 5.6. Guided by the OSCAR H2020 Code of Conduct and the internal Open Science Strategy (D5.24), the consortium has initiated actions across all seven Open Science pillars. While several activities are still in early stages, foundational steps and strategic alignments have been achieved across the board.

Looking forward, the Engage 2 consortium will focus on:

- **Operationalise Open data resources:** The Open data section on the Engage Wiki, is now operational, pointing to the https://mode-s.org/atmdata/, which is a platform chosen to support sustained accessibility beyond the project's lifespan.
- **Further the Open Science Alliance:** inform the survey respondents and other interested stakeholders of the availability of the Open data platform, and call on their contribution to a functioning, community-driven Open Science in ATM research, via the Open data platform.
- **Support Open source contributions:** Begin identifying software/code produced, if any, in catalyst-funded and PhD projects. Monitor code usage and sharing and implement a dedicated GitHub or similar repository linked to the Wiki to increase visibility and reuse.
- **Advance Open methodology and Open peer review:** Provide documentation templates and incentives for PhD students and catalyst projects to transparently describe methodologies and research processes. Encourage the submission to Journal of Open Aviation Science, and any other journal with open peer review[9].
- **Promote best practices across stakeholders:** Actively showcase successful case studies and best practices identified in the survey and project activities during upcoming workshops, summer schools, and newsletters.
- **Monitor and adapt the strategy:** Continue using the Open Science Implementation Collector Tool to track progress and identify emerging needs.

By building on existing successes and addressing current gaps through these targeted next steps, Engage 2 is well-positioned to strengthen its role in shaping a transparent, collaborative, and reproducible air traffic management research ecosystem. The initiative is firmly on track to achieve its long-term Open Science objectives, with continued holistic progress on collaborative engagement, ongoing monitoring, and a commitment to proactive knowledge sharing—core values at the heart of the Open Science ethos.

[9] To the best of our knowledge, JOAS is the only such journal in aviation area. Others can be found in the atmospheric physics and similar areas of expertise.

6 Annex I

Open data and science for ATM Survey on Google Forms. Annex attached.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

7 Annex II Engage 2 Open Science Measurable Targets and Timeline

Open Science Pillar	Target	KPI	Timeline
Open Science General	Open Science Guidelines for SESAR JU Project Coordinators	1-paged Open Science Guideline document to be shared with SESAR JU Project Coordinators	M31
Open Access	Extend Green OA to all; encourage Diamond/Gold OA; explore Open Research Europe	Evaluate how many publications are Green OA versus Diamond OA, and aim for at least 1 Diamond until the end of the project	Ongoing till the end of the project
	Latest SIDS publications in Diamond/Gold OA publications on the Wiki	SIDS conference publications on the Wiki as soon as published by SJU and ATRDS	Ongoing till the end of the project
Open Data	Datasets identified for the Open ATM data	Datasets available on the Wiki	Ongoing till the end of the project
Open Source	Identify all code outputs, where available	Inventory of codes documented	Ongoing till the end of the project
	If identified and available, added to the Open data for ATM	Code source, explanation, and link to it added to the Open data for ATM page	Ongoing till the end of the project
Open Methodology	Methodology required in Catalyst/PhD outputs	At least 20 reports/theses with methodologies	Ongoing till the end of the project
Open Peer Review	OPR submissions, if possible	submissions tracked	Ongoing till the end of the project
OER	Ensure all OERs licensed under CC BY 4.0 or equivalent	At least 5 OERs licensed materials available on the wiki, including	Ongoing till the end of the project

		Engage and Engage 2 Educational resources	
OER	Users accessing OERs on the Wiki. Ensure all OERs are licensed under CC BY 4.0 or equivalent	At least 30 registrations/visits on the OERs on the Wiki analytics	Ongoing till the end of the project
Citizen Science	Participants engaged in events	1000 citizens	Ongoing till the end of the project

Open data and science for ATM

The benefits of adopting an open science approach are to be found through the independent verification and validation of reported impacts/results and achieved performance levels, i.e., through reproducibility. This can only be achieved through: (1) open access to scientific methods and data utilised; (2) open access to (analytical) code and methods; (3) open review of reported analyses/research. The proper application of such practices can reduce the innovation cycles in ATM, which is much needed by industry and society.

Engage 2 aims to bridge the gap between industry and academia in ATM research, by considering the great importance of open science for supporting the intended European performance gain and growth.

This survey is divided into three parts: open data requirements, reproducibility and on an 'open science alliance' for ATM. The survey takes about 10 minutes to complete.

* Indicates required question

1. Which best describes your organisation?

   Mark only one oval.

   - ◯ Research organisation
   - ◯ Industry
   - ◯ Small or medium-sized enterprise (SME)
   - ◯ Higher education institution
   - ◯ Other: _____

2. How important is open science to your business/organisation?

   Mark only one oval.

   - ◯ Not important
   - ◯ Quite important
   - ◯ Important
   - ◯ Highly important

Open data requirements

We would appreciate it if you could share your experience and opinions regarding data accessibility in ATM research, the corresponding barriers, and the (further) opportunities that open data could create.

3. Could you share with us the name or description of data sources you use, that are **free and accessible** (and accessible under what conditions/constraints)?

   _____

   _____

   _____

   _____

   _____

4. Are there data that **require payment for gaining access** that you use in research? Which ones? Under what conditions/constraints?

5. Are there data that you **would like to use** in research but cannot, as the **price** is too high for access? Which ones?

6. Are there data that you are aware of, but **cannot access** (regardless of price)? Could you **describe** the data, and the **reason** behind the impossibility of access?

7. Have you identified types of data that **do not exist today**, but would be useful for ATM research? Could you describe them?

8. Could you share your thoughts on the **opportunities and benefits** of making data open in ATM research? Please mention specific impacts, where possible.

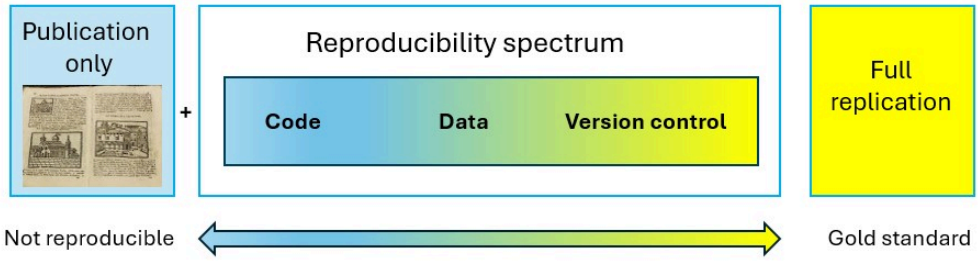
9. Do you see (other) **barriers** related to data access, usability, clarity and sharing? Could you describe them?

Reproducibility and solutions

Reproducibility is an important principle of the research process, as we can have more confidence in results that are confirmed through multiple findings, increasing the transparency of research. Full reproducibility in ATM research is hampered by limitations imposed re. data sharing. If the data (especially input) cannot be shared, the desired comparability and reproducibility across projects and between research groups is at best very limited.

It is proposed that the openness, transparency and reproducibility of research under open science practices can enable faster innovation cycles of the ATM Solutions under development. ATM Solutions are new operational concepts, procedures and relevant technologies.

Reproducibility spectrum of research



10. In your opinion, could **ATM research reproducibility** speed up the time it takes to mature ideas, e.g. towards deployment / higher TRLs?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Not sure
- ◯ Other: _____

11. In which open science activities do you currently participate? Please select all that apply, and add under "Other", as necessary:

Tick all that apply.

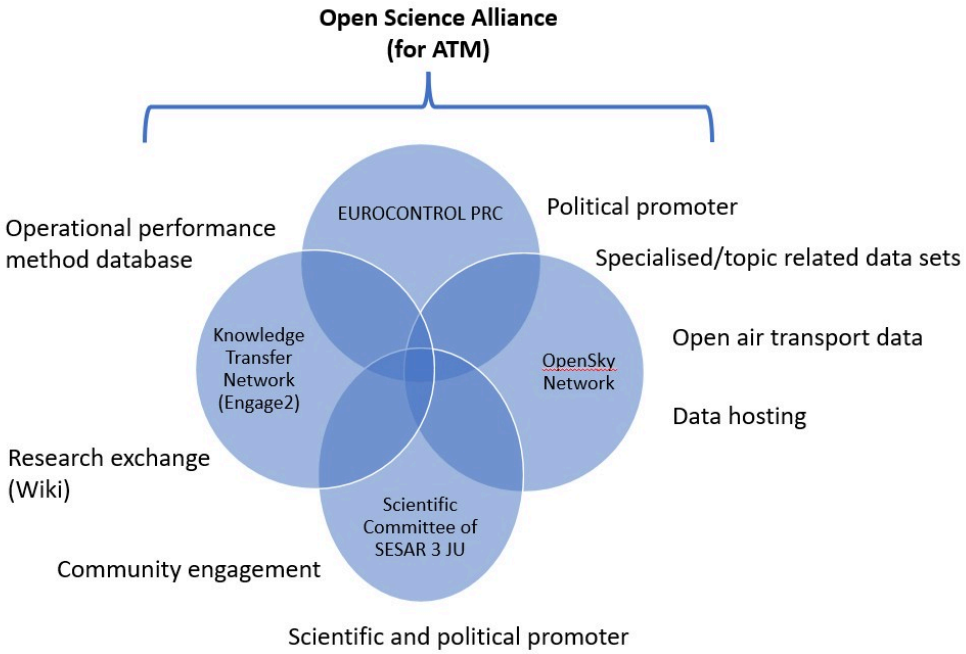
- [ ] Publishing articles as open access
- [ ] Publishing (application) code for research purposes (under open license)
- [ ] Publishing input data used
- [ ] Publishing output data generated
- [ ] Other: _____

'Open science alliance' for ATM

The concept of an 'open science alliance' fully encompasses all 'open' principles: open access (to publications), open data (sharing research data), open source/code (sharing software), open methodology (sharing models, methods, etc.), open peer review and open educational resources. The collaborative principles proposed for this new alliance are open in nature,
at the moment, and being developed through consultations such as this survey. The alliance would, however, be free to join, and based on voluntary and optional activities (such as joining an on-line workshop to discuss further ideas).

The initial alliance was introduced by a SESAR Innovation Days paper and presentation. The alliance intends to build on existing collaborations between EUROCONTROL PRC, the Scientific Committee of the SESAR 3 JU, OpenSky Network, Engage 2 and the wider research and ATM community.

Source: Roadmap for a European open science alliance for ATM research



12. Would you like to join the open science alliance?

Mark only one oval.

- Yes
- No

13. Please let us know if you have any suggestions as to how to further develop the alliance:

14. Would you like to receive the copy of the results of this survey?

Mark only one oval.

- Yes
- No

Joining 'Open science alliance'

If you opted to join the 'Open science alliance' and/or receiving the copy of results, you can leave your email address as a means of contact, in the following (final) section of the survey.

Skip to question 15

Privacy sheet

Engage 2 is a collaborative project involving Deep Blue Srl, University of Westminster, Technische Universitaet Braunschweig, Univerzitet U Beogradu, Fundacion Instituto de Investigacion Innaxis, Frequentis, EASN Technology Innovation Services, Eurocontrol, and Università degli Studi di Trieste.
The project has received funding from the SESAR Joint Undertaking under the European Union's Horizon Europe research and innovation programme under grant agreement No 101114648.

Participants' personal data (first name, last name, organization name, country, email address) will only be used by Engage 2 for the purposes of the project. Only in case specific permission is given, they may also be used to invite the participants to take part in future research activities and commercial initiatives. Personal data will be collected, processed and protected according to the General Data Protection Regulation (GDPR) (EU) 2016/679. Participants will have the right to request access to and rectification or erasure of personal data or restriction of processing concerning the data or to object to processing as well as the right to data portability just sending an email to the responsible of data treatment listed hereafter. They will also have the right to lodge a complaint with a supervisory authority.

RESPONSIBLE FOR DATA TREATMENT IN ACCORDANCE TO THE GDPR (CONTROLLER)

Deep Blue S.r.l., Via Daniele Manin, 53 - 00185 Rome RM (Italy)

CONTROLLER'S REPRESENTATIVE IN THE SPECIFIC PROJECT
Micol Biscotto - Project Coordinator

After reading the information sheet above

15. I hereby give my consent to the processing of my personal data needed to join Engage 2 Community and receive future newsletters and other initiatives related to the project *

Mark only one oval.

- ◯ Yes
- ◯ No

16. I hereby give my consent to be contacted by the Engage 2 Consortium members for matters related to scientific research, including regarding alliance membership and/or for a copy of the survey results. *

Mark only one oval.

- ◯ Yes
- ◯ No

17. I hereby give my consent to be contacted by the Engage 2 Consortium members for promotional and commercial initiative *

Mark only one oval.

- ◯ Yes
- ◯ No

18. I understand that my personal data will be held and processed in confidence and in accordance with the principles laid out by GDPR *

Mark only one oval.

- ◯ Yes
- ◯ No

If you opted to joining 'Open science alliance', receiving a copy of results and to be contacted by the Engage 2 Consortium members, please leave your email below.
If you prefer to remain anonymous and do not want to provide your email address for future communications, please write N/A

19. Your email *

_____