SESAR's European Knowledge Transfer Network – benefits delivered, opportunities ahead

Andrew Cook and Tatjana Bolić
University of Westminster
Airspace World 2023, Geneva, 10 March 2023

SESAR 2020 SHOWCASE

#SESARShowcase

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

#EuropeForAviation

Outline

- **Background and overview**
  - context; objectives; a tale of two KTNs
- **Thematic challenges and projects**
  - provenance; industry role; three examples

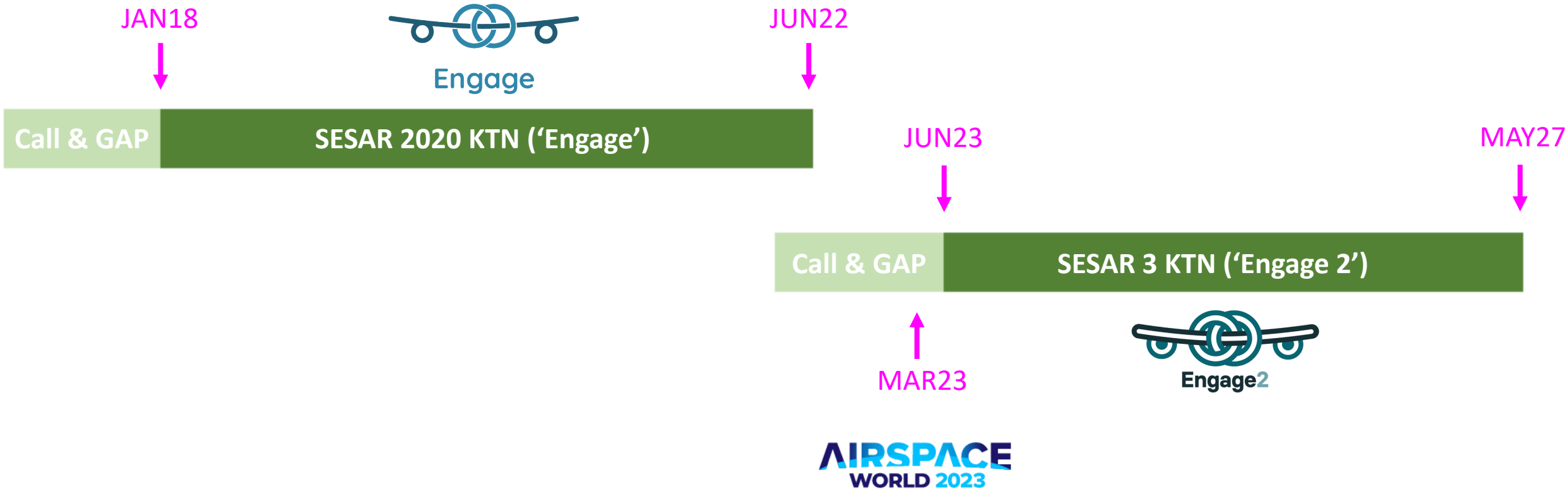
Q&A #1

- **The EngageWiki, maps and repository**
- **PhDs and educational elements** (very brief insight)
- **Heads-up on Engage 2 & getting involved**

Q&A #2, close

1. Background and overview

Background and overview



Engage: call open: 15DEC16-11MAY17; project ran 01JAN18-30JUN22
Engage 2: call open: 07APR22-13OCT22; project runs 01JUN23-31MAY27 (tbc)

Background and overview

Engage

sesar JOINT UNDERTAKING

UNIVERSITY OF WESTMINSTER
(coordinator)

EUROCONTROL

EASA European Aviation Safety Agency

FREQUENTIS

innaxis

TU Delft
Delft University of Technology

UNIVERSITY OF BELGRADE

UNIVERSITY OF TRIESTE

engagektn.com

wikiengagektn.com

twitter.com/EngageKTN

Background and overview

Advanced Logistics Group (ALG)
AGIFORS - Airline Group of the International Federation of Operational Research Societies
Air Traffic Controllers European Unions Coordination (ATCEUC)
airBaltic
Airport Gurus
Airport Regions Conference (ARC)
American Airlines
ANS CR
Aslogic
Association for the Scientific Development of ATM in Europe (ASDA)
Autoridade Nacional da Aviação Civil (ANAC)
Barcelona Supercomputing Center (BSC)
Boeing Research and Technology Europe (BR&T-Europe)
Bundesaufsichtsamt für Flugsicherung (BAF)
Cirium
Civil Aviation Authority (CAA)
COOPANS Consortium
Department for Transport (UK)
Direction des Services de la Navigation Aérienne (DSNA)
Direktorat civilnog vazduhoplovstva Republike Srbije (DCV)
Egis
European Meteorological Services Network (EUMETNET)
European Passengers' Federation (EPF)
Executive Airlines
Ferrovial Agroman
Finnair
Flughafen München / Munich Airport
Gestair SL
Heathrow Airport Limited

HEMAV - High Endurance Multipurpose Aerial Vehicles
Honeywell Aerospace
HungaroControl
Icelandair
IFSTTAR - Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux
INFORM - Institut für Operations Research und Management GmbH
International Air Transport Passenger Association (IATPA)
International Federation of Air Traffic Controllers' Associations (IFATCA)
International Federation of Air Traffic Safety Electronics Associations (IFATSEA)
Irish Aviation Authority (IAA)
LFV - Luftfartsverket
London Luton Airport
Lufthansa Systems
Manchester Airport
NATS
Naviair
Network Manager - nominated by the European Commission
NEXTOR II Consortium - University of California, Berkeley and University of Maryland
PACE Aerospace Engineering & Information Technology
Pegasus Airlines
QinetiQ Ltd
Raytheon UK
Sabre Airline Solutions
skeyes
SWISS - Swiss International Air Lines
TÜBİTAK - The Scientific and Technological Research Council of Turkey
Turkish Airlines

Background and overview

- ‘One-stop’ European knowledge hub, concepts roadmap, research repository
- 4 series of SESAR Innovation Days (non-disruptive; industry)
- 4 series of thematic challenge workshops (plus *ad hoc*)
- 3 European summer schools (Belgrade ’19, virtual event ’20, virtual event ’21)
- ~~10~~[9] PhDs; ~~16~~[18] catalyst fund projects; ~~65~~[58] deliverables
- Future ATM skilled work-force; student mobility
  - under-/post-graduate teaching & training initiatives
  - internships & employer links
  - journal publication grants; (travel) grants

40% of €4m as consortium effort

D3.9 *The Engage wiki*

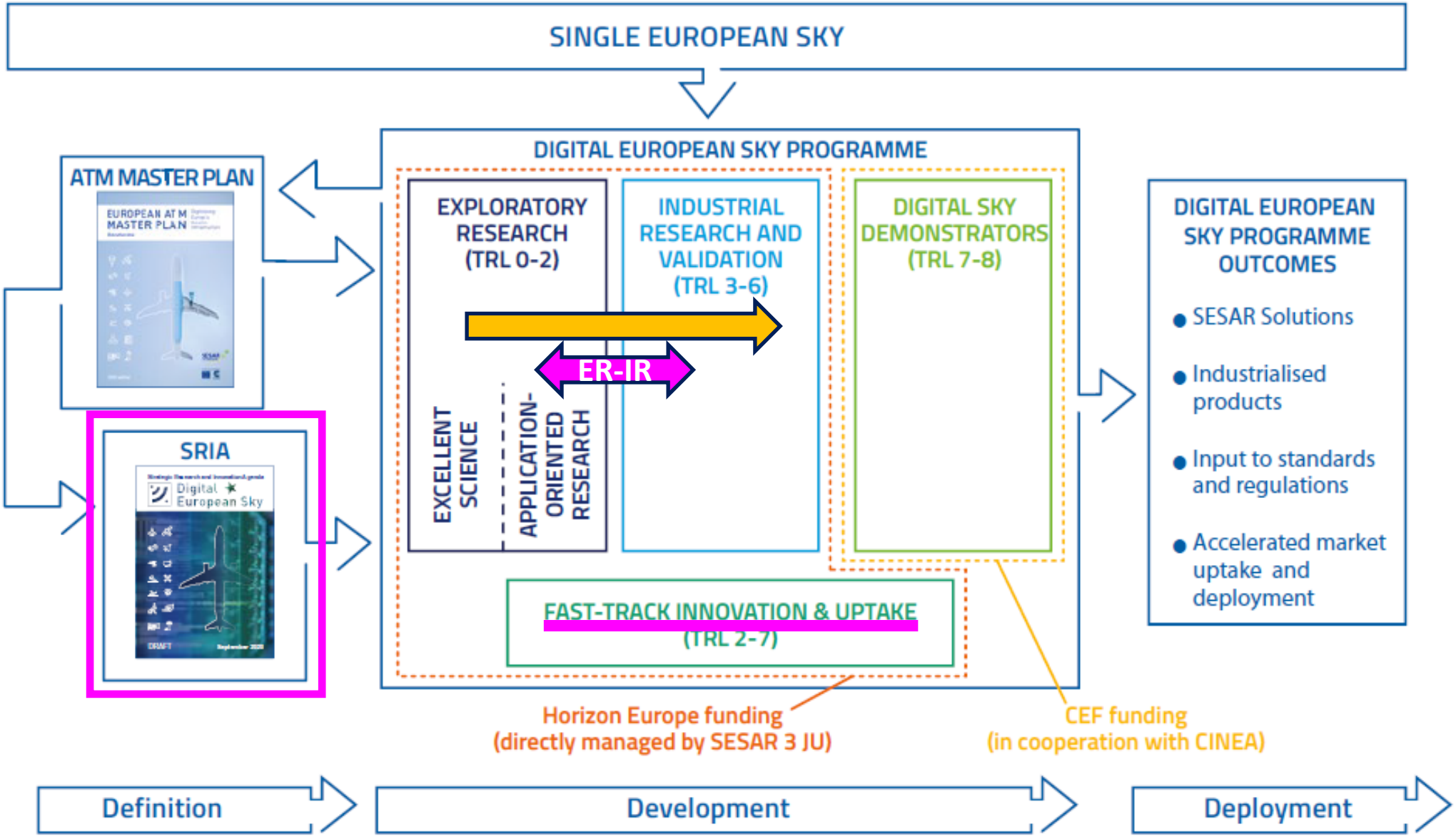
D3.10 *Research and innovation insights*

SESAR Digital Academy

Thematic challenges

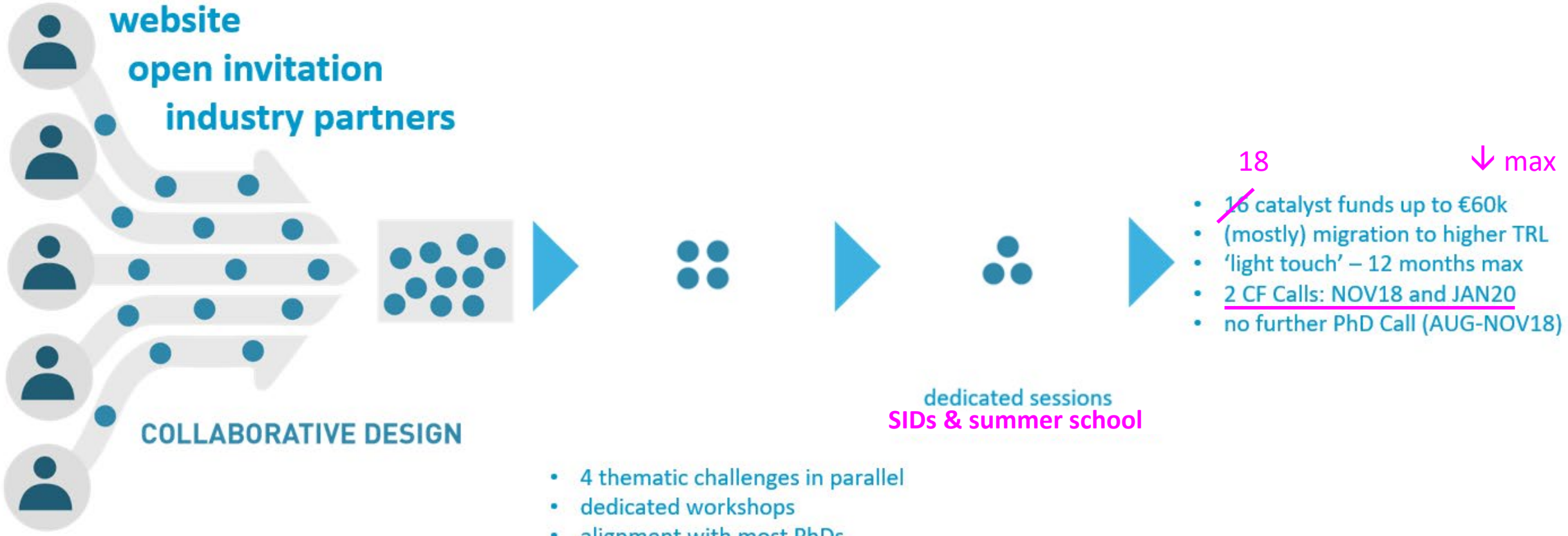
Integrate IR and ER

Background and overview



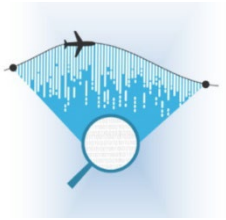
2. Thematic challenges and projects

Thematic challenges and projects
Industry: role in proposing and evaluating



Thematic challenges and projects
Workshops through to 2021, informing SESAR 3

#1. CNS vulnerability and security
Paula López, Innaxis



#2. Data-driven trajectory prediction
"AI, ML and automation"
Dirk Schaefer, EUROCONTROL

#3. Efficient use of MET data
Tatjana Bolić, Uni. of Westminster

#4. Novel market mechanisms in ATM
"Economic incentives for future ATM implementation"
Andrew Cook, Uni. of Westminster

D3.10

Research and innovation insights

Thread (TCs in brackets)	SRIA flagship(s)	Summary
1 (1)		**Establish and develop a SESAR 3 cybersecurity community:** 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 cyber-attacks. Further investigations are necessary to mitigate these vulnerabilities, moving towards a cyber-resilient system, fully characterising ATM data, its confidentiality, integrity and availability requirements, taking into account the fact that new and old ATM systems will continue to operate concurrently for years to come. All these issues are especially challenging in a multi-stakeholder, multi-system environment such as ATM, where confidentiality and trust are key. Nevertheless, the cybersecurity awareness and security culture is still rather immature in ATM research, whilst there is much interest in addressing this topic and creating a SESAR 3 cybersecurity community.
	5	**Virtualisation and cyber-secure data sharing:** This flagship addresses several high-level R&I needs/challenges, with that of 'cyber resilience' describing the need for monitoring and adapting to the changing threat landscape and emergence of new actors, aiming at the development of cyber-resilience guidelines and procedures tailored to ATM. However, a large and positive impact could be obtained through continuous collaboration and updates within a dedicated SESAR 3 cybersecurity community. This flagship is the place for setting up such guidelines and procedures, although not necessarily the best place for the establishment and nurturing of a cyber community, which might be developed through the SESAR 3 KTN or Digital Academy, overarching the flagship and its corresponding work components and actors.

Engage2

+ tracking outcome flows

Catalyst fund projects – wave 1

Project title	Coordinator	Consortium partners
Probabilistic **weather avoidance** routes for medium-term storm avoidance ('PSA-Met')	Universidad de Sevilla	MeteoSolutions GmbH
Airport-scale severe **weather nowcasting** ('CARGO')	Università degli Studi di Padova	LMU Munich; GReD srl; Leonardo GmbH
Authentication and **integrity for ADS-B**	TU Kaiserslautern	SeRo Systems GmbH
Data-driven **trajectory imitation** with reinforcement learning	University of Piraeus Research Center	Boeing Research and Technology Europe
A data-driven approach for dynamic and adaptive **trajectory prediction** ('DIAPasON')	CRIDA	Deep Blue; ZenaByte
Operational alert products for ATM via SWIM ('OPAS')	Royal Belgian Institute for Space Aeronomy	-
An interaction metric for an efficient **traffic demand management**: requirements for the design of data-driven protection mechanisms ('INTERFACING')	Aslogic 2011 SL	-
MET enhanced ATFCM	France Aviation Civile Services	MetSafe
Exploring future **UDPP concepts** through computational behavioural economics	Nommon Solutions and Technologies	-
The drone identity - investigating **forensic-readiness of U-space services**	Open University	NATS

Catalyst fund projects – wave 2

Project title	Coordinator	Consortium partners
Proof-of-concept: practical, flexible, affordable **pentesting platform** for ATM/avionics **cybersecurity** (‘ATM-cybersec’)	University of Jyväskylä	-
Safe drone flight - assuring **telemetry data integrity** in U-space scenarios (‘SDF’)	NATS	Open University
Flight centric **ATC with airstreams** (‘FC2A’)	NEOMETSYS	ENAC
Meteo sensors in the Sky (‘METSIS’)	NLR	AirHub BV
Probabilistic information integration in uncertain data processing for **trajectory prediction** (‘PIU4TP’)	CIRA	-
Collaborative **cybersecurity management framework**	Winsland Ltd	Movable-type; MSDK Research; BULATSA
Role of markets in **AAS deployment** (‘RoMiAD’)	Think Research Ltd	-
Weather impact prediction for ATFCM (‘WIPA’)	France Aviation Civile Services	MetSafe

Thematic challenges and projects

	Open	TC1	TC2	TC3	TC4	Σ
		cyber	TP	MET	market	
PhDs	2	-	5	2	2	10
CF Wave 1	-	2	3	4	1	10
CF Wave 2	1	3	1	2	1	8
Σ	3	5	9	8	4	28

Some reflections

- Catalyst fund projects **'light touch' approach effective**; (required) industry context valuable; **good 'catalysts'**
- Projects delivered **very high value for money** (ambitious)
- Virtual formats (e.g. workshops) offered **greater accessibility**;
  difficult to manage **high & low TRL** in same events

Thematic challenges and projects

Engage

sesar JOINT UNDERTAKING

Three examples
(then a pause for Q&A)

Operational alert Products for ATM via SWIM (OPAS)

Royal Belgian Institute for Space Aeronomy (BIRA)

Mentoring and advisories from

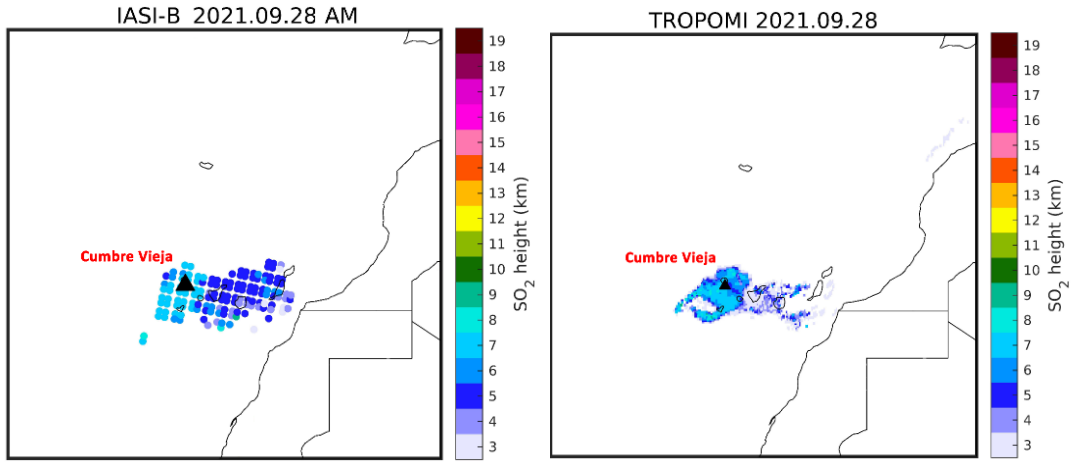
EUROCONTROL and Rolls-Royce

Development of a SWIM Technical Infrastructure Yellow Profile service providing notification & data access to volcanic SO_2 height

Objectives:

1) Algorithmic development of TROPOMI (**satellite sensors**) SO_2 height **[Extended iterative spectral fitting]**
2) Operational implementation of SO_2 height **[Automatisation]**
3) Tailored alert products of SO_2 height **[AI and machine learning]**
4) **Implementation of SO_2 height early warnings** **[Build on existing service]**
5) **SWIM registry of OPAS as a notification service (Yellow Profile)** **[Design, definition, publication]**

Key results



Visualisation

- **Algorithm development and operational run of SO_2 height (from TROPOMI satellite sensors)**
  - → Use of BIRA facilities and expertise in NRT SO_2 retrievals (*Brenot et al. 2014, NHESS; Theys et al. 2017, AMT*)
  - → **Validation using external observations** (*Brenot et al. 2020, SIDs*) → **TRL4**
- **Alert products of SO_2 height from TROPOMI and upgrade for IASI sensors**
  - → **Benefits of early warning system:** SACS (Support to Aviation Control Service)
    & Transfer of EUNADICS-AV (European Natural Airborne Disaster Information and Coordination System for Aviation)
    development (*Brenot et al. 2021, NHESS**) → **TRL5**
- **SWIM Yellow Profile Notification service: "OpasSo2lhDatasetNotification"**

https://eur-registry.swim.aero/services

* NHESS is an interactive, open-access journal of the European Geosciences Union

WIPA

Weather impact prediction tool for ATM

July 1st, 2020 to July 30th, 2021

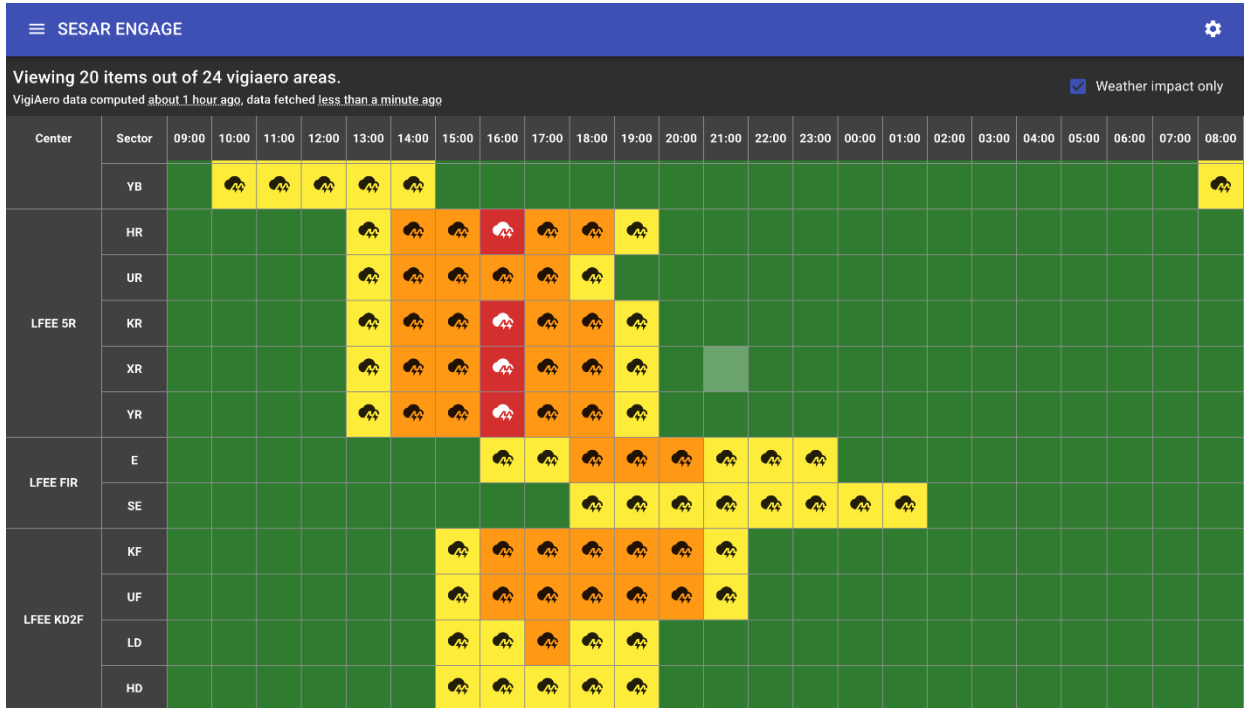
Objectives & approach

Ambition: to provide weather hazards impact information for ATFCM

- 3 steps
  - Use cases definition
  - Delivery of WIPA tool as a SWIM webservice
    - built on Engage 'MET Enhanced ATFCM' results: multi-model convection forecast
  - Technical and operational validation
    - DSNA air traffic controllers' involvement

Expected benefits: (i) anticipation of hazardous weather effect on capacity; (ii) better use of weather regulations; (iii) better use of airspace

Key results



Thunderstorm impact, per hour, per sector for the next 24H+

dgac DSNA

WIPA operational validation

Aix and Reims ATC rooms

May-July 2021

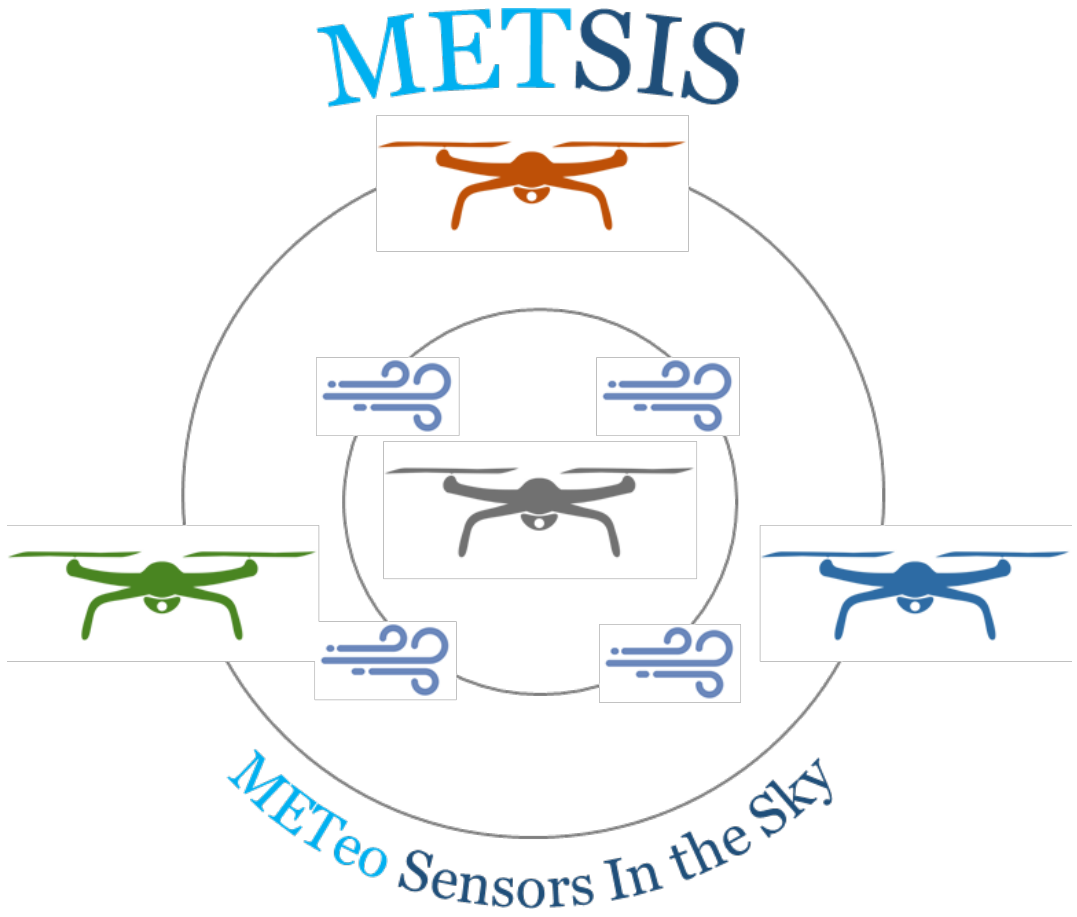
Key results

- From technical validation (15 reference days)
  - Thunderstorm behaviour different between Mediterranean and continental area: local tuning is needed on weather impact
  - ATM complexity needed to be introduced through consideration of ATM hotspots
  - For further experiments: using MET regulations from the NM,
    => need for an automated post ops analysis tools

- From operational validation (3 months validation)

cf. CDA

  - Different operational approach to hazardous weather between Aix and Reims ATCOs
  - Strengths of the tool: temporal progression of weather events, hourly update of the forecast, lightning impact information on the sectors
  - Better anticipation of ATC workload



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

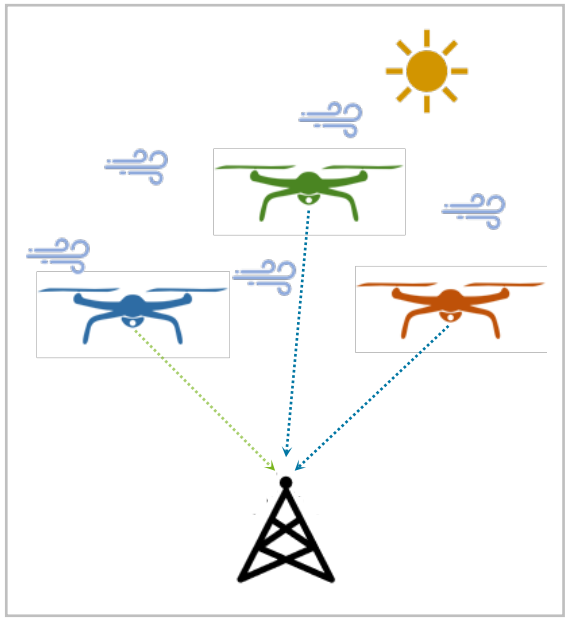
Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

Objectives

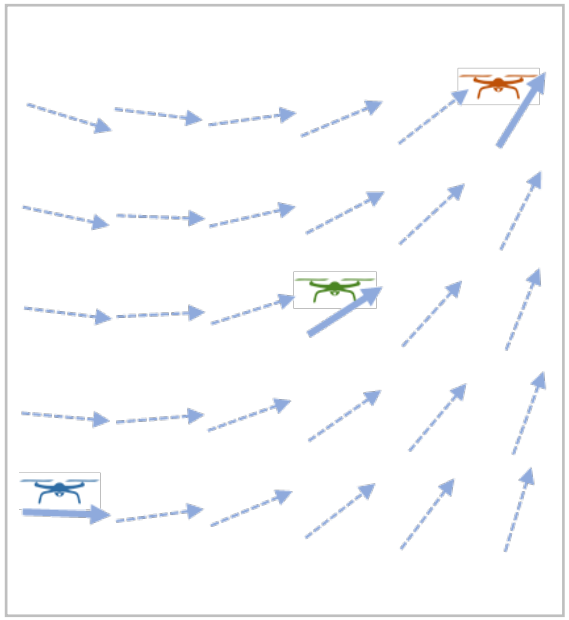
1. Determine accuracy of METSIS concept in presence of static obstacles to estimate low altitude winds below 500 ft
2. Determine how low-altitude wind information should be communicated to drone operators within a U-space system

Concept overview

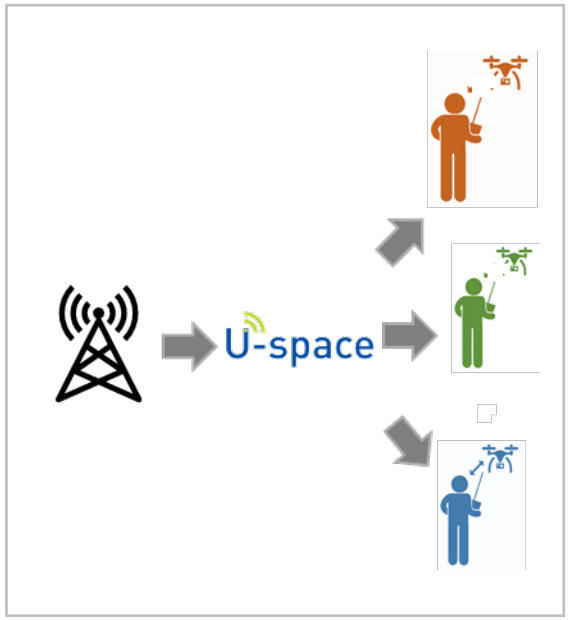
Using drones as an aerial sensor network for low altitude hyper-local wind now-casting



Step 1: Airborne drones measure **instantaneous wind states** and transmit data to a ground station



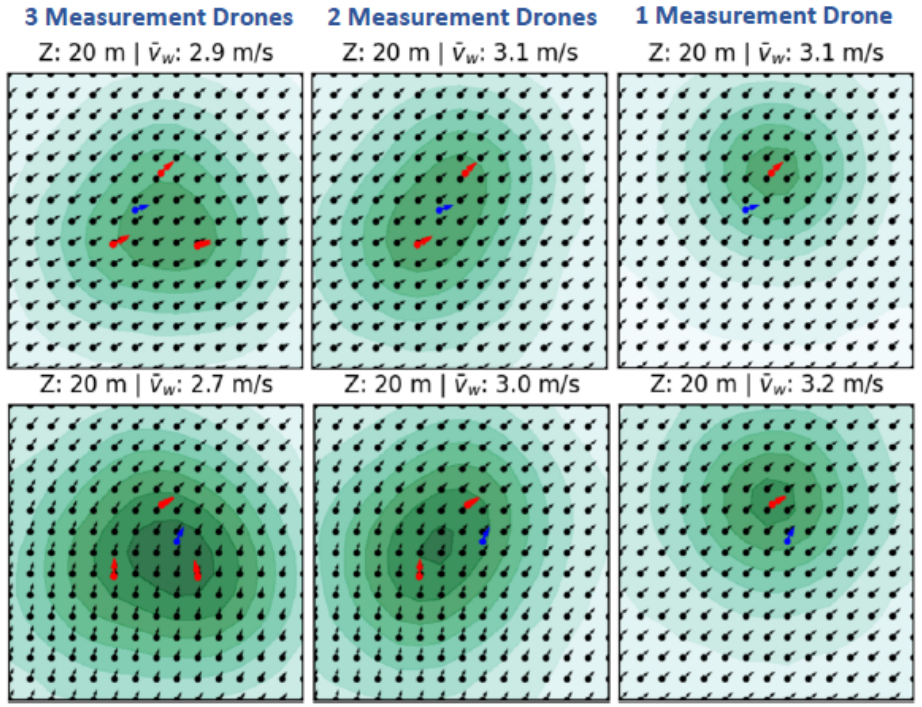
Step 2: Ground station uses the meteo particle model to estimate the **wind field in real time**



Step 3: The ground station communicates wind field data to **drone operators** via the **U-space weather information service**

Next steps, and key results

- Key results
  - Concept is feasible
    - on average, speed is reasonably accurate for both static and dynamic conditions – very promising
  - Accuracy is promising but needs to be further improved
    - direction is less accurate than the WMO standard, particularly in dynamic conditions – caused by propeller induced flow over the sensors during dynamic conditions and low wind speeds
- Future research
  - Increase scalability and accuracy of concept
  - Looking for partners to cooperate with

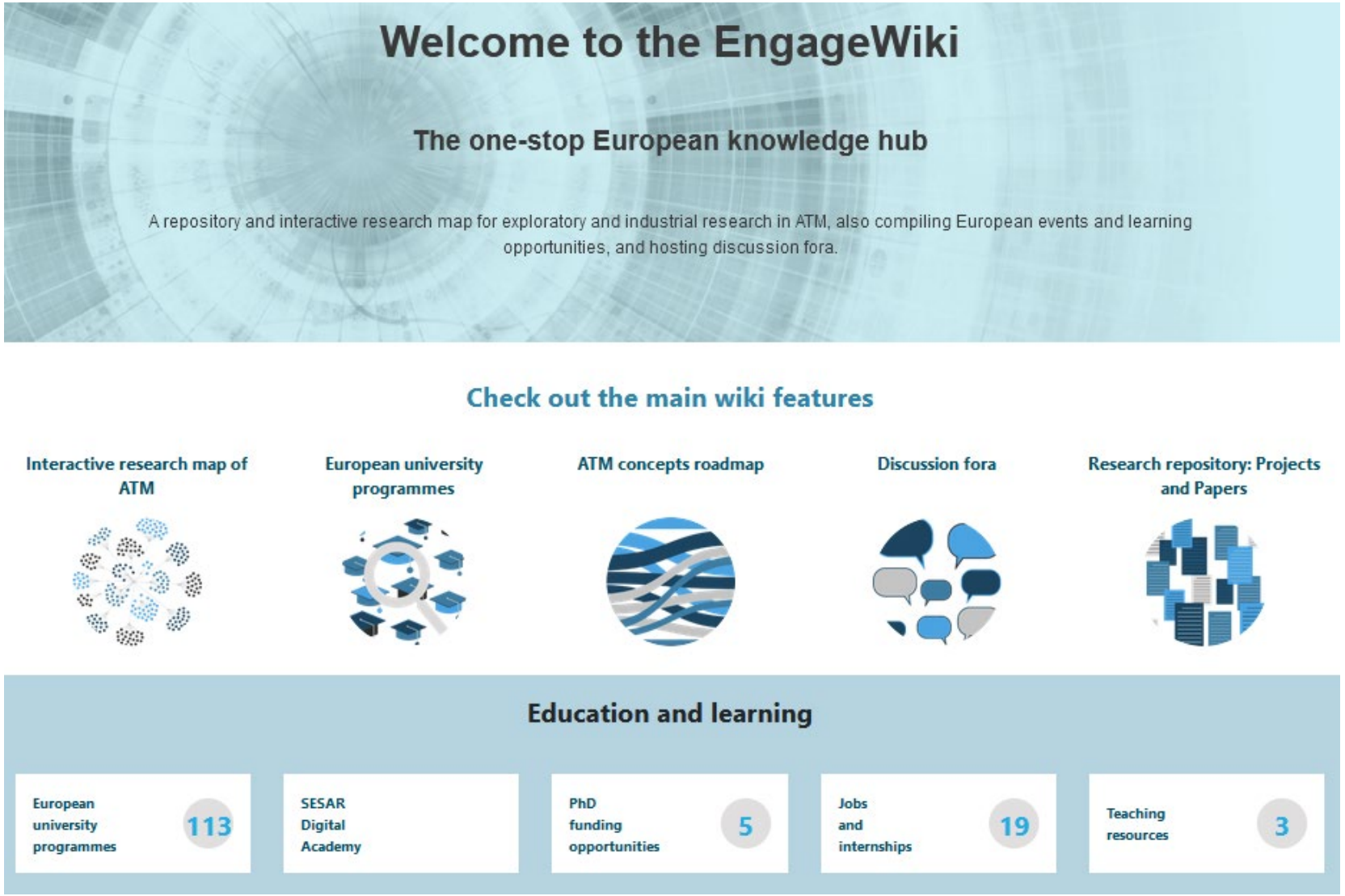


SIDs 2021 paper

Q&A #1

3. The EngageWiki, maps and repository

The EngageWiki, maps and repository



Multiple firsts in ATM

Interactive research map

Interactive concepts roadmap

Combined repository

(later)

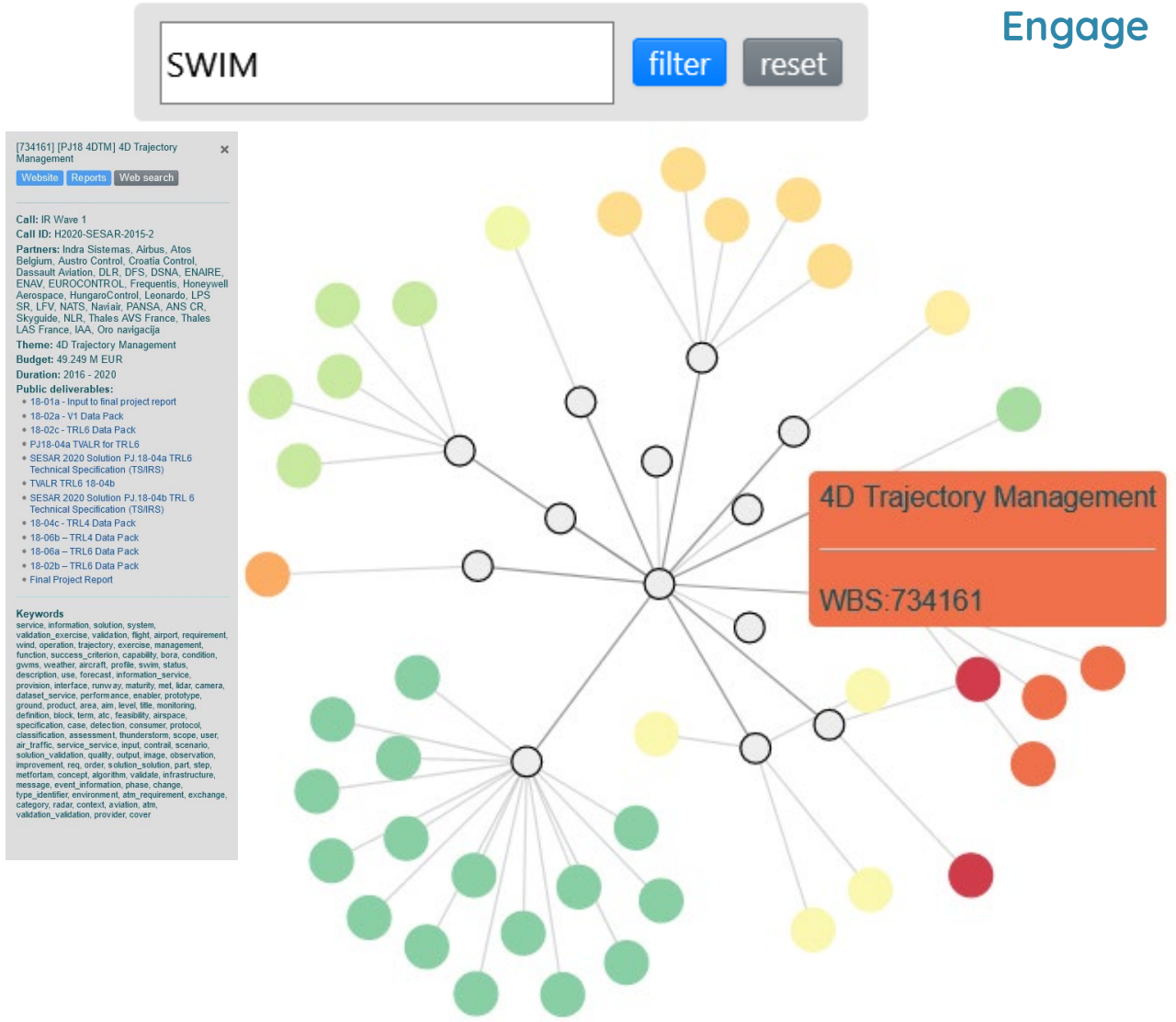
The EngageWiki, maps and repository

EngageWiki: interactive research map of ATM

[video link]

The EngageWiki, maps and repository

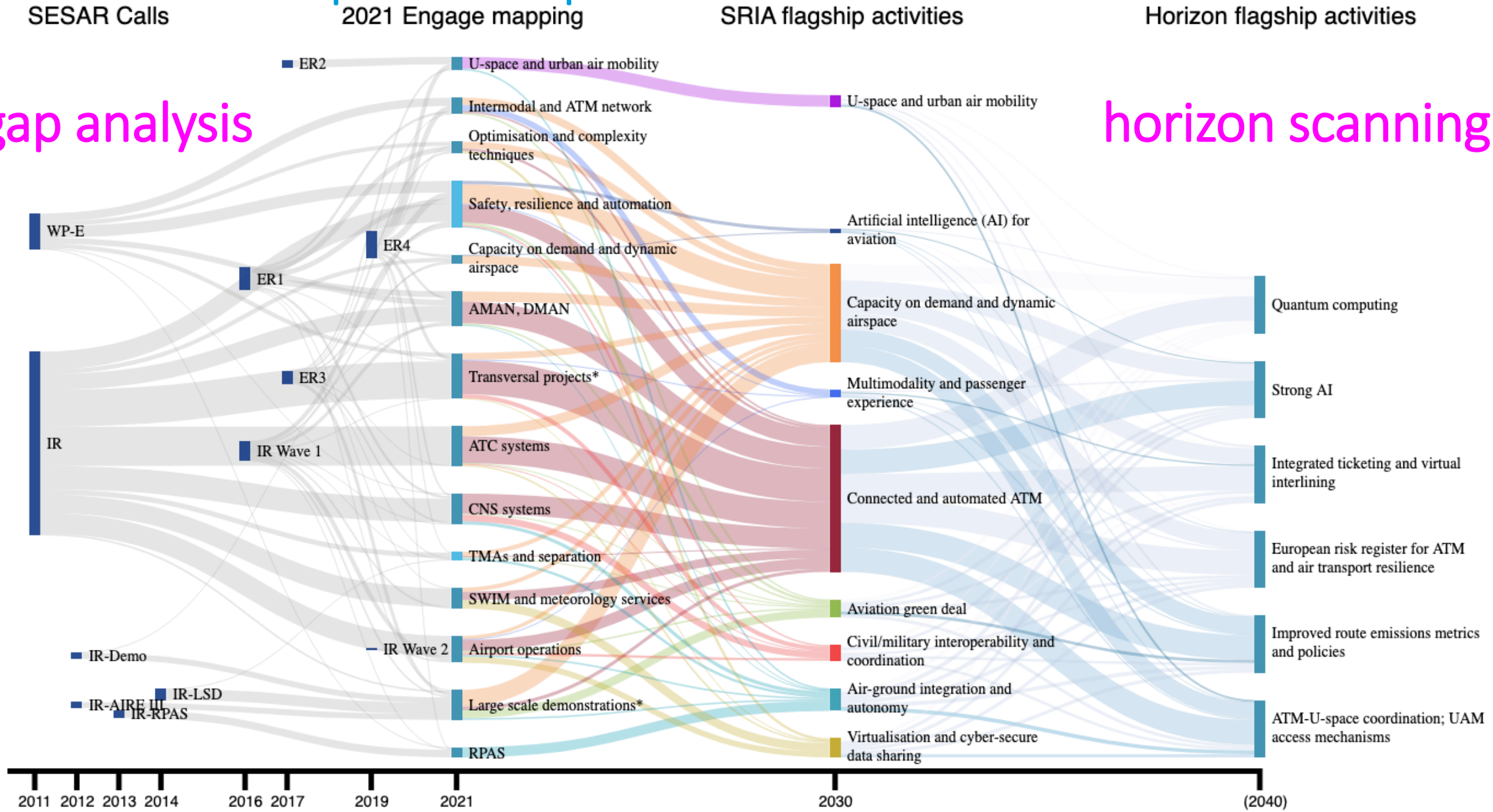
ER & IR



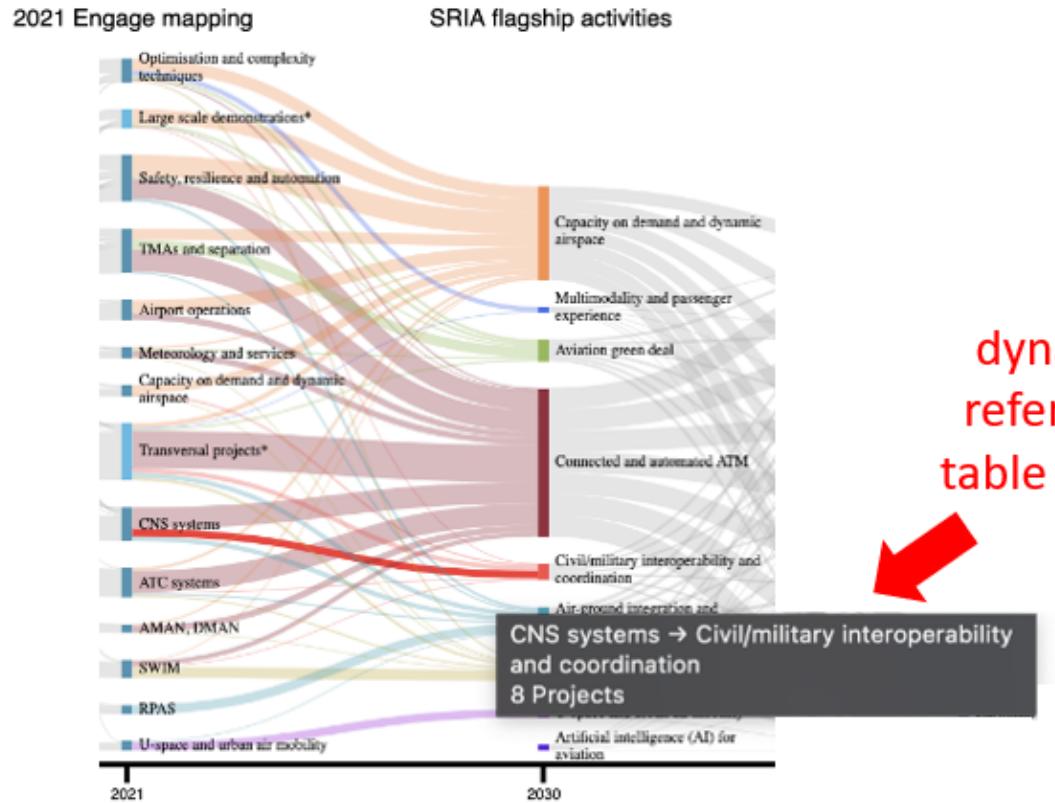
Interactive concepts roadmap

gap analysis

horizon scanning



ER & IR



dynamic reference table below

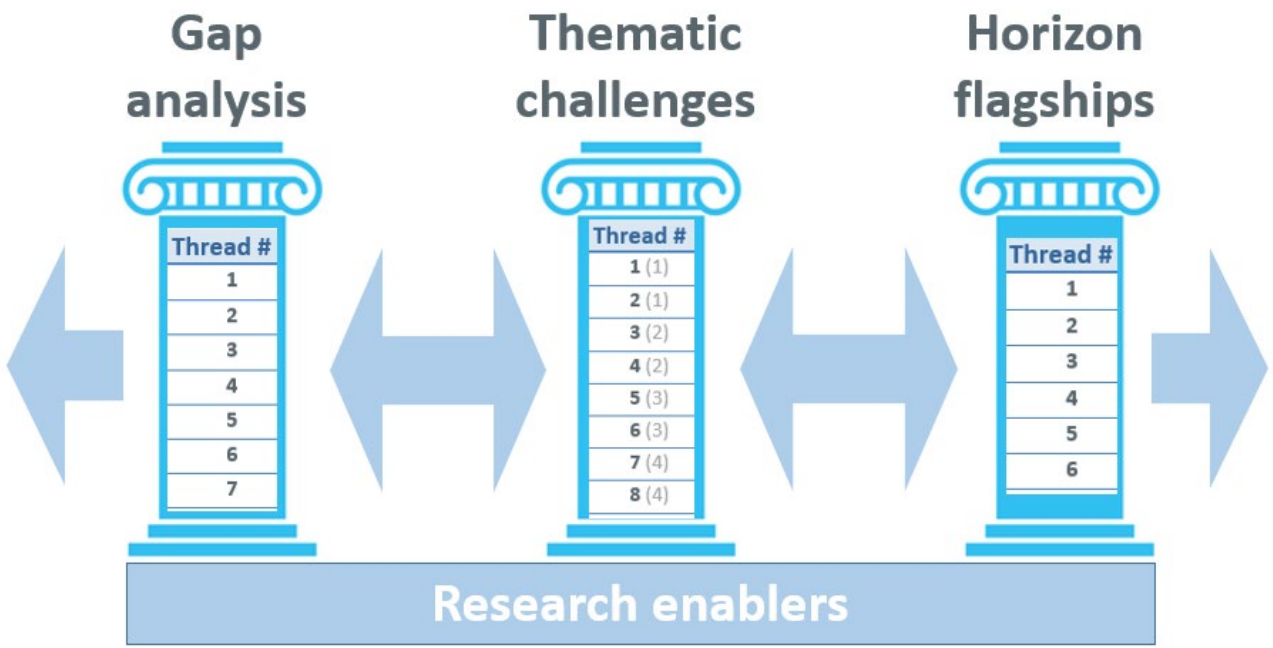
CNS systems → Civil/military interoperability and coordination
8 Projects

Link: CNS systems → Civil/military interoperability and coordination

Number of projects: 8

Project Name	SESAR Call	Engage mapping	SRIA flagship activities	Research repository
[09.24] ADS-B In/Out for military aircraft	IR	CNS systems	Civil/military interoperability and coordination	Link
[15.01.07] CNS System of System definition and roadmap	IR	CNS systems	Civil/military interoperability and coordination	Link
[15.00] Global Co-ordination & Management	IR	CNS systems	Civil/military interoperability and coordination	Link
[09.20] Military Data Link Accommodation	IR	CNS systems	Civil/military interoperability and coordination	Link
[15.02] Non Avionic CNS System	IR	CNS systems	Civil/military interoperability and coordination	Link
[15.04] Surveillance Infrastructure Rationalisation	IR	CNS systems	Civil/military interoperability and coordination	Link
[15.04.01] Surveillance Infrastructure Rationalisation	IR	CNS systems	Civil/military interoperability and coordination	Link
[15.04.05.b] Surveillance ground system enhancements for ADS-B (Prototype development)	IR	CNS systems	Civil/military interoperability and coordination	Link

The EngageWiki, maps and repository



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Research and innovation insights

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	5	**Virtualisation and cyber-secure data sharing:** This flagship addresses several high-level R&I needs/challenges, with that of 'cyber resilience' describing the need for monitoring and adapting to the changing threat landscape and emergence of new actors, aiming at the development of cyber-resilience guidelines and procedures tailored to ATM. However, a large and positive impact could be obtained through continuous collaboration and updates within a dedicated SESAR 3 cybersecurity community. This flagship is the place for setting up such guidelines and procedures, although not necessarily the best place for the establishment and nurturing of a cyber community, which might be developed through the SESAR 3 KTN or Digital Academy, overarching the flagship and its corresponding work components and actors.

(slides on methodology in this pack)

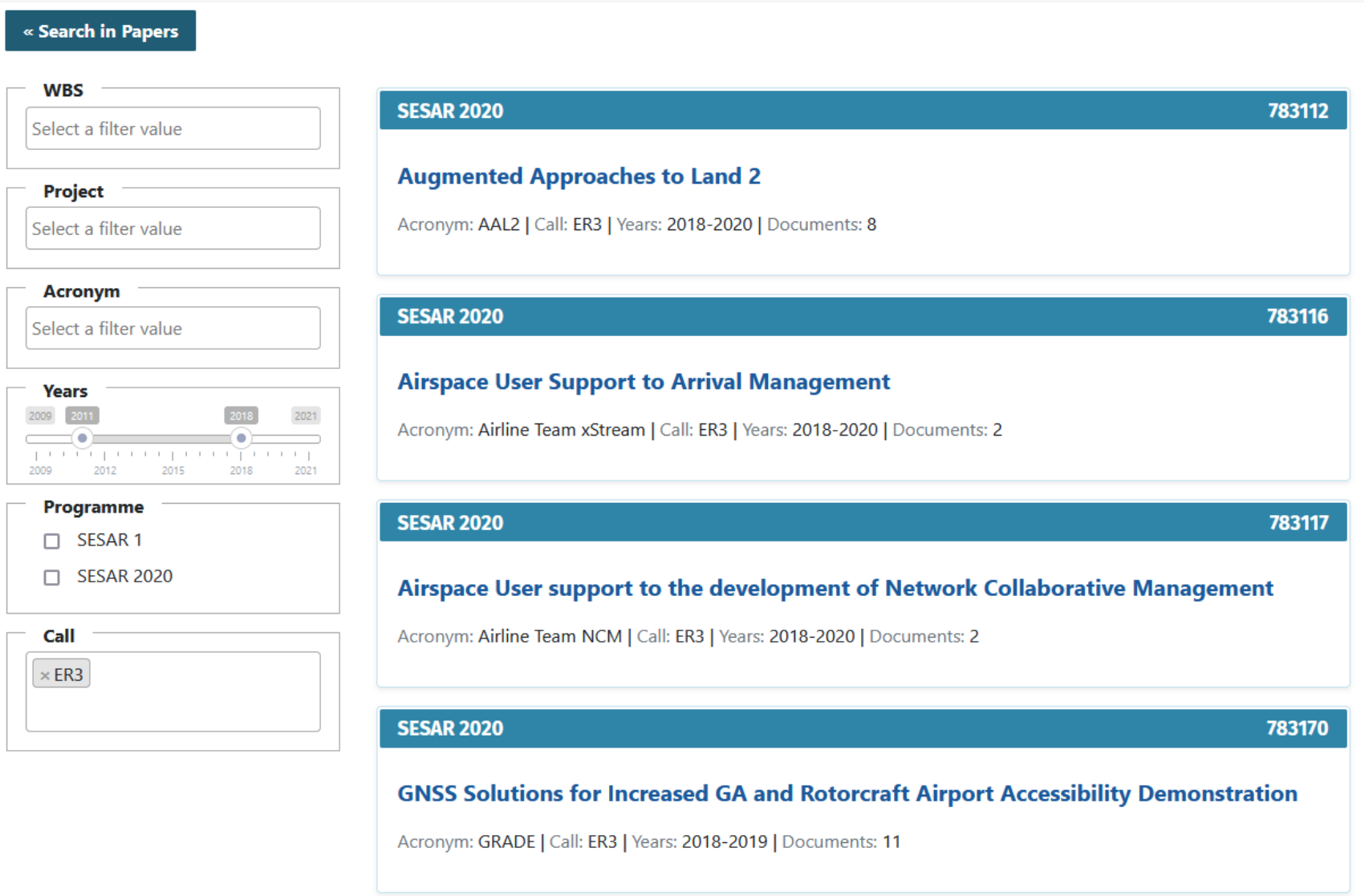
The EngageWiki, maps and repository

EngageWiki: research repository

[video link]

The EngageWiki, maps and repository

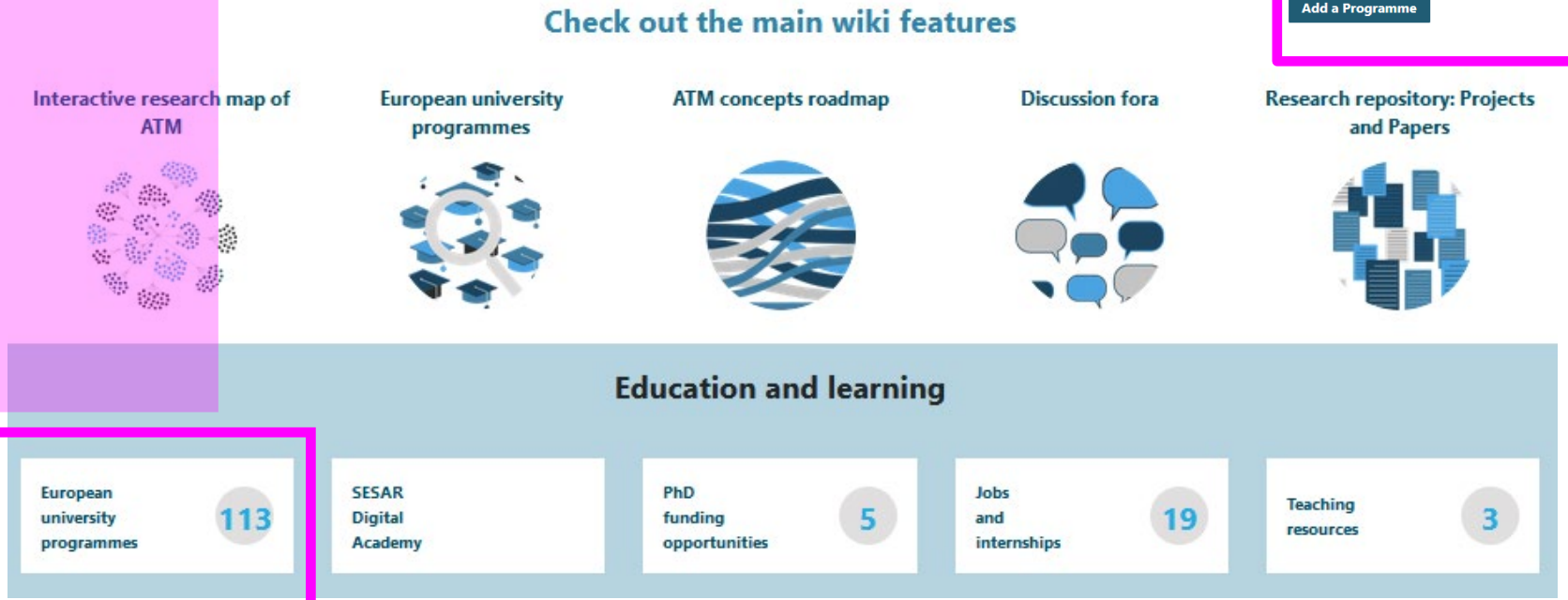
ER & IR

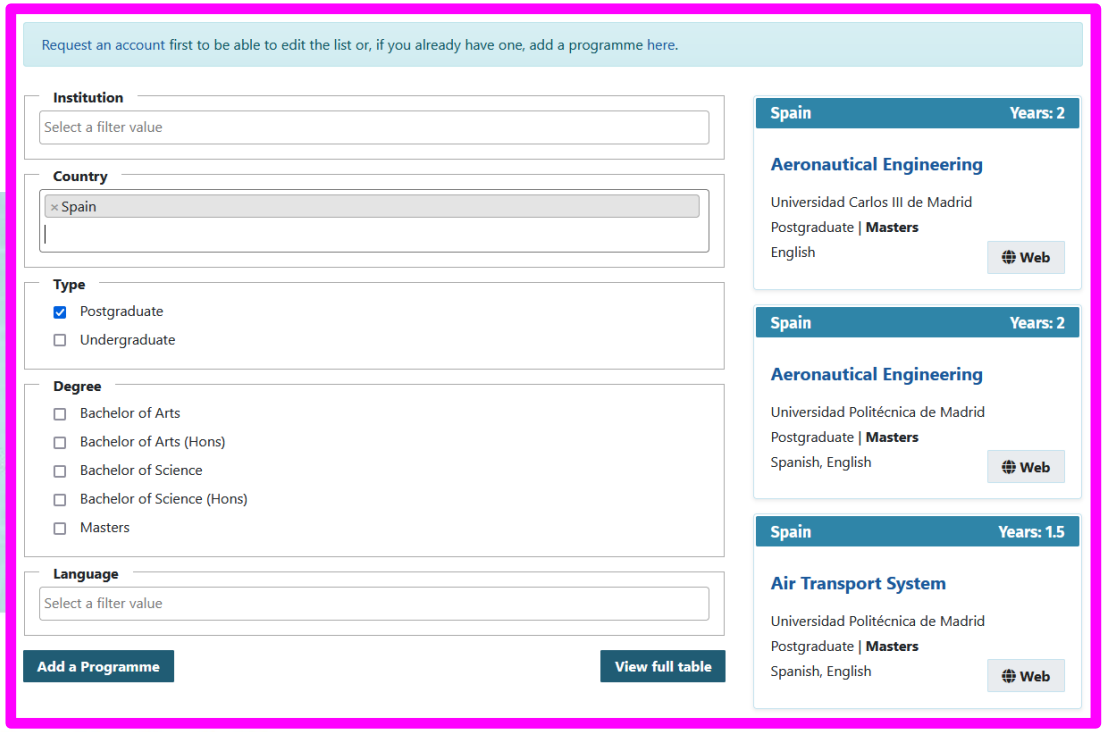


4. PhDs and educational elements (very brief insight)

SESAR Digital Academy

PhDs and educational elements





Free teaching resources

Introduction to ATM
Airline planning and operations
Airport planning and operations

[video link]

PhDs and educational elements

PhDs (1…5) … application-oriented, industry engaged

Candidate	Jonas Langner
PhD title	Decision support system for airline operation control hub centre
Proponent	TU Braunschweig

Candidate	Alevizos Bastas
PhD title	Trajectory planning for conflict-free trajectories: a multi agent reinforcement learning approach
Proponent	University of Piraeus

Candidate	Evgenii Munin (to 15APR22)
PhD title	Detection, classification, identification and mitigation of GNSS signal degradations by means of ML
Proponent	Ecole Nationale de l'Aviation Civile (ENAC)

Candidate	Manuel Mateos
PhD title	Machine learning for aircraft trajectory prediction: a solution for pre-tactical ATFCM
Proponent	Nommon (Madrid), with Technical University of Catalonia (UPC)

Candidate	Ralvi Isufaj
PhD title	Deep multi-agent reinforcement learning applications in ATM
Proponent	Universitat Autònoma de Barcelona (UAB)

PhDs and educational elements

PhDs (6…10) … application-oriented, industry engaged

Candidate	Anastasia Lemetti
PhD title	Integrating weather prediction models into ATM planning
Proponent	Linköping University

Candidate	Homeyra Khaledian
PhD title	Advanced statistical signal processing for next generation trajectory prediction
Proponent	Technical University of Catalonia (UPC)

Candidate	Eduardo Andrés
PhD title	A pilot/dispatcher support tool … enhanced provision of thunderstorm forecasts considering … uncertainty
Proponent	Universidad Carlos III de Madrid (UC3M)

Candidate	Sashiko Shirai Reyna
PhD title	Second generation agent-based modelling for improving APOC operations
Proponent	Amsterdam University of Applied Sciences (AUAS), with ENAC

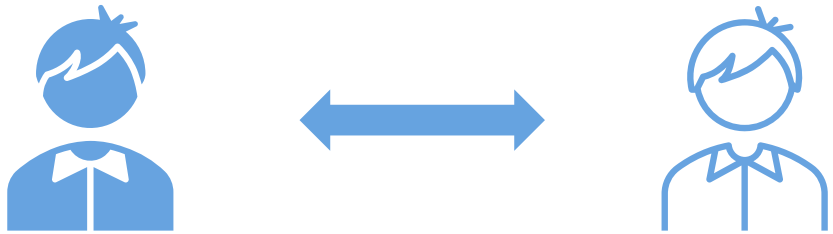
Candidate	Jan Evler
PhD title	Resource-constrained airline ground operations: optimizing schedule recovery under uncertainty
Proponent	TU Dresden

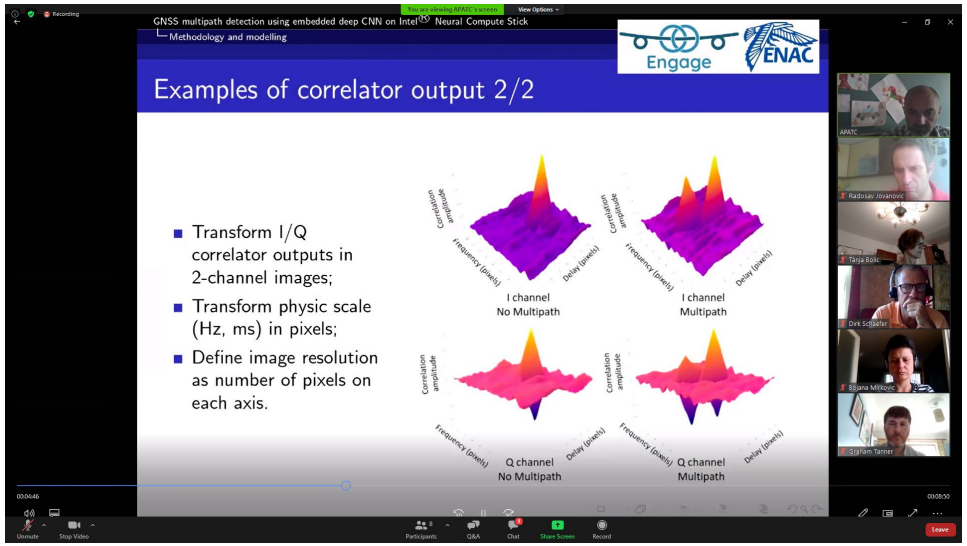
PhDs and educational elements

- Summer school 2019

PhDs and educational elements

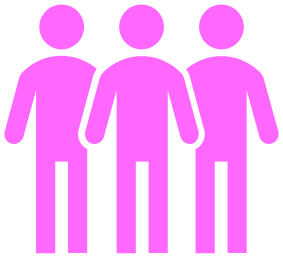
- Summer school 2020





PhDs and educational elements

- Summer school 2021



industry

PhDs and educational elements

Monday 30 AUG AM

Eva Puntero (SJU)

Luca Crecco (SJU)

Diogene De Souza (Heathrow Airport)

Alan Marsden (EUROCONTROL)

Monday 30 AUG PM

Olivia Nunez (SJU)

Gideon Wormeester (Skyguide)

Emmanuel Isambert (EASA)

Rainer Koelle (EUROCONTROL)

Johan Martensson (EUROCONTROL)

Tuesday 31 AUG PM

Daniel Schuller (NATS)

Lorna Herda (Skyguide)

Ruben Rodriguez (CRIDA)

Wednesday 01 SEP AM

Ruben Rodriguez (CRIDA)

Olivia Nunez (SJU)

Teresa Reis (NATS)

Thursday 02SEP AM

Luca Crecco (SJU)

Kamel Rebai (MetSafe)

Edward Holmes (NATS)

Thursday 02 SEP PM

Riccardo Massacci (SJU)

Anaïs Lacroix (Skyguide)

Jose Manuel Cordero Garcia (CRIDA)

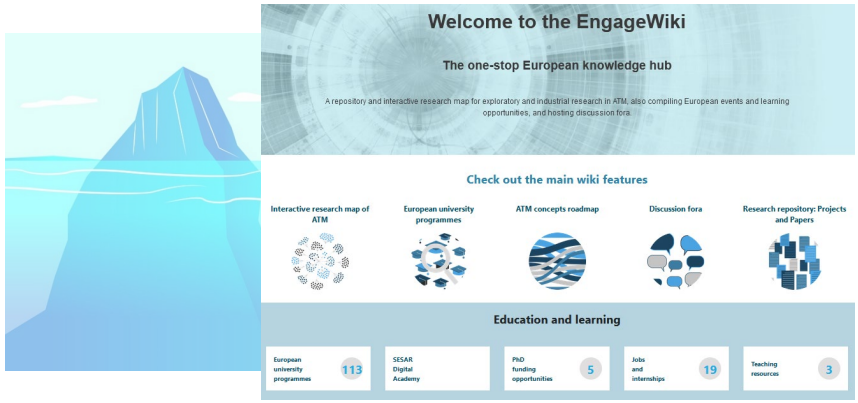
Nadine Pilon (EUROCONTROL)

Giuseppe Murgese (EUROCONTROL)

ER & IR

5. Heads-up on Engage 2 & getting involved

Engage 1 … in numbers



Wide range of synergistic elements underpinned by key overall objectives, such as integrating ER and IR

- supported 4 SESAR Innovation Days; ran 3 summer schools; 14 thematic challenge workshops (+ others)
- 4 thematic challenges; supporting 18 projects, working with 31 unique institutions, producing appx. 130 research outputs
- supported 10 PhDs (financing and co-mentoring), working with 21 unique institutions, producing appx. 100 research outputs; plus travel bursaries, publication grants, training course places; 3 rounds of additional budgetary support to PhDs
- research repository describes >350 projects, >1400 deliverables/reports and >650 conference papers
- database of >110 under-& post-graduate teaching programmes
- 3 introductory teaching courses
- >300 events publicised; appx. 100 job and internship ads
- appx. 60 industry partners

Research and innovation insights

D3.10

Engage 2 … the new team (pending GA)

Engage2

deepblue

(coordinator)

EUROCONTROL

FREQUENTIS

innaxis

easn

UNIVERSITY OF BELGRADE

Technische Universität Braunschweig

UNIVERSITY OF TRIESTE

UNIVERSITY OF WESTMINSTER

ASDA

Association for the Scientific Development of ATM in Europe

For industry – why and how to get involved

Why

- co-developing (research) needs directly with application-oriented academia: improved 

- getting new domains onto research agenda (short- and medium-term); e.g. catalyst funding to support
- shaping new tools (e.g. repository, mapping) and their functionality at the design stage – more user-centred
  - access to match-making platform – mobile app, identify *mutual* opportunities and align with skill pathway maps
- supporting the next generation of ATM operational and engineering staff
  - two-way processes, and often altruistic, e.g. SESAR Digital Academy / EUROCAE WG-125

Over 120 references to 'industry' in proposal!

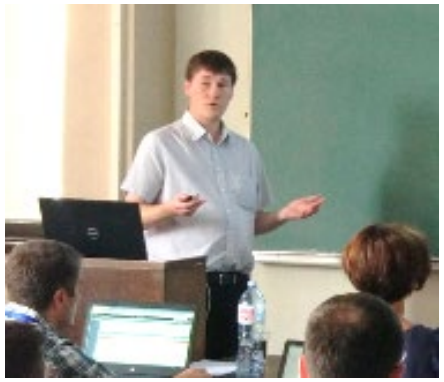
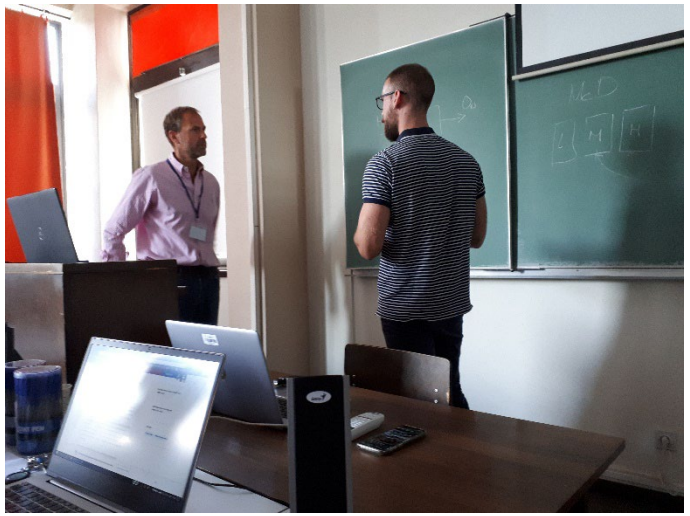
How

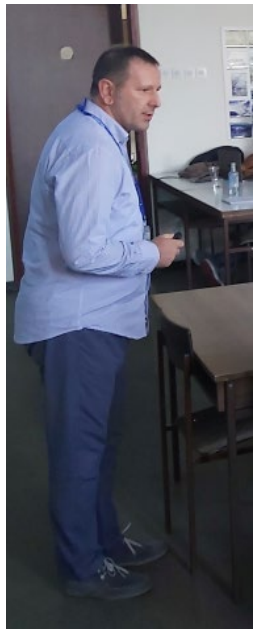
- **Industry Board** (more formal role); deeper integration into network; dedicated WP5
- roundtable consultations aimed at industry to help embed engagement across KTN and ensure relevance
- **18 events**, with ***industry design input***, including interdisciplinary & thematic workshops, plus open days (hosted at universities, inviting industry) and hackathons (driving digitalisation solutions for ATM)

Next

- promotion via SJU channels; re-inviting Engage 1 industry partners; other partners identified in advance
- in interim: **cookaj@westminster.ac.uk**

Thank you



Q&A #2

Stand-by slides

Background and overview
Extract from the Call

"**Communication** – organisation of workshops and symposiums … summer schools …

Observatory and roadmap – monitoring, identification and analysis of new opportunities for innovative ATM research of relevance to the evolution of the European ATM system and the development of a long-term roadmap … beyond SESAR 2020 …

Take-up – stimulate the transfer of exploratory research results towards ATM applications-oriented research and onwards towards industrial research…

Future ATM Skilled work-force – supports European ATM education and training in the ATM Community to develop new talent with a deep knowledge of the future ATM scientific research needs which will sustain a supply of bright young ATM research talent in the long term as well as stimulating the next generation of ATM operational and engineering staff …

Support to SJU initiatives – support the organisation of the SESAR Innovation Days research conference and the SESAR Young Scientist Award …"

D3.10 – Table 2-9 extract

D3.10

Research and innovation insights

Table 2-9. Research threads for the gap analysis pillar & relationships with SRIA flagships

Thread	SRIA flagship(s)	Summary
1		**Additional focus on safety performance:** In the analyses presented on the semantic similarity index for each of the projects in our database with respect to the descriptions of the nine SRIA flagship activities, it is noteworthy that the two weakest-linked past projects are safety related. This raised the question regarding the extent to which the SRIA is sufficiently safety oriented, given the clearly accepted view of the priority of this operational performance criterion.
	1 	**Connected and automated ATM:** The SRIA has not allocated safety as an area of specific work *per se*, but rather as a horizontal performance criterion forcing safety evaluations to be undertaken in each area. However, the foreseen contributions of the nine flagship activities to the safety dimension seem to be quite modest, from "maintaining" to "maintained if not improved", falling rather short, it seems, of earlier ACARE/SES objectives of a ten-fold safety improvement. This flagship (connected and automated ATM) aims at higher levels of automation and specific tools for safety improvement in higher levels of automation. It would be of value to stress even more the need for a well-designed and executed safety assessment, as that is usually the stepping stone for faster development and deployment, especially for safety-critical innovations. Approaches to safety assessment developed since SESAR 1 could add value here.
2		**Developing techniques for dynamic risk modelling:** The analyses presented here flagged that modelling in some projects often ran ahead of corresponding validation and use. Therefore, developing techniques for dynamic risk modelling was supported, with, *inter alia*, a suggestion that R&D relating to human performance management systems should be analysed further before selective follow-up could be recommended.
	1, 2  	**Connected and automated ATM; Air-ground integration and autonomy:** These two flagships propose research into safety-critical areas, which require rigorous safety assessments. It would be of value to stress the need for well-designed and executed safety assessments for research performed in these flagships (also for other flagships, but the link to these two is more critical). However, it is readily acknowledged that material on the application of dynamic risk modelling is included in the *Guidance to Apply SESAR Safety Reference Material**, whereas it would be endorsed that actual safety assessments should deploy tools specific to the safety requirements in question.

D3.10 – Table 2-11 extract

D3.10

Research and innovation insights

Table 2-11. Research threads for the thematic challenges pillar & relationships with SRIA flagships

Thread (TCs in brackets)	SRIA flagship(s)	Summary
1 (1)		**Establish and develop a SESAR 3 cybersecurity community:** 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 cyber-attacks. Further investigations are necessary to mitigate these vulnerabilities, moving towards a cyber-resilient system, fully characterising ATM data, its confidentiality, integrity and availability requirements, taking into account the fact that new and old ATM systems will continue to operate concurrently for years to come. All these issues are especially challenging in a multi-stakeholder, multi-system environment such as ATM, where confidentiality and trust are key. Nevertheless, the cybersecurity awareness and security culture is still rather immature in ATM research, whilst there is much interest in addressing this topic and creating a SESAR 3 cybersecurity community.
	5	**Virtualisation and cyber-secure data sharing:** This flagship addresses several high-level R&I needs/challenges, with that of 'cyber resilience' describing the need for monitoring and adapting to the changing threat landscape and emergence of new actors, aiming at the development of cyber-resilience guidelines and procedures tailored to ATM. However, a large and positive impact could be obtained through continuous collaboration and updates within a dedicated SESAR 3 cybersecurity community. This flagship is the place for setting up such guidelines and procedures, although not necessarily the best place for the establishment and nurturing of a cyber community, which might be developed through the SESAR 3 KTN or Digital Academy, overarching the flagship and its corresponding work components and actors.
2 (1)		**Support a culture of responsible disclosure & sharing experimental scenarios*:** In order to improve the cybersecurity awareness and security culture research in particular, in ATM, there is a need for common data sets and synthetic data. Responsible disclosure mechanisms for research and, more importantly, for the ATM community, are particularly relevant. Such mechanisms tend to be highly bureaucratic and troublesome, complicated further for researchers by some tech companies making use of cease-and-desist orders. This is a very complex topic in cybersecurity – and for data privacy in general, across the flagships, impacting research output validation, for example (since projects use different input data).

D3.10 – Table 2-13 extract

D3.10

Research and innovation insights

Table 2-13. Research threads for the horizon flagships pillar & relationships with SRIA flagships

Thread	SRIA flagship(s)	Summary
1		**Quantum computing:** Quantum computers use quantum physics properties to enable certain types of computations to be performed vastly quicker than classical computers. A fundamental advantage of quantum computers is the ability to consider large numbers of combinations simultaneously. Quantum computing could expose cybersecurity vulnerabilities, through solving integer factorisation problems, which underpin many public key cryptographic systems, including blockchain applications, thus already generating improved cybersecurity research. Quantum computing is likely to bring particular opportunities for simulation, especially when coupled with machine learning and AI.
	8	**Artificial intelligence (AI) for aviation:** whilst the strongest correspondence of quantum computing is unsurprisingly with the 'AI' flagship, the wider implications for this new technology are very broad and deep, considering the applications of much faster solutions to search space and combinatorial problems, potentially offering vastly improved capabilities both for operational/tactical searches of improved solutions to complex capacity constraints in ATM, and e.g. (safety) validation. Exposing cybersecurity vulnerabilities and supporting public key cryptographic systems are clearly important in the ATM context regarding not only CNS, but also in the context wider of information exchange over networks, supporting SWIM and privileged data exchange (e.g. for UDPP).
2		**Strong AI:** this is also known as general AI or artificial general intelligence, usually referring to a form of AI whereby a computer has intelligence comparable to that of humans, with the ability to solve problems, learn, and plan future contingencies. Reinforcement learning is arguably a sufficient basis for strong AI, e.g. with the inclusion of agents that learn through interaction with the environment through operational sensors. Coupled with deep neural networks, more powerful dimension reduction and polynomial classification, such technologies could help to build better predictive models from specific aircraft and component safety profiles through to full socio-technical system models at the design stage.
	8, 1	**Artificial intelligence (AI) for aviation:** the strongest correspondence of strong AI is not unexpectedly with the 'AI' flagship, which cites "AI for prescriptive aviation". Whilst strong AI represents a step-shift in the state of the art, it builds on the current science, for example, whereby the coupling of advanced sensor technologies with ML/AI techniques, could support system development in multiple contexts, such as risk mitigation, system diagnoses, performance assessment, forecasting, predictive support and design. **Connected and automated ATM:** may be supported specifically through more efficient resource allocation for humans and machines, although this is just one of many other SRIA flagships potentially impacted strategically and tactically e.g. through strong AI's foresight capabilities, 'strong emergence' and policy generation.

HORIZON-SESAR-2022-DES-ER-01-WA3-1

SESAR Digital Academy initiative. The network will support the European ATM education and training required to develop new talent with a deep knowledge of future ATM scientific research needs, sustain a supply of bright young research talent in the long term and stimulate the next generation of ATM operational and engineering staff. To achieve this, the selected consortium will carry out at least the following activities.

- It will launch calls for PhD research projects, managing the call text, the selection process, funding and promotion, and coordinating the participation of the funded PhD students in key SESAR Digital Academy events. It will also be responsible for signposting other financial support opportunities for students pursuing PhDs and other postgraduate theses or dissertations on innovative research ideas.
- It will facilitate placements and/or training opportunities, offering students a chance to develop new skills and gain valuable industry experience.
- It will support the promotion of the SESAR Young Scientist Award campaigns, helping to ensure the visibility of the campaign and encouraging aviation students to submit applications.
- It will support the SESAR 3 JU in the preparation and execution of webinars and other similar events (see also the following bullet point).

D3.9

- D3.9: The Engage wiki – functionality and user-manual
- Details on the data sources in the wiki; repository functionality
- How the interactive map was built, deriving the clusters
- Concepts roadmap – relationship with the SRIA
  - Horizon flagships – seeding future-oriented research ideas (e.g. ‘strong AI’)
- University progs, teaching resources, internships, PhD Calls
  - how to engage and edit yourself (instructions also in the wiki itself)
- Full provision to maintain in 2022, videos, handover to SJU
  - *Detailed* lessons (e.g. attacks); next steps (e.g. building discussion fora, SESAR 3)

D3.10

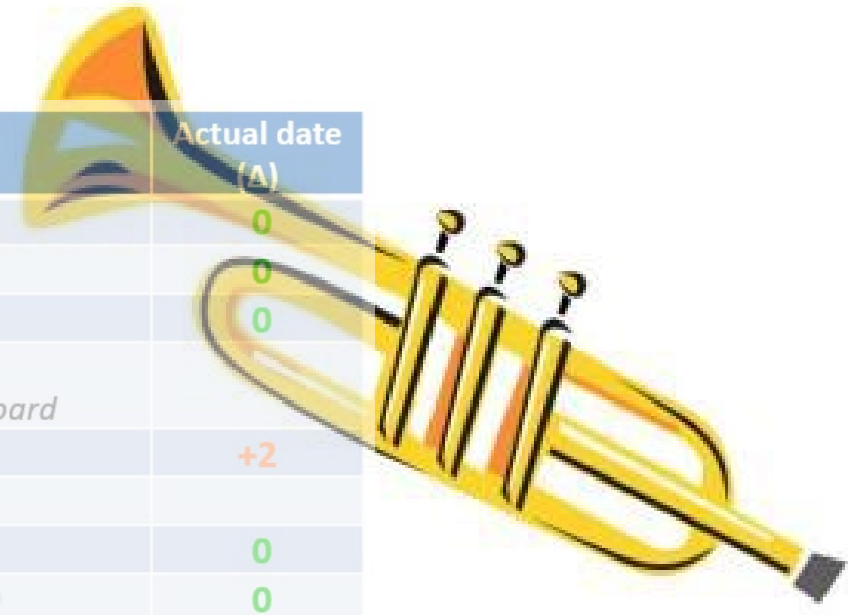
- Research enablers
  - Data and code issues (e.g. access, licencing framework, synthetic data)
  - Community collaboration (people, networks, momentum)
  - Extending the SESAR KPI state of the art
  - Distributed and remote simulations (Covid-19)
- Research platforms
  - *Possibilities* for the wiki going forward
  - Sources of project data – consolidation and recency
  - Format and implementation of virtual workshops

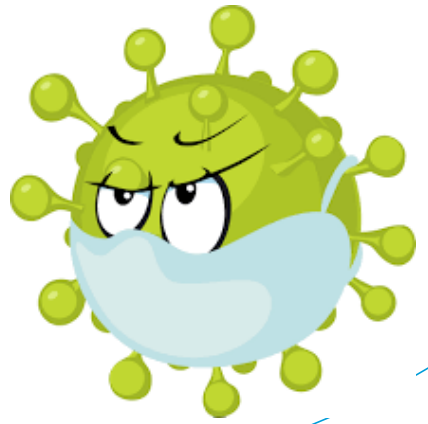
Detailed lessons learned across the KTN

Thematic challenges and projects

Second Call for CF projects

Scheduled date	Activity	Actual date (A)
06JAN20	Call opened (Commission's Participant Portal; Engage website)	0
30MAR20	Ensure everything ready for the evaluation process	0
06APR20	**Call closes (2 day turnaround)**	0
	– submission checks *– resolve any potential conflicts of interest; allocation to Awards Board*	
08APR20	**Evaluation begins (4 weeks to contracting process)**	+2
	– 3 weeks for the evaluation, incl. Easter break	
20APR20	Reminder to Awards Board about evaluations	0
28APR20	**Evaluation deadline** (latest to return evaluations to ECTL)	0
	– 1 week to process and determine the outcome (up to 8 projects)	
05MAY20	Funding decision finalised	+1
06MAY20	**Send notification letter to all proposers**	+1
06MAY20	UoW contracting process begins; then UoW to each CF2 project coordinator	+1
11MAY20	Start consolidating evaluation feedback across evaluators (110 forms)	–5
[endMAY]	Send detailed, consolidated feedback (+ve/-ve outcomes) prior to launch	0
08JUN20	CF2 projects begin launching (once agreement signed)	–8
03JUL20	All CF2 projects launched	0

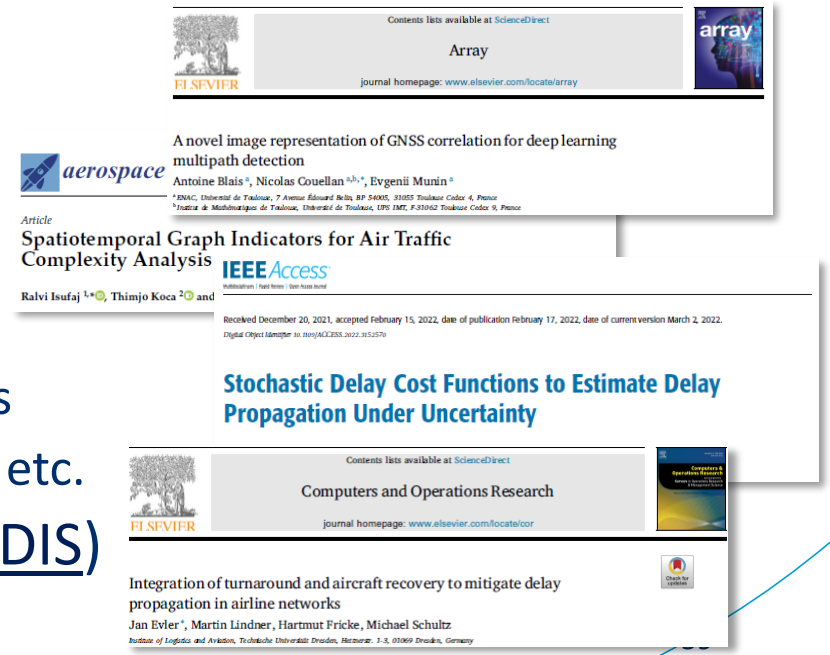




C&D highlights

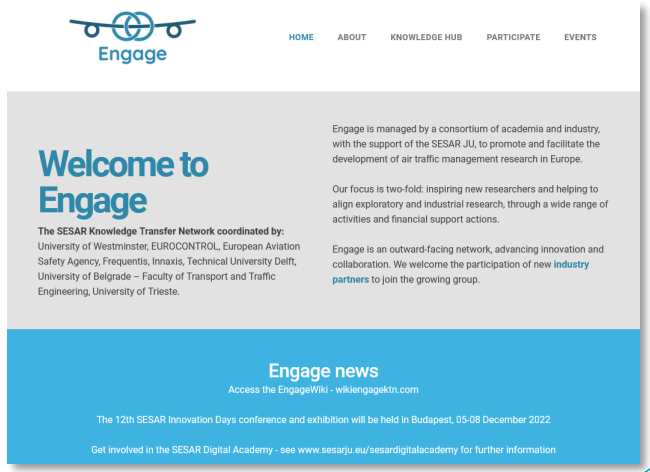
- Engage C&D activities have
  i. supported European ATM **education & training** in the ATM community
  ii. stimulated the **transfer of ER** results towards ATM application-oriented research
    - Engage PhDs & CF projects have produced **over 200 research outputs**, including:
      - 15 open access journal articles (peer-reviewed)
      - 40 conference papers (peer-reviewed)
      - 100+ presentations at workshops & other events
      - plus book chapters, code, tools, videos, posters, etc.
    - **50 publications** logged in EC Portal (via CORDIS)

e.g. ATM R&D Seminar, EIWAC, EMSS, ICRAT, OpenSky, SIDs conferences



C&D highlights

- Website
  - engagektn.com launched in M1 (JAN18)
  - ≈52k page views over the lifetime of Engage; **approx. 1000 hits per month**, with peaks in the build-up to key KTN activities e.g. PhD/CF Calls, summer schools & workshops
  - top 3 pages: home (incl. news items), thematic challenge workshops & events
  - key information is being maintained **after the closure of Engage**: SIDs conference & Call opportunities



C&D highlights

- Social media
  - twitter.com/EngageKTN launched in MAY18; **850+ followers**
  - supported & promoted content relevant to ATM community; supported all S3JU Tweets for the duration of Engage
  - key content is being supported **after the closure of Engage**, e.g. SIDs 2022 conference & its Call for contributions
  - custom banners to help promote key events

PhDs and education – SDA

SESAR Digital Academy

PhDs and education – SDA

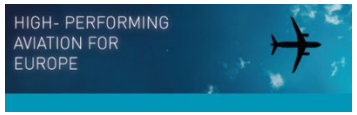
June 2021

EngageWiki

Introduction to ATM
Airline planning and operations
Airport planning and operations

Free use for all academic / research institutions

Engage website



SESAR JU E-News

SESAR JU website

E-mail subscribers

PhDs and education – SDA

EngageWiki: European university programmes

[video link]

PhDs and education – SDA
PhD: Jonas Langner

Candidate	Jonas Langner
PhD title	Decision support system for airline operation control hub centre (‘DiSpAtCH’)
Lead supervisor	Prof. Dr.-Ing. Peter Hecker
Proponent	TU Braunschweig
Summary	During **airline disruption**, decision making mainly relies on the experience of staff working in the operation control centre. ‘DiSpAtCH’ is developing a **decision support tool using machine learning** algorithms – three ML modules have been defined of which one aims to propose a suitable action/solution in a disrupted situation. Since the required training data are unavailable, an airline simulation tool has had to be built in order to produce generic operational data of an airline and its daily operations.
Start date	15JUL19
End date	(14JUL22) Q3 2022 +2 months
Final reporting	Approved
Funding	€125 792 (99.8%)

D5.18

PhDs and education – SDA
PhD: Alevizos Bastas

Candidate	Alevizos Bastas
PhD title	Trajectory planning for conflict-free trajectories: a multi agent reinforcement learning approach (RL4CFTP)
Lead supervisor	Prof. George Vouros
Proponent	University of Piraeus
Summary	This PhD is exploring **AI/machine learning algorithms** in order to **plan conflict-free trajectories** in computationally efficient ways, for a large number of trajectories across airspace in multiple FIRs.
Start date	29MAR19
End date	(28MAR22) NOV 2022 +8 months
Final reporting	Approved
Funding	€41 554 (89.1%)

D5.19

PhDs and education – SDA
PhD: Evgenii Munin

Candidate	Evgenii Munin
PhD title	Detection, classification, identification and mitigation of GNSS signal degradations by means of machine learning
Lead supervisor	Prof. Nicolas Couellan
Proponent	ENAC
Summary	The quality of the position calculated by on-board GPS equipment can be reduced when the received signal is degraded. The objective of this PhD was to use **machine learning techniques** to detect, classify, identify and **reduce the impairments of the Global Navigation Satellite System signals** seen by the on-board receiver.
Start date	16APR19
End date	(15APR22) (N/A; candidate *withdrew from PhD*)
Final reporting	Publishable final report only (no formal assessment; no further payment)
Funding	€43 811 (69.9%)

D5.20

PhDs and education – SDA
PhD: Manuel Mateos

Candidate	Manuel Mateos
PhD title	Machine learning for aircraft trajectory prediction: a solution for pre-tactical ATFCM
Lead supervisor	Dr. Xavier Prats
Proponent	Nommon (with UPC)
Summary	The overall goal is to develop and evaluate innovative approaches to **air traffic demand forecasting based on AI and machine learning** techniques, focusing on the pre-tactical phase of the ATFM process. The solution being developed aims to improve the predictive performance of the NM's PREDICT tool while being able to cope with the entire set of flights in the ECAC network in a computationally efficient manner.
Start date	01MAR19
End date	(28FEB22) SEP 2022 +7 months
Final reporting	Approved
Funding	€87 834 (100.0%)

D5.21

PhDs and education – SDA
PhD: Ralvi Isufaj

Candidate	**Ralvi Isufaj**
PhD title	Deep multi-agent reinforcement learning applications in ATM
Lead supervisor	Dr. Miquel Angel Piera
Proponent	UAB
Summary	This PhD is built on the future work proposals of the AGENT ER project and seeks possible improvement of several critical aspects of the system through the application of **machine learning** techniques. There are two goals in this project: **define airspace complexity in a way that challenges current definitions** and overcomes their limitations, and investigate how ML can be **applied to safety** in aviation. These problems have been investigated for en-route traffic at the tactical level, as well as UAV systems.
Start date	01MAY19
End date	(30APR22) JUL 2022 +3 months
Final reporting	Approved
Funding	€45 586 (91.2%)

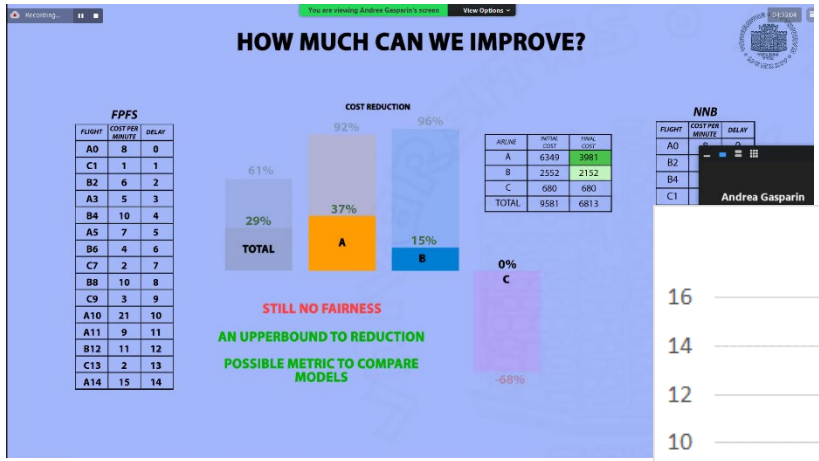
D5.22

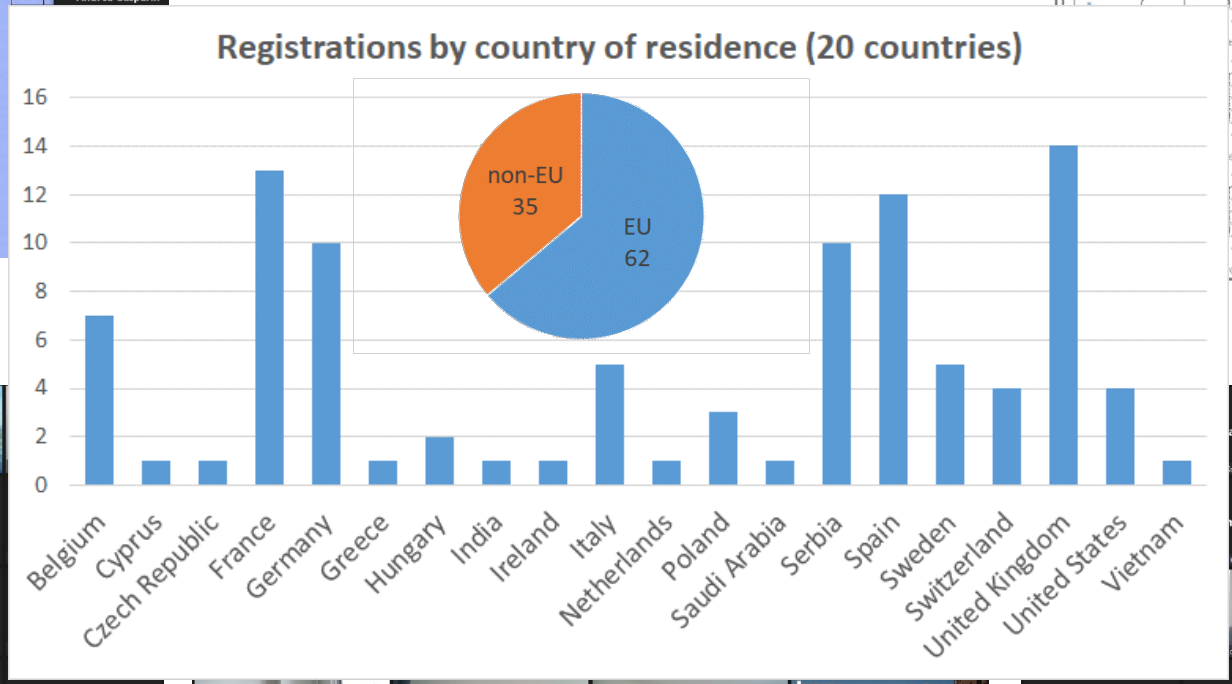
	09.45-10.00	10.00-11.15	11.30-12.30	Lunch break	13.30-14.10	14.10-14.45	15.00-15.30	
MON 30AUG	**Opening** *Andrew Cook (UoW) & Lorenzo Castelli (University of Trieste)*	**Airline and airport operations centres** *Jonas Langner (TU Braunschweig), Sashiko Shirai Reyna (Amsterdam UAS/ENAC)*	**Panel discussion** Moderator: *Bojana Mirkovic (University of Belgrade-FTTE)*		**Signal processing for trajectory prediction** *Homeyra Khaledian (UPC Barcelona)*	**Panel discussion** Moderator: *Junzi Sun (TU Delft)*	**SESAR Young Scientist Award** *Junzi Sun (TU Delft)*	
		11.15-12.00	12.00-12.30		13.30-14.45	15.00-16.00		
TUE 31AUG		**The Engage wiki** *Pablo Hernandez (Innaxis)*	**Teaching resources in the wiki** *(University of Belgrade-FTTE*)*		**DCB hotspot detection and machine learning for traffic demand prediction** *Sergi Mas Pujol (UPC Barcelona), Manuel Mateos (Nommon/UPC Barcelona)*	**Panel discussion** Moderator: *Lorenzo Castelli (Uni. of Trieste)*		
		10.00-11.15	11.30-12.30		13.30-15.30	15.30-16.00		
WED 01SEP		**Machine learning and traffic deconfliction** *Alevizos Bastas (University of Piraeus), Ralvi Isufaj (UAB Barcelona)*	**Panel discussion** Moderator: *Fedja Netjasov (Belgrade-FTTE)*		**Shaping a future European ATM Academy** *SESAR Scientific Committee*	**Engage PhDs Q&A** *UoW*		
		10.00-11.15	11.30-12.30		13.30-14.45	15.00-16.00	16.15-17.00	17.00-17.15
THU 02SEP		**Weather prediction / forecasting models** *Anastasia Lemetti (Linköping University), Eduardo Andrés (Universidad Carlos III Madrid)*	**Panel discussion** Moderator: *Tatjana Bolic (University of Westminster)*		**Flight prioritisation, UDPP and route charging** *Jan Evler (TU Dresden), Andrea Gasparin (University of Trieste), Natalia Solčianska, (University of Trieste)*	**Panel discussion** Moderator: *Andrew Cook (University of Westminster)*	**Future research horizons** *Dirk Schaefer (EUROCONTROL)*	**Close and what's coming next** *Andrew Cook (UoW)*

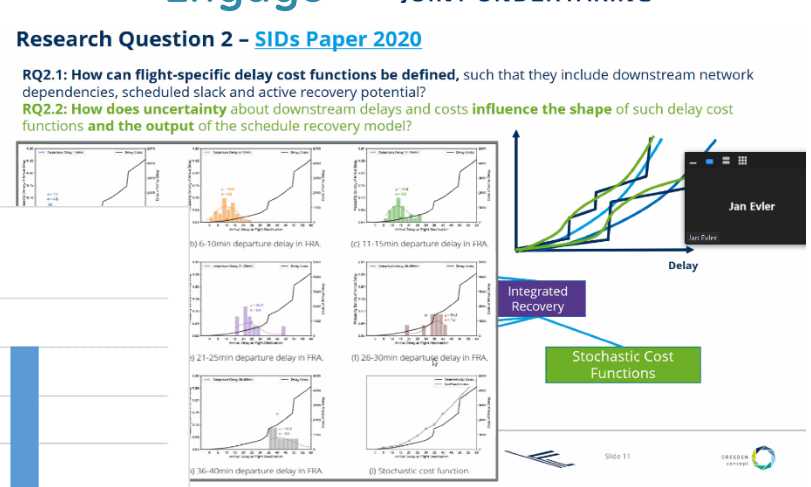
**Bojana Mirkovic, Fedja Netjasov, Danica Babić*

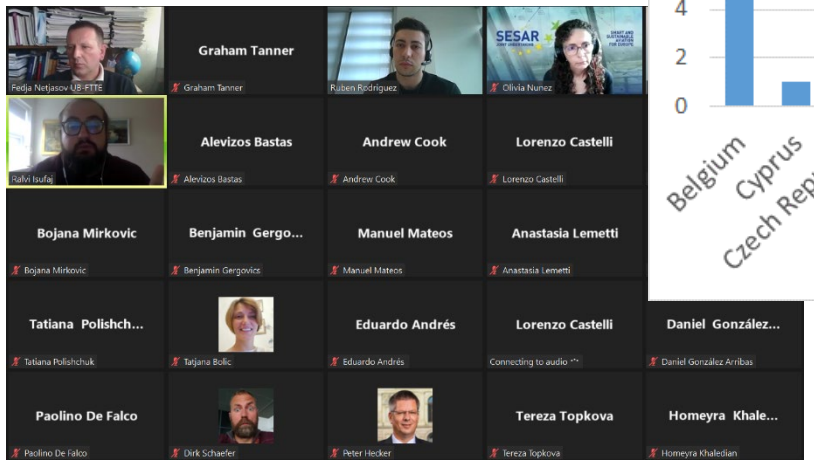
PhDs and education – SDA Summer schools

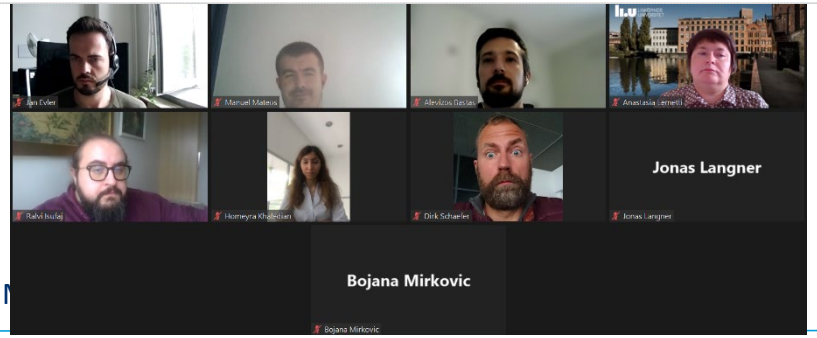
97 participants

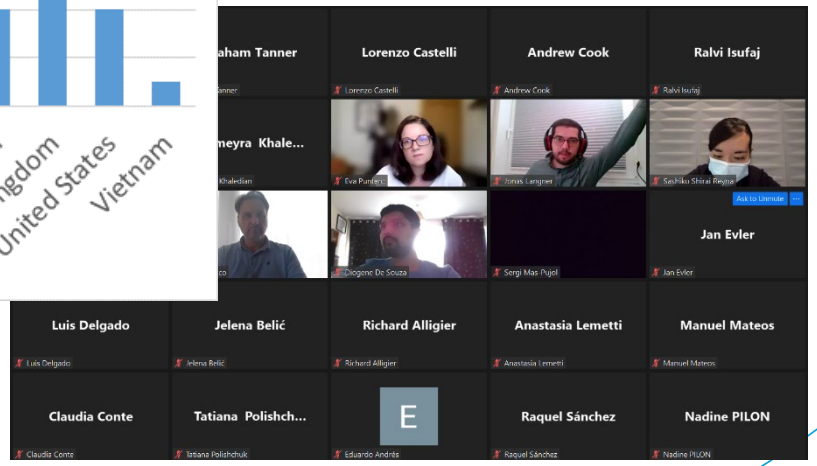












PhDs and education – SDA Summer schools

Monday 30 AUG AM

Eva Puntero (SJU)

Luca Crecco (SJU)

Diogene De Souza (Heathrow Airport)

Alan Marsden (EUROCONTROL)

Monday 30 AUG PM

Olivia Nunez (SJU)

Gideon Wormeester (Skyguide)

Emmanuel Isambert (EASA)

Rainer Koelle (EUROCONTROL)

Johan Martensson (EUROCONTROL)

Tuesday 31 AUG PM

Daniel Schuller (NATS)

Lorna Herda (Skyguide)

Ruben Rodriguez (CRIDA)

Wednesday 01 SEP AM

Ruben Rodriguez (CRIDA)

Olivia Nunez (SJU)

Teresa Reis (NATS)

Thursday 02SEP AM

Luca Crecco (SJU)

Kamel Rebai (MetSafe)

Edward Holmes (NATS)

Thursday 02 SEP PM

Riccardo Massacci (SJU)

Anaïs Lacroix (Skyguide)

Jose Manuel Cordero Garcia (CRIDA)

Nadine Pilon (EUROCONTROL)

Giuseppe Murgese (EUROCONTROL)

Thank you panellists!

PhDs and education – SDA
PhD: Anastasia Lemetti

Candidate	Anastasia Lemetti
PhD title	Integrating weather prediction models into ATM planning (‘IWA’)
Lead supervisor	Dr. Valentin Polishchuk
Proponent	Linköping University
Summary	The PhD applies **probabilistic weather modelling techniques**, that consider the influence of bad weather conditions on the solutions developed in related projects and integrates them into optimisation frameworks. The optimisation framework for **arrival route planning in TMA** has been enhanced with a convective weather avoidance technique. Probabilistic weather products have then been used to obtain an ensemble of staffing solutions, from which the probability distributions of the **number of necessary ATCOs were derived**. Proposed solutions were successfully tested using historical flight data from Swedish airports.
Start date	01MAR19
End date	(28FEB22) Q1 2024 (*+24 months*)
Final reporting	Approved
Funding	€102 000 (100.0%)

D5.23

PhDs and education – SDA
PhD: Homeyra Khaledian

Candidate	Homeyra Khaledian
PhD title	Advanced statistical signal processing for next generation trajectory prediction
Lead supervisor	Dr. Xavier Prats
Proponent	UPC
Summary	Reliable guidance mode information, i.e. the constraints and commands that specify how the aircraft should behave in order to perform a desired trajectory, is fundamental for air- or ground-based trajectory prediction. This research has focused on **identifying aircraft guidance modes in the vertical plane**, including a new **probabilistic perspective of the trajectory prediction** problem using signal processing mathematical tools.
Start date	01AUG19
End date	(31JUL22) MAY 2023 +10 months
Final reporting	Approved
Funding	€50 000 (100.0%)

D5.24

PhDs and education – SDA
PhD: Eduardo Andrés

Candidate	Eduardo Andrés
PhD title	A pilot/dispatcher support tool based on the enhanced provision of thunderstorm forecasts considering its inherent uncertainty ('STORMY')
Lead supervisor	Dr. Manuel Soler
Proponent	UC3M
Summary	The **location and timing of thunderstorms** are hard to predict with certainty, and this **stochasticity** is an important element that methodologies for aircraft trajectory planning must consider. This PhD uses **two heuristic approaches** (scenario-based rapidly-exploring random tree and augmented random search) that rely on the iterative manipulation of graphs, producing results in seconds through the use of GPU programming.
Start date	01FEB19
End date	(31JAN22) SEP 2022 +8 months
Final reporting	Approved
Funding	€64 226 (98.8%)

D5.25

PhDs and education – SDA
PhDs: Sashiko Shirai Reyna

Candidate	Sashiko Shirai Reyna
PhD title	Second generation agent-based modelling for improving APOC operations
Lead supervisor	Prof. Daniel Delahaye
Proponent	AUAS (with ENAC)
Summary	The objective of this work is to create a **decision support tool to help the airport operation centre** with the integration of different approaches, by **mitigating the conflicts of critical resources**. Conflicts are related to different processes of the airport management and capacity (e.g. **runway, taxiway, gates and ground handling**). To solve these conflicts, an adapted simulated annealing heuristic combined with a time decomposition approach (sliding window) is used.
Start date	01OCT19
End date	(30SEP22) NOV 2022 +2 months
Final reporting	Approved
Funding	€101 988 (98.5%)

D5.26

PhDs and education – SDA
PhD: Jan Evler

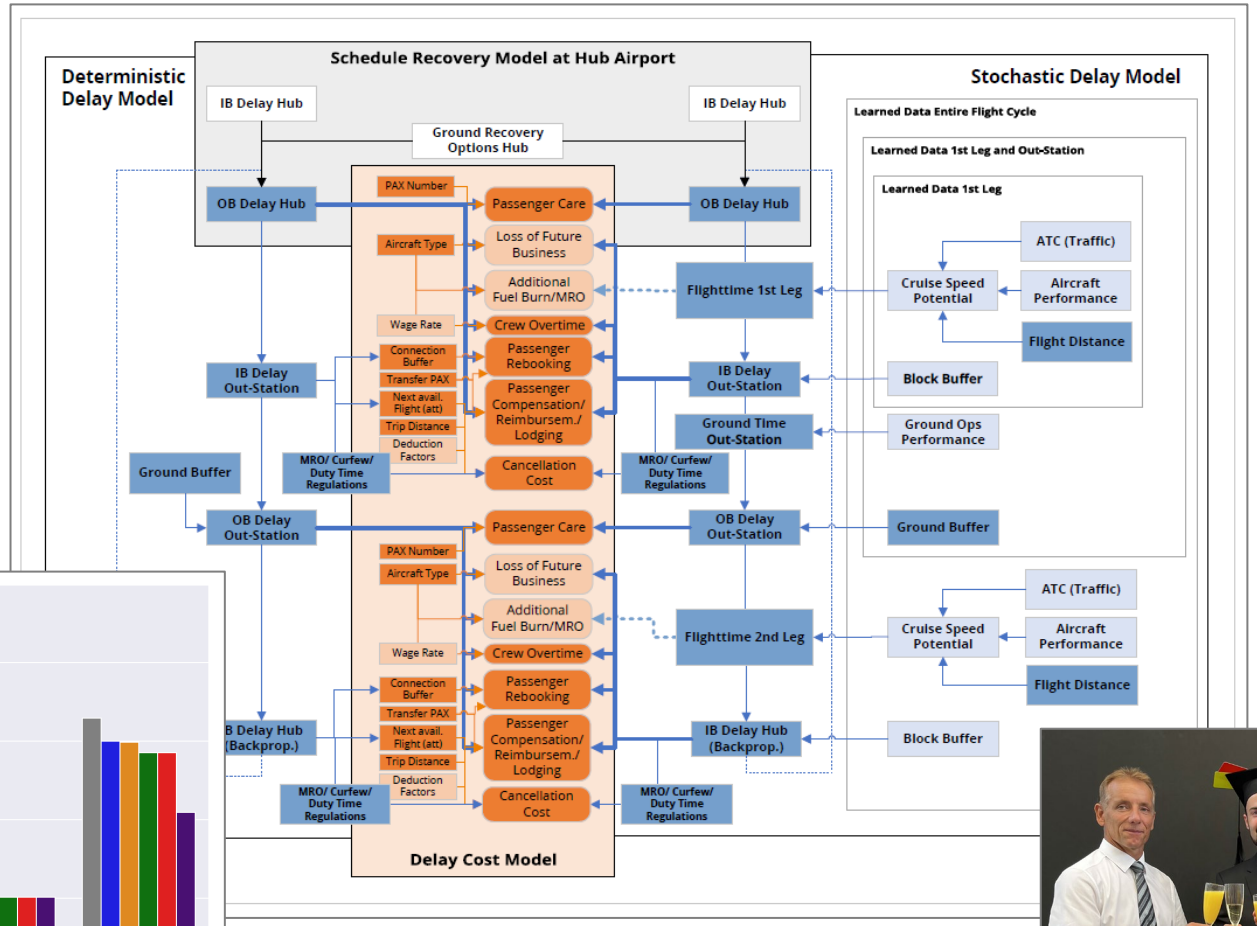
Candidate	Jan Evler
PhD title	Resource-Constrained Airline Ground Operations: Optimizing Schedule Recovery under Uncertainty *(originally 'Stochastic control of tactical airline operations in hub airport networks')*
Lead supervisor	Prof. Dr.-Ing. Hartmut Fricke
Proponent	TU Dresden
Summary	While ATFM regards each flight as an individual entity when it controls sector capacity utilisation, airlines evaluate each flight as part of an aircraft rotation, crew pairing and passenger itinerary. As a result, **ATFM slot regulations are poorly coordinated with the resource interdependencies within an airline network**, such that the **aircraft turnaround is the major contributor** to primary and reactionary delays in Europe. This PhD bridges the gap between both paradigms by developing an **integrated schedule recovery model** that enables airlines to define their optimal flight priorities for schedule disturbances arising from ATFM capacity constraints.
Start date	01JUN19
End date	(31MAY22) FEB 2022 *(-3 months)*
Final reporting	Approved
Funding	€122 284 (93.9%)

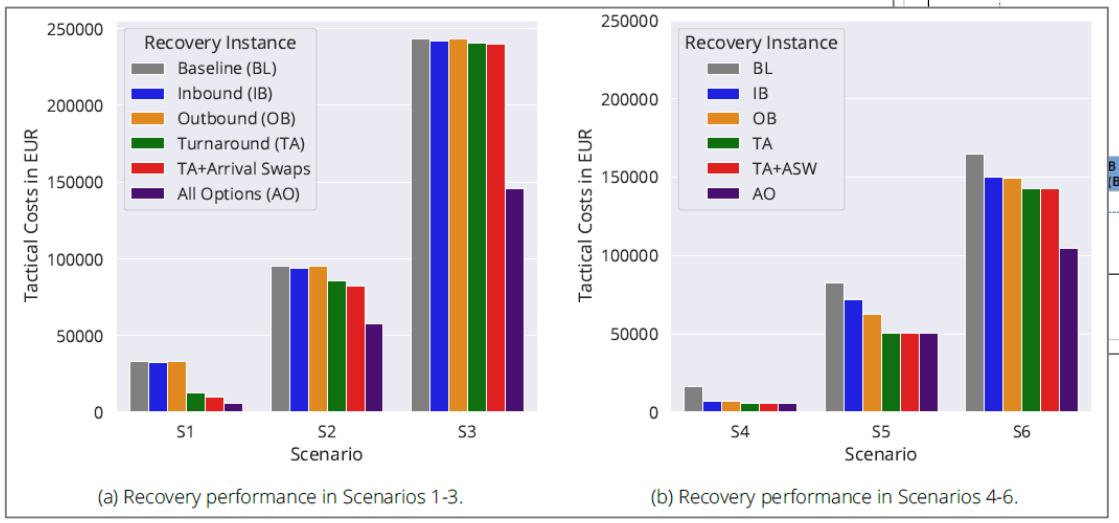
D5.27

PhDs and education – SDA

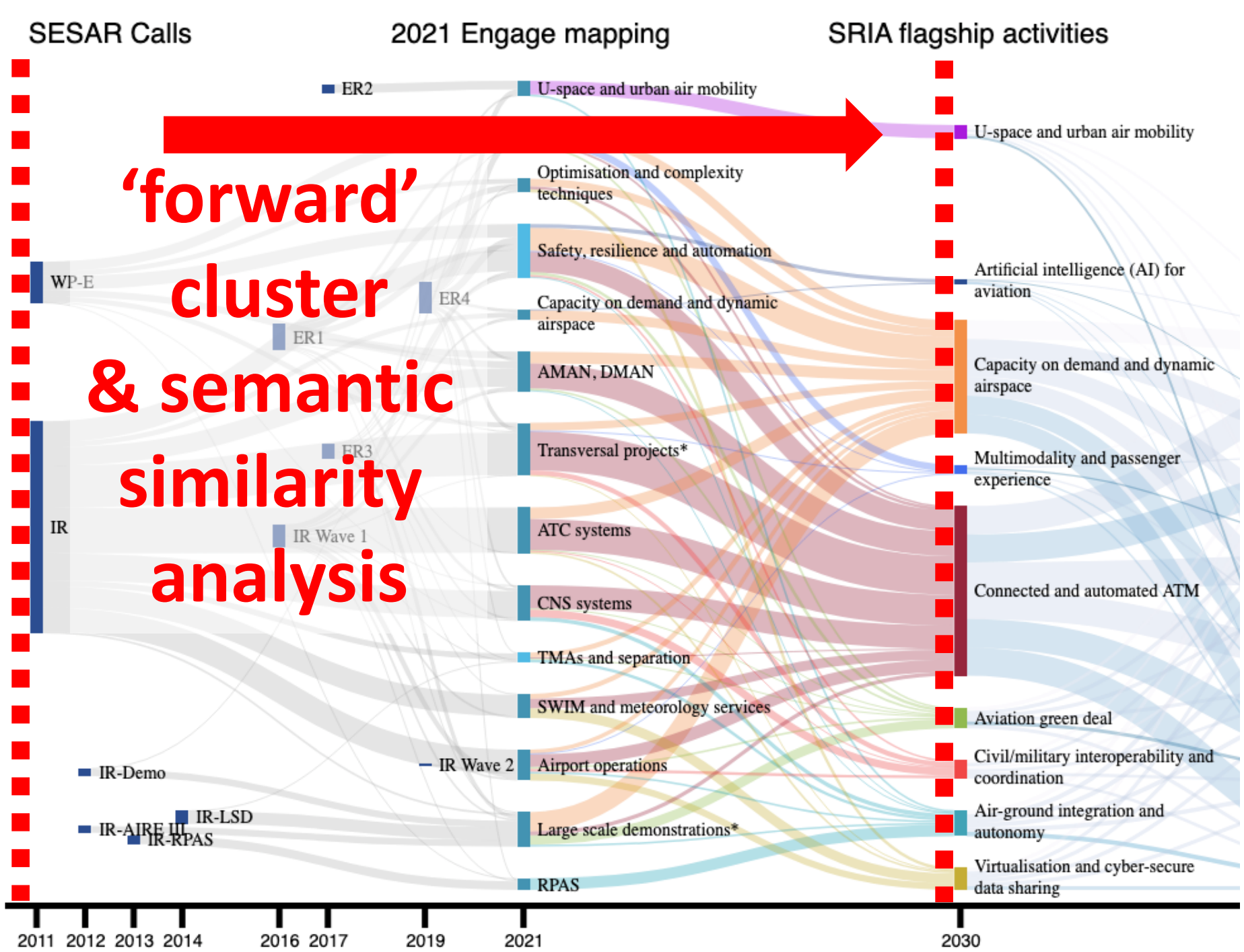
"Thank you once again for this wonderful opportunity and your energy invested in organising this very instructive project. I very much appreciated the steady feedback from industry and other academic stakeholders and to cooperate with the best innovators and scholars in Europe."

PhDs and education – SDA
PhD: Jan Evler



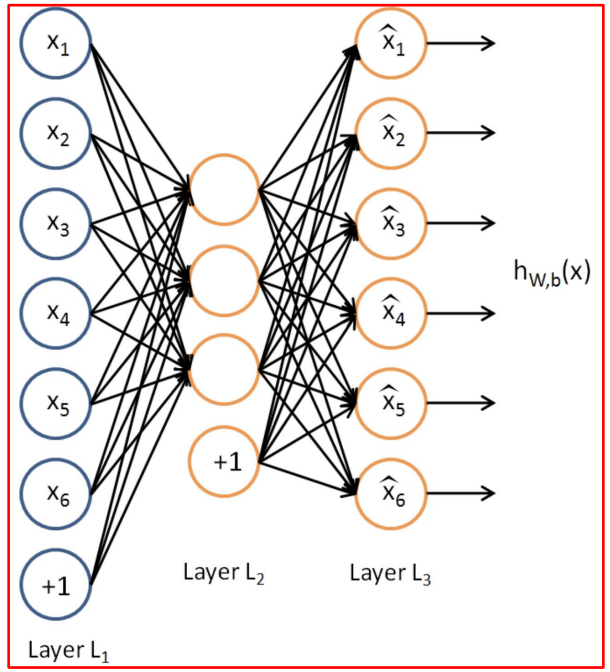


15 August 2022

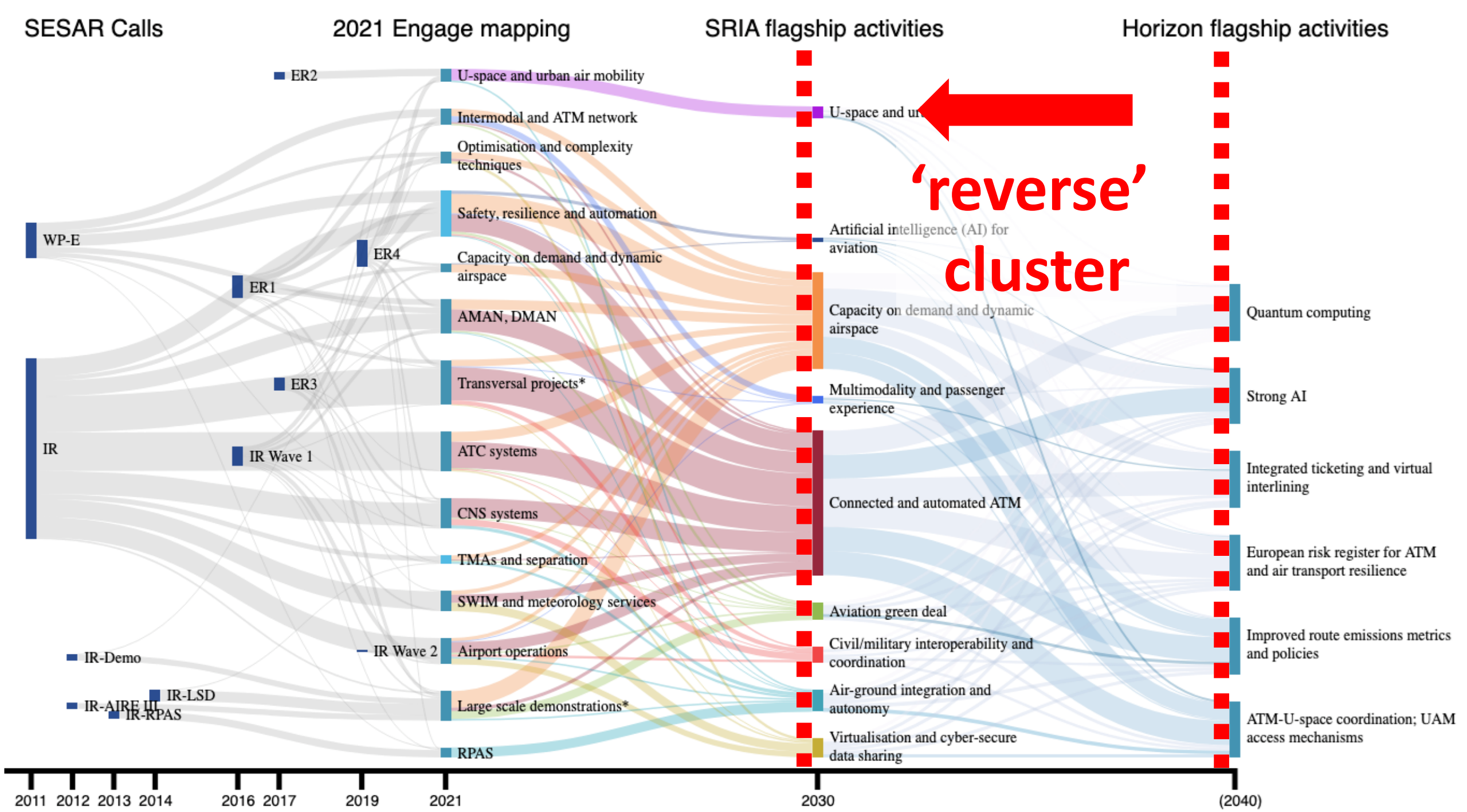


‘forward’ cluster & semantic similarity analysis

gap analysis



(1) Multi-dimensional vectorisation; auto-encoder (unsupervised ML) model; **(2)** experts


SESAR Calls
2021 Engage mapping
SRIA flagship activities
Horizon flagship activities
'reverse' cluster
WP-E
IR
ER1
ER2
ER3
ER4
IR Wave 1
IR Wave 2
IR-Demo
IR-AIRE III
IR-LSD
IR-RPAS
U-space and urban air mobility
Intermodal and ATM network
Optimisation and complexity techniques
Safety, resilience and automation
Capacity on demand and dynamic airspace
AMAN, DMAN
Transversal projects*
ATC systems
CNS systems
TMAs and separation
SWIM and meteorology services
Airport operations
Large scale demonstrations*
RPAS
U-space and ur
Artificial intelligence (AI) for aviation
Capacity on demand and dynamic airspace
Multimodality and passenger experience
Connected and automated ATM
Aviation green deal
Civil/military interoperability and coordination
Air-ground integration and autonomy
Virtualisation and cyber-secure data sharing
Quantum computing
Strong AI
Integrated ticketing and virtual interlining
European risk register for ATM and air transport resilience
Improved route emissions metrics and policies
ATM-U-space coordination; UAM access mechanisms
2011
2012
2013
2014
2016
2017
2019
2021
2030
(2040)