Data-driven Trajectory Prediction

Overview from the Engage KTN

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Engage thematic challenge 2 workshop

Universitat Politècnica de Catalunya, 6 November 2018

SESAR JOINT UNDERTAKING

Founding Members
EUROPEAN UNION EUROCONTROL

Data-driven Trajectory Prediction
Overview

- Background on Engage and thematic challenges
- Context for thematic challenge 2
- Wrap-up and next steps
    - funding opportunities

Background on Engage and thematic challenges

– the SESAR Knowledge Transfer Network

engagektn.com

Industry partners

Advanced Logistics Group (ALG)
AGIFORS - Airline Group of the International Federation of Operational Research Societies
Air Traffic Controllers European Unions Coordination (ATCEUC)
airBaltic
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)
Belgocontrol
Boeing Research and Technology Europe (BR&T-Europe)
Bundesaufsichtsamt für Flugsicherung (BAF)
Civil Aviation Authority (CAA)
COOPANS Consortium
Department for Transport (UK)
Direction des Services de la Navigation Aérienne (DSNA)
Direktorat civilnog vazduhoplovstva Republike Srbije (DCV)
European Meteorological Services Network (EUMETNET)
European Passengers' Federation (EPF)
Executive Airlines
Ferrovial Agroman
Finnair
FlightGlobal
Flughafen München / Munich Airport
Gestair SL
Helios
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)
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
SWISS - Swiss International Air Lines
Thomas Cook Airlines
TÜBİTAK - The Scientific and Technological Research Council of Turkey
Turkish Airlines

The Engage KTN

Overview

Key features and objectives (2018-2021)

- Better integrate more applied/industrial & exploratory research (two-way process)
    - mutual benefit, integrated into the fabric, funded; interdisciplinary
- Education and training: future ATM skilled workforce
    - “develop new talent with a deep knowledge of the future ATM scientific research needs ... stimulating the next generation of ATM staff”
    - PhD and graduate thesis Call (appx. €1m, open until 01NOV18)
    - 3 summer schools (2019: Belgrade); ATC training courses; lecture progs
    - SESAR Innovation Days (03-07DEC18, University of Salzburg)
- Knowledge hub as a ‘go-to’ source, single point of entry for ATM knowledge
    - popular demand: improved search functionality; consolidated repository
- Not only larger concepts, but sum of large number of support actions
    - multiple grants; ‘light touch’

free of charge

thematic challenges

Thematic challenges and workshops

Overview

Engage

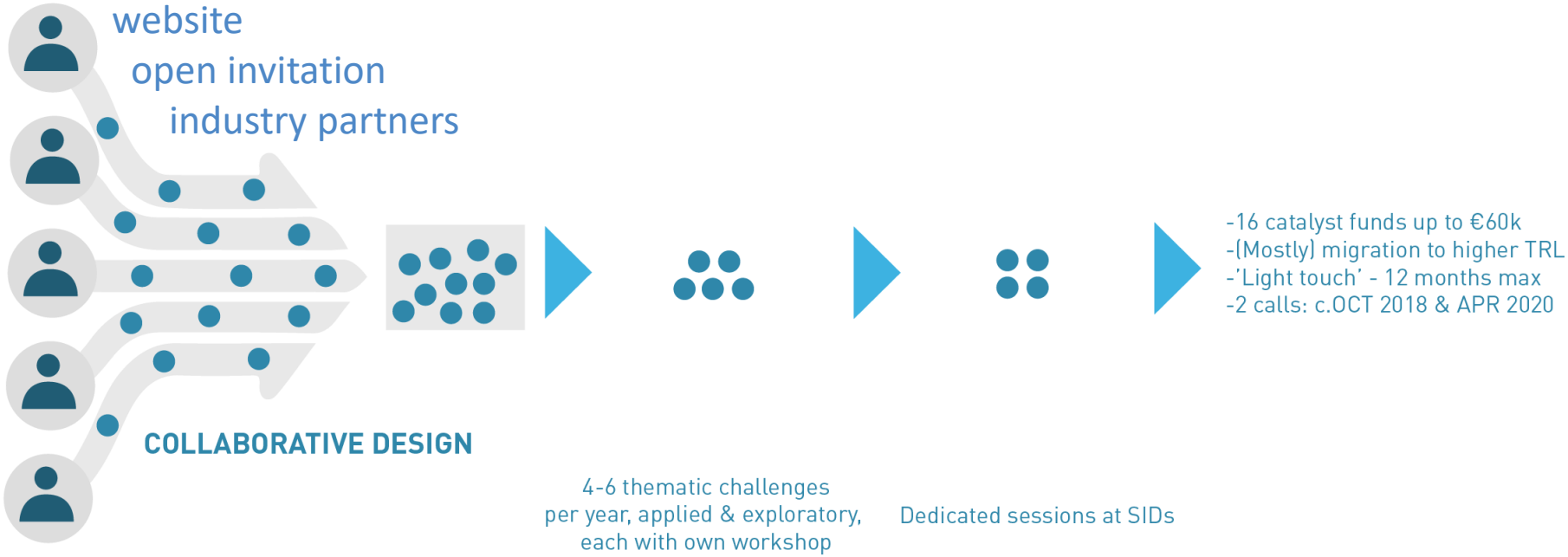
HOME ABOUT KNOWLEDGE HUB PARTICIPATE EVENTS CONTACTS

Engage Thematic Challenges

At the core of the KTN is the definition of various thematic challenges: new ideas suggested by the research community, not already included within the scope of an existing SESAR project. They are developed along with the ATM concepts roadmap and complementarily with some of the network's PhDs and theses.

Thematic challenges and workshops

Overview



- Thematic challenges at core: applied-orientation; help to mature exploratory research
- Industry partners: willingness to share information and data
- Each challenge has (a) dedicated workshop(s)
- Selected challenges may be investigated further through, e.g.:
  - **(1)** **Engage catalyst funding** (NB. consortium members ineligible), Call published by 16NOV18
  - **(2)** Engage PhDs/theses

Thematic challenges and workshops

Thematic challenge 1 – Vulnerabilities and global security of the CNS/ATM system

Workshop: Date/location TBC – Bringing together the ATM community and security experts to enable a more privacy-preserving, cyber-resilient, fault-tolerant and secure ATM system.

CNS/ATM components (e.g., ADS-B, SWIM, datalink, Asterix) of the current and future air transport system present vulnerabilities that could be used to perform an 'attack'. Further investigations are necessary to mitigate these vulnerabilities, moving towards a cyber-resilient system, fully characterising ATM data, its confidentiality, integrity and availability requirements. A better understanding of the safety-security trade-off is required. Additional security assessments for legacy systems are also needed to identify possible mitigating controls in order to improve cyber-resilience without having to replace and refit. Future systems security by design is essential: a new generation of systems architectures and applications should be explored to ensure confidentiality, cyber-resilience, fault tolerance, scalability, efficiency, flexibility and trust among data owners. Collaborative, security-related information exchange is essential to all actors in aviation. This is specially challenging in a multi-stakeholder, multi-system environment such as ATM, where confidentiality and trust are key.

Fuller text here

Thematic challenges and workshops

Thematic challenge 2 – Data-driven trajectory prediction

Workshop: 06 November 2018, Universitat Politècnica de Catalunya (UPC), Barcelona, Spain – ATM stakeholders and data scientists discussing the airspace users' needs, methodologies and benefits of improved trajectory prediction.

Draft programme here. Please use the **contacts** page to register.

Accurate and reliable trajectory prediction (TP) is a fundamental requirement to support trajectory-based operations. Lack of advance information and the mismatch between planned and flown trajectories caused by operational uncertainties from airports, ATC interventions, and 'hidden' flight plan data (e.g., cost indexes, take-off weights) are important shortcomings of the present state of the art. New TP approaches, merging and analysing different sources of flight-relevant information, are expected to increase TP robustness and support a seamless transition between tools supporting ATFCM across the planning phases. The exploitation of historical data by means of machine learning, statistical signal processing and causal models could boost TP performance and enhance the TBO paradigm. Specific research domains include machine-learning techniques, the aggregation of probabilistic predictions, and the development of tools for the identification of flow-management 'hotspots'. These could be integrated into network and trajectory planning tools, leading to enhanced TP.

Fuller text here

Thematic challenges and workshops

Thematic challenge 3 – Efficient provision and use of meteorological information in ATM

Workshop: 13 November 2018, SESAR Joint Undertaking (SJU), Brussels, Belgium – Atmospheric scientists and ATM stakeholders shaping a more efficient provision and use of meteorological information in future aviation.

Draft programme here. Please use the **contacts** page to register.

The main objective of this challenge is to improve overall ATM system performance by providing better user-support tools based on improved meteorological ('met') products. The focus is on the synergy of several methods and techniques in order to better meet the needs of operational users and to support aviation safety (e.g., through creating early warning systems) and regulation-makers (e.g., moving from text-based to graphical information provision). All stakeholders may benefit from this synergy: ANSPs (e.g., sector reconfiguration and separation provision), airlines (e.g., storm avoidance), airport operators (e.g., airport management under disruptive events), and the Network Manager (e.g., demand-capacity balancing). The challenge is, therefore, to bring the following perspectives closer: (a) for meteorological/atmospheric science, the development of products tailored to ATM stakeholders' needs, which are unambiguous and easy to interpret; (b) for stakeholders, the identification of the most suitable information available and its integration into planning and decision-making processes.

Fuller text here

Thematic challenges and workshops

Thematic challenge 4 – Novel and more effective allocation markets in ATM

Workshop: 25 October 2018, University of Westminster (UoW), London, UK – A range of speakers from the behavioural sciences, economics, and ATM, debating approaches to improved modelling and methods in this new interdisciplinary area.

Final programme here. Please use the **contacts** page to register.

This research explores the design of new allocation markets in ATM, taking into account real stakeholder behaviours. It focuses on designs such as auctions and 'smart' contracts for slot and trajectory allocations. It seeks to better predict the actual behaviour of stakeholders, compared with behaviours predicted by normative models, taking into account that decisions are often made in the context of uncertainty. Which mechanisms are more robust against behavioural biases and likely to reach stable and efficient solutions, equitably building on existing SESAR practices? The research will address better modelling and measurement of these effects in ATM, taking account of 'irrational' agents such as airline 'cultures'. A key objective is to contribute to the development of improved tools to better manage the allocation of resources such as slots and trajectories, and incentivising behaviour that benefits the network – for example by investigating the potential of centralised markets and 'smart' contract enablers.

Fuller text here

Context for thematic challenge 2

Context for thematic challenge 2_1

Trajectory-based operations rely on trajectory prediction (TP)

- Accurate and reliable trajectory prediction (TP) required to minimize mismatch between planned and flown trajectories
- Allowing more accurate and robust planning for AO, ANSP and network manager
- Accuracy and timeliness of data and information paramount

Numerous sources of deviations

- Airports operations
- ATC interventions
- Unknown parameters (cost indexes, take-off weights) and unknown AU intentions
- Different stakeholders use different TPs
- Meteo, passengers, etc.

Context for thematic challenge 2_2

Benefits of enhanced TP

- Better management of airspace and airport capacity/resources (less unused capacity, less buffers required)
- Better match between NM/ANSP interventions and AO preferences

Avenues for improvement

- Merging information from different sources
- Often historic datasets show patterns unknown to TP
- Inferring AU intentions

Data science and data-driven techniques hold the potential to improve TP

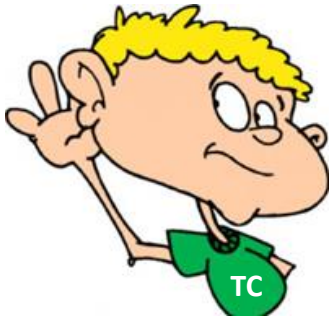
- Machine-learning/deep learning techniques
- Statistical signal processing
- Causal models

Heads-up for the discussion session

Heads-up for the brainstorming session

- **We are going to ask you to suggest:**
  - what specific follow-up research is likely to be useful to mature the state of the art (incl. flagging what may be addressed by catalyst funding)
  - what measures of success could be used to assess progress of challenge:
    - **short-term:** wholly within catalyst-funded project
    - **longer-term:** outside/beyond such a project (could be *identified* within it)
  - what are likely barriers to prevent progress towards maturing challenge – how might we overcome them?

- **listening mode:** to refine (dynamic) challenge text



Facilitated Brainstorming$_1$

We will split into three stakeholder groups

- Network manager
- Airspace user
- ANSP

Taking the perspective of the stakeholder they represent groups will brainstorm **"What specific follow-up research is likely to be useful to mature the state of the art"**

Presenting and refining results in plenary including prioritizing

Facilitated Brainstorming$_3$

1. **Brainstorming**: I WISH… (IW) or HOW TO…? (H2) on Post-It notes, pin up notes on the wall in no specific order (20 min)
2. **Grouping** into themes: participants move Post-Its around to create groups of related ideas (ideally 3-5 themes)
3. **Naming** the theme: each group finds a suitable title for the themes they have identified and writes them on larger Post-Its
4. **Defining** the theme on the flipchart: participants stick large Post-Its on a flipchart page (each) or copy the name of the theme, then they write "this theme is mainly about:" producing 3-4 bullet points per theme, one flipchart page per theme
5. **Prioritising** themes: groups select what they think are their top 2 based on group discussion
6. For the top 2 challenges identify **measures of success** could be used to assess progress of challenge:
   a. **short-term:** wholly within catalyst funded project
   b. **longer-term:** outside/beyond such a project
7. Identify **likely barriers** to prevent progress towards maturing challenge – how might we overcome them?

Facilitated Brainstorming$_4$

Brainstorming

Grouping

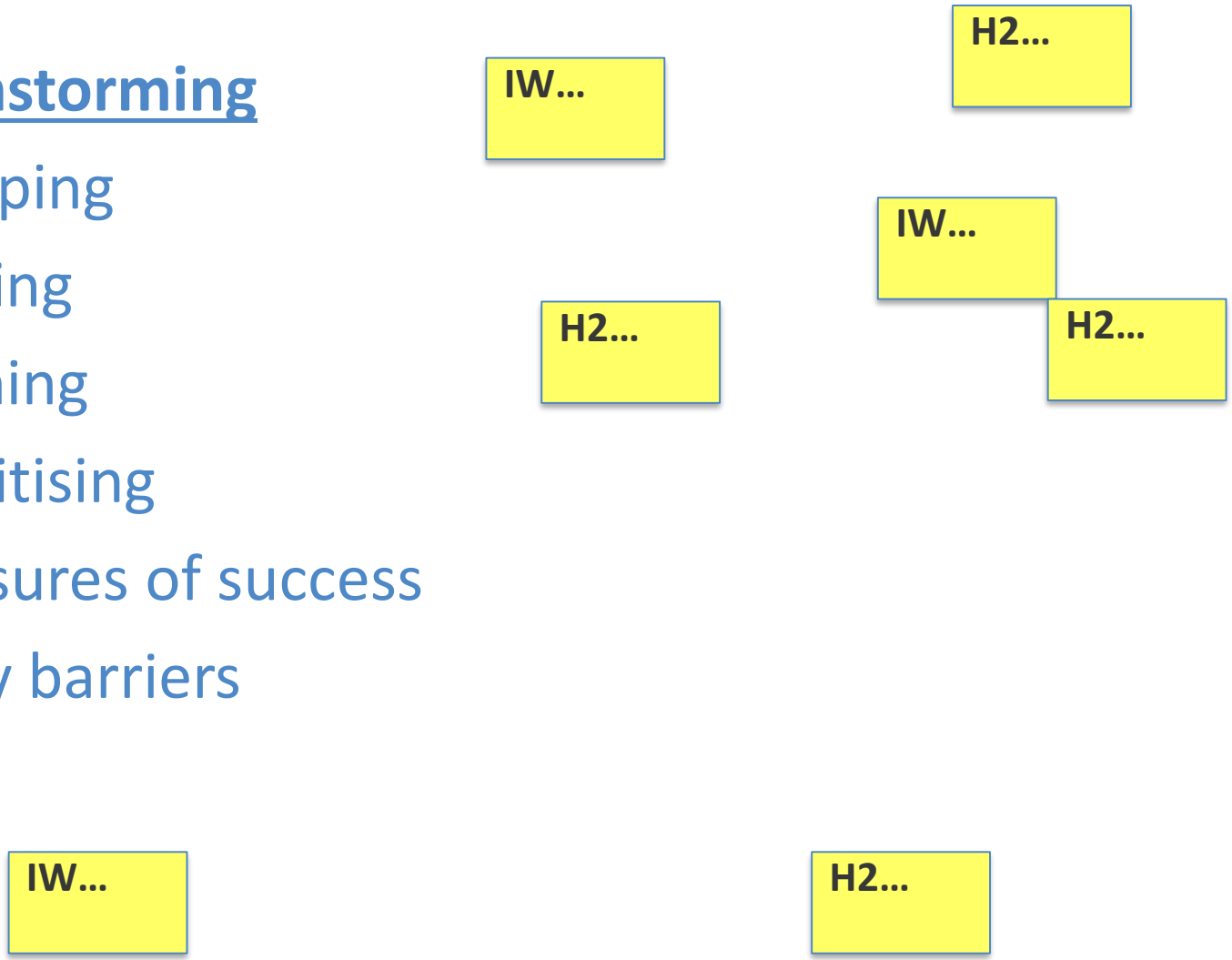
Naming

Defining

Prioritising

Measures of success

Likely barriers



Facilitated Brainstorming$_5$

Brainstorming

Grouping

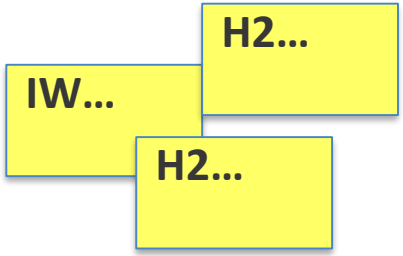
Naming

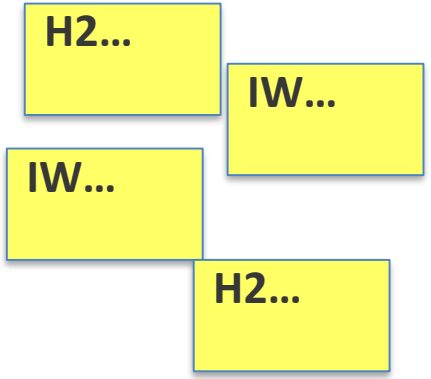
Defining

Prioritising

Measures of success

Likely barriers





Facilitated Brainstorming$_6$

Brainstorming

Grouping

Naming

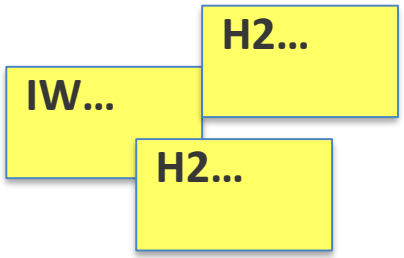
Defining

Prioritising

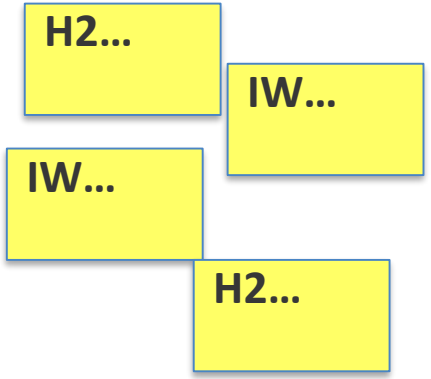
Measures of success

Likely barriers

Globally interoperable local solutions



Never-ending eternity



Facilitated Brainstorming$_7$

Brainstorming

Grouping

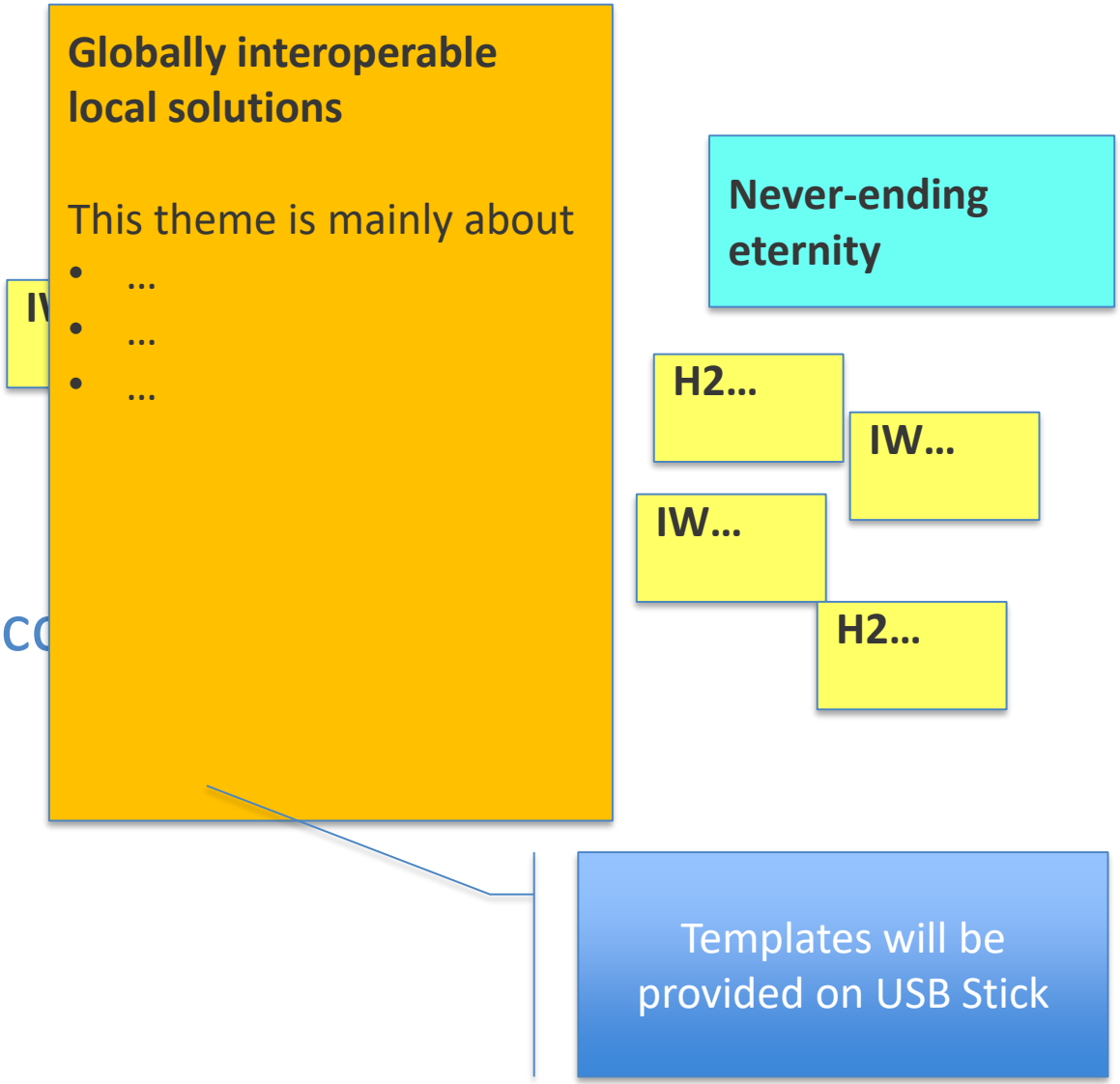
Naming

Defining

Prioritising

Measures of succ

Likely barriers



Facilitated Brainstorming$_8$

Brainstorming

Grouping

Naming

Defining

Prioritising

Measures of succ

Likely barriers

2 Globally interoperable local solutions

This theme is mainly about

- …
- …
- …

1 Never-ending eternity

This theme is mainly about

- …
- …
- …

Facilitated Brainstorming$_9$

Brainstorming

Grouping

Naming

Defining

Prioritising

Measures of suc

Likely barriers

2 Globally interoperable local solutions

This theme is mainly about
- …
- …
- …

Measures of success
- Short-term:…
- Longer-term:…

1 Never-ending eternity

This theme is mainly about
- …
- …
- …

For top 2

Facilitated Brainstorming$_{10}$

Brainstorming

Grouping

Naming

Defining

Prioritising

Measures of succ

Likely barriers

For top 2

2 Globally interoperable local solutions

This theme is mainly about
- …
- …
- …

Measures of success
- Short-term:…
- Longer-term :…

Likely barriers:
- …
- …

1 Never-ending eternity

This theme is mainly about
- …
- …
- …

Measures of success
- Short-term:…
- Longer-term :…

Likely barriers:
- …
- …

Plenary debriefing and Pareto voting

Stakeholder groups present their conclusions

- Theme description, measures of success, likely barriers
- Use powerpoint and templates provided in this presentation
- 5 min per groups
- Clarifications and comments – but no endless discussions!
- Some refinement and adaptations based on discussion

Pareto voting

1st 2nd 3rd

Stakeholder Network manager/Airspace user/ANSP
Theme Please name theme

This theme is mainly about:

- …
- …
- …

Measures of success could be used to assess progress of challenge:

- short-term: wholly within catalyst funded project
- longer-term: outside/beyond such a project
- …
- …

Likely barriers

- Likely barriers to prevent progress towards maturing challenge…
- how might we overcome them…

Wrap-up and next steps

Wrap-up and next steps

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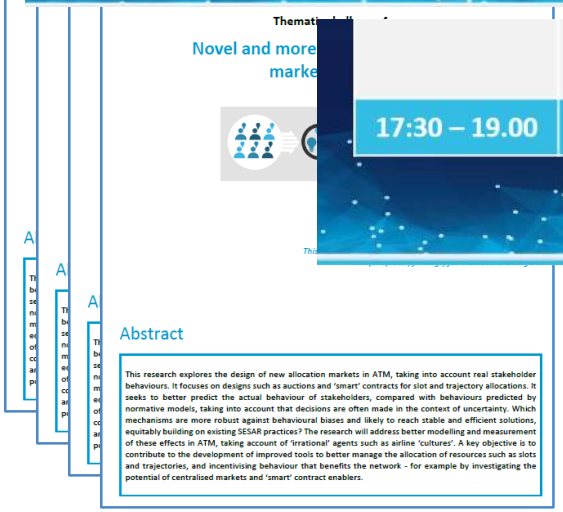

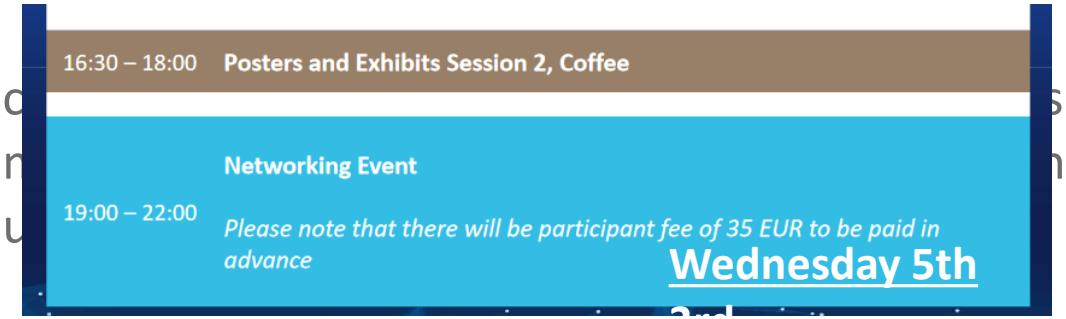

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- presentation at the SESAR Innovation Days
- posters; consortium members available
- feeds final stages of ER4 Call (appx.€40M; Q1 2019)

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Engage KTN

Thank you

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Founding Members

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