MultiModX

Feedback Report #2

Project Acronym: MultiModX

Project budget combined amount: 1 750 380 €

Duration: 30 months

Project start date: 01/07/2023

Project end date: 31/12/2025

Partners: 6 partners from 5 countries

Project coordinator: Bauhaus Luftfahrt EV

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Welcome & Overview of MultiModX

Kay Ploetner

Agenda at a Glance

- Welcome and Introduction: Overview of MultiModX and workshop goals.
- MultimodX Insights: Details about our project, approach, and ongoing work.
- Feedback Session: Input on preliminary results and suggestions for the project's future.

Workshop Goals

1. Familiarisation: Understand MultiModX's scope and objectives.
2. Scientific Approach: Learn about our methodologies and intermediate findings.
3. Feedback and Suggestions: Provide input to refine our work as we move towards the project's conclusion.
4. Industry Relevance: Ensure alignment with practical, future applications to foster innovation.

Project Background

MultimodX is funded by SESAR JU and aims to enhance the digitalisation of air travel across Europe. SESAR JU supports initiatives that align with this mission, and MultiModX is here to deliver innovative solutions to better plan and coordinate multi-modal travel, focusing on air transport as a core mode.

Our Mission

Our mission is to drive air-rail cooperation and create passenger-centric solutions that benefit all stakeholders. With partners including Bauhaus Luftfahrt (Germany), Nommon (Spain), the University of Westminster (UK), TU Dresden (Germany), Union International des Chemins de Fer – UIC (France), and Airport Regions Council – ARC (Belgium), we are developing cutting-edge decision support tools and frameworks for the future of transportation.

Key Activities

1. Air-Rail Schedule Synchronisation: Developing capabilities for aligning future air and rail travel schedules.
2. Passenger Management During Disruptions: Creating advanced solutions to manage passenger flow effectively during disruptions, whether in the air or on the ground.
3. Understanding Passenger Travel Patterns: Identifying traveller types, their routes, and how policies and regulations can support seamless air-rail connections.
4. Assessing Solutions and Indicators: Establishing methods for assessing the impact of proposed solutions, identifying key indicators, and measuring changes to make informed decisions.

What We're Not Focusing On

- We work with current infrastructure and do not propose major infrastructure updates (e.g., HSR lines).
- We do not cover data exchange, service contracts, or smart contracts, as these areas are addressed by our sister project, SIGN-AIR (https://www.sign-air.eu).

Current Status and Next Steps

We're at the halfway mark of our 2.5-year project. Having received initial feedback during our first workshop in Paris, we've developed early prototypes designed to show what future capabilities might look like.

Scenario Development, Case Studies & Performance Assessment

Eric Tchouamou Njoya

Case Studies Overview

MultiModX is focusing on three main case studies involving intermodal travel within specific regions of Europe:

- Domestic travel within Spain (e.g., Madrid to Barcelona)
- Domestic travel within Germany (e.g., Frankfurt to Munich)
- International travel between major cities like Frankfurt and Madrid

Our baseline scenario is set in 2019, representing typical journeys in that year, while the reference scenario looks ahead to projected future journeys between these cities.

Passenger Archetypes: A Deep Dive

Our analysis considers the varying behaviours and sensitivities of passengers by categorising them into distinct archetypes based on factors like travel frequency, purpose, and preferred modes of transport. This approach aims to more accurately reflect passenger needs and preferences.

We identify six unique archetypes:

MultiModX

Passenger archetypes

- Travel patterns

The habitual traveler	The sporadic global traveler	The holiday globetrotter
• High frequency • Domestic destinations • Leisure purposes • Slightly prefer trains	• International destinations • Clear preference for air-travel	• Long trips during holiday-periods • International destinations • Clear preference for air-travel

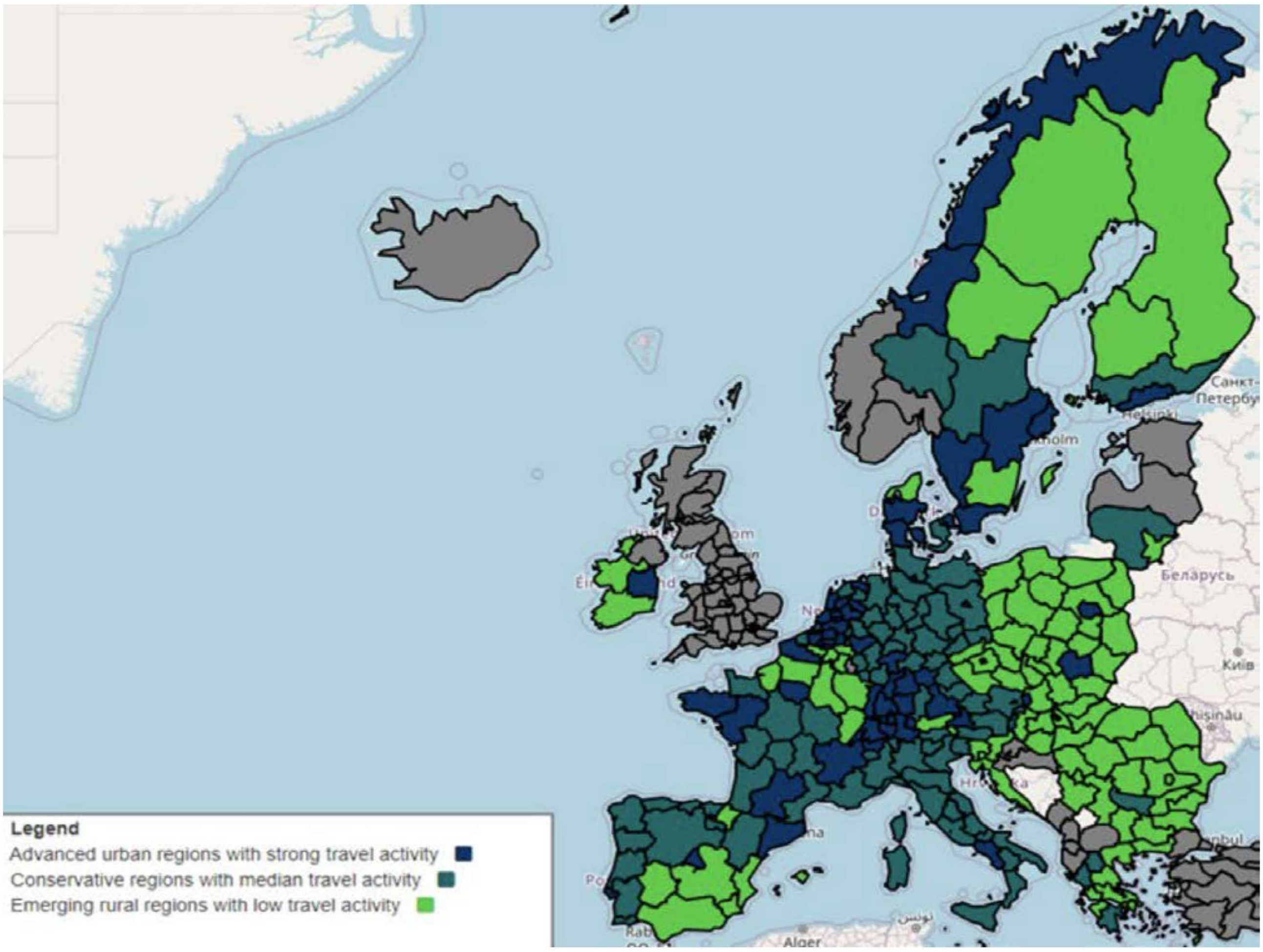
The holiday globetrotter	The sporadic GenX traveler	The summer traveler
• Long trips during holiday-periods • International destinations • Clear preference for air-travel	• Travel during non-peak periods • Domestic destinations • Private purposes (e.g. visiting family and friends)	• Long trips exclusively in July or August • Domestic destinations • Clear preference for trains

Regional Archetypes

The research focuses on evaluating the potential of multimodal transport at the national level by clustering EU regions based on publicly available data. Factors used for clustering include air and rail traffic, socio-demographic metrics (e.g., per capita income), energy distribution, tourism volume, and digital technology adoption, resulting in three distinct regional archetypes:

- Dark Blue: Advanced urban regions with high travel activity.
- Light Blue: Conservative regions with moderate travel activity.
- Green: Emerging rural regions with low travel activity.

These archetypes are characterised by factors such as population density, income, technology adoption, and air and rail travel patterns. Examples include Berlin as an advanced region and Andalusia as an emerging rural region.



Merging Archetypes for Scenario Development

The study integrates passenger archetypes with regional archetypes by analysing the share of passengers within each category for a given region. This integration supports the development of multimodal scenarios.

Policy options, scheduling, and disruption management scenarios are applied to reference data and validated against baseline scenarios. Case studies focus on Germany, Spain, or a combination of regions, with specific scenarios tailored to individual case studies. Further details about these scenarios are addressed in subsequent presentations.

Luis Delgado

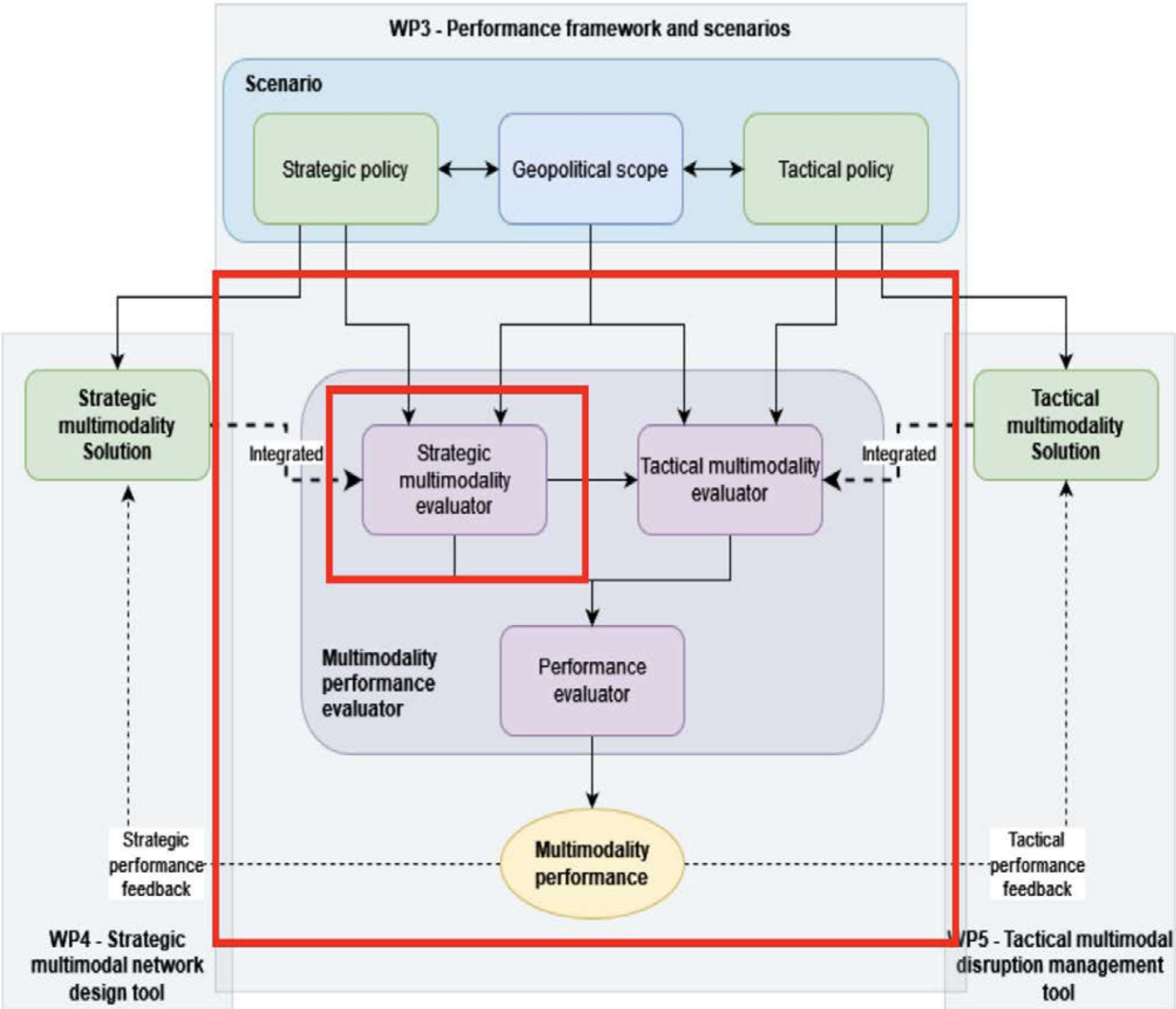
Performance Assessments – General Overview

In today's interconnected world, seamless travel across air, rail, and other modes of transportation is more critical than ever. To achieve this, we are developing a comprehensive evaluation framework that addresses the complexity of multimodal systems while prioritising the needs of passengers.

Our innovative approach focuses on delivering mobility solutions through data-driven insights and policy-sensitive strategies. By aligning long-term planning with evolving passenger preferences and demands, we aim to create a future where transfers are effortless, disruptions are minimised, and door-to-door journeys are optimised.

Evaluating Multimodal Mobility: Strategic and Tactical Perspectives

Let's explore how we measure the performance of multimodal transportation systems, focusing primarily on air and rail mobility. This evaluation encompasses both strategic and tactical dimensions.



Strategic Evaluation: Planning for Seamless Mobility

Strategic evaluation revolves around defining and analysing the network – schedules, timetables, and intermodal connectivity. By assessing these components, we aim to optimise passenger transfer efficiency and create a well-coordinated mobility framework. This involves understanding demand and supply dynamics:

- Demand: Passengers' needs are modelled using archetypes based on preferences like price sensitivity, environmental concerns, and connection tolerances. The demand shifts from airport-to-airport travel in aviation to region-to-region journeys in a multimodal context, emphasising a door-to-door perspective.
- Supply: This includes flight schedules, train timetables, fleet constraints, infrastructure limits, and policies (e.g., emissions taxes, short-haul flight bans, or train subsidies).

The interplay between demand and supply allows us to simulate scenarios and evaluate their outcomes, benchmarking networks to determine the best-performing solutions.

Tactical Evaluation: Handling Operational Realities

Tactical evaluation comes into play on the day of operations, focusing on real-time disruptions such as delayed flights or trains. These disturbances range from minor delays within acceptable thresholds to severe disruptions like broken links in key routes.

Here, the goal is maintaining smooth mobility for passengers despite disruptions. By modelling individual itineraries and network performance, we identify strategies to minimise disruptions' impacts, ensuring passengers still reach their destinations with minimal inconvenience.

Multimodal Evaluation Framework

To conduct these evaluations, we employ a comprehensive Multimodal Evaluator, which integrates:

1. Demand Inputs: Passenger preferences, origins, and destinations.
2. Supply Inputs: Transportation networks, schedules, and scenario conditions (e.g., policy changes).
3. Outputs: Indicators of passenger itineraries and network performance, emphasising a passenger-centric, door-to-door perspective.

This iterative framework allows us to test «what-if» scenarios, such as modifying schedules, adjusting policies, or forecasting future demand changes (e.g., post-COVID environmental sensitivities).

Performance Indicators: From Aviation to Multimodality

To measure success, we rely on a tiered system of performance indicators:

1. Futuristic Indicators (Level 3): Ideal metrics like total door-to-door travel time, which are highly desirable but require advanced data integration.
2. Model-Driven Indicators (Level 2): Metrics we can simulate based on current data, providing insights into potential improvements.
3. Operational Indicators (Level 1): Established metrics, mainly aviation-focused, that can be adapted for multimodal use within the SESAR Performance Framework.

Our work includes initiating the definition of these indicators and data gaps, and developing methodologies to elevate lower-level indicators toward more holistic evaluations.

Collaborative Efforts and Future Directions

in collaboration with other explorative and industrial research projects with a stake in multimodality and SESAR performance (e.g. ER projects SING-AIR, MAIA and IR projects such as Travel Wise, PEARL, JARVIS)

We aim to adapt aviation-centric frameworks to incorporate multimodal and passenger-centric views in collaboration with complementary explorative and industrial research projects with a stake in multimodality and the SESAR Performance Framework, part of the Multimodal and Passenger Experience Flagship, such as PEARL – Performance Evaluation for SESAR (https://www.sesarju.eu/projects/pearl), AMPLE3 – SESAR3 ATM Master Planning and Monitoring (https://www.sesarju.eu/projects/ample3), SIGN-AIR (https://www.sign-air.eu), MAIA – Multimodal Access for Intelligent Airports (https://maiasesarproject.eu/), Travel Wise – Transformation of aviation and railway solutions towards integration and synergies (https://sesar.eu/projects/Travel%20wise), JARVIS – Just a rather very intelligent system (https://www.sesarju.eu/projects/JARVIS).

This involves:

- Building an open-access digital catalogue of indicators.
- Organising workshops and expert consultations to refine strategies.
- Evaluating policy impacts (e.g., emissions regulations or infrastructure investments) on network performance and passenger experience.

Case study

The Spain case study evaluates rail and flight data to assess multimodal travel options through the MultiModX project. Data were sourced from Renfe, Spain's rail operator, and flight schedules detailing departure and arrival times, airlines, and seat availability were also included. Different data sources are used to construct representative supply and demand characteristics: anonymised mobile phone data to create intra-Spain region-to-region demand; Renfe, Spain's rail operator, datasets to build rail timetables; flight schedules extracted from OAG datasets; access and egress and connectivity between modes estimated with mobility tools, etc.

The analysis provided the option to create multimodal journeys and ensured that connections between flights occurred within the same airline alliance to avoid the complexity of purchasing separate tickets.

The focus was on regional travel rather than direct station-to-station or airport-to-airport connections. For instance, to travel from the Girona region, one option is to reach Girona airport, which takes an average of 130 minutes from home to flight departure, with a return time of 70 minutes. These figures were informed by mobile phone tracking data. Alternatively, accessing the local train station requires less than an hour, while driving to Barcelona, though longer, might offer direct flight options.

Connectivity was another critical factor. The minimum connection time between flights in Madrid was found to be approximately 100 minutes for domestic travel, whereas train-to-train connections typically required a minimum of 10 minutes, given that transfers are often on the same or adjacent platforms.

Travel times from train stations to airports were also analysed, for example, from Chamartín or Atocha in Madrid, averaging between 100 and 120 minutes to reach the flight at the airport and about 90 minutes from arrival time at the airport to the train on the return journey. These estimates were based on data from Google Maps and considerations for security checks and other factors. This is particularly relevant in Madrid, where flight connection times can be substantial but are relatively close when considered in the multimodal context.

The estimation of possible itineraries between regions revealed travel patterns between them. For instance, there were many direct flights and train options between Barcelona and Madrid regions. Each itinerary's total travel time, including access and egress times, was evaluated to allow comparisons between travel modes. This analysis demonstrated that flights often provided shorter travel times while having longer access and egress times, whereas train options could be competitive in total estimated door-to-door time.

The study also examined more intricate scenarios involving multimodal routes, such as travel between Vitoria and Cádiz, which might include flights from nearby airports like Bilbao or connections through intermediary stations like Miranda de Ebro. These options varied in total travel time but often featured shorter access and egress periods.

Historical data were leveraged to estimate demand between specific regions, showing, for example, that around 9,400 potential travellers between Barcelona and Madrid preferred trains over flights (approximately 7,300 versus 2,100, respectively). This analysis can be used to estimate capacity-demand imbalances.

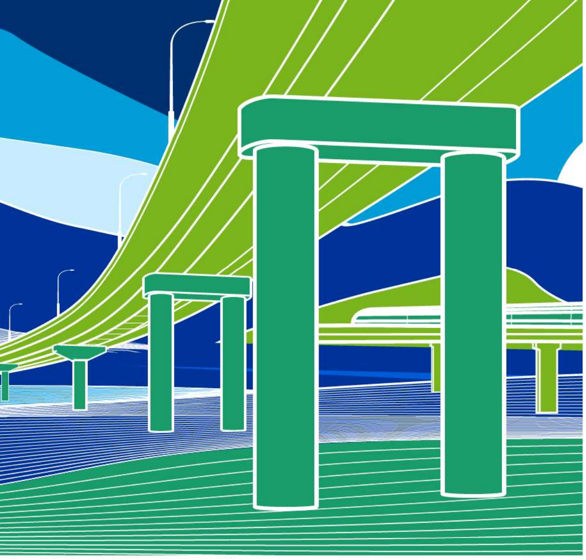
By defining itineraries and considering passenger preferences, the project enabled the calculation of total travel costs, emissions, waiting times, and connectivity across modes. Additionally, connectivity analysis extended to the accessibility of regions from various airports, showing, for instance, that Madrid airport connected to 50 regions (at NUTS-3 level) in Spain, while Barcelona airport reached around 35.

For regional assessments, the project could calculate average travel times and available options from specific areas, such as Galicia, and consider different departure times. Though evaluating preferred arrival times was not included in this phase, it could be incorporated in future analyses to provide deeper insights into travel behavior.

The study also explored policy impacts, such as the potential effects of a flight ban for routes under 2.5 hours. This analysis indicated changes in accessibility to various regions and highlighted areas more impacted by such a policy, providing a means to assess infrastructure and regional connectivity.

Lastly, the project expanded its scope to include international travel analysis, focusing on Madrid airport connectivity and examining potential multimodal itineraries involving trains and flights. For example, travel from cities like Barcelona, Valencia, Alicante, Malaga, and Seville to Madrid and onward destinations was assessed.

The study found that multimodal connections could be more time-efficient in some scenarios due to reduced waiting times compared to flying, particularly in areas with high train frequency and access options.



Ricardo Herranz

Intro to Solution – 2

Strategic Air-Rail Schedule Design

The project focuses on enhancing timetable synchronisation, aiming at aligning schedules across transport modes to improve travel options, particularly air-rail multimodal options. The main goal is to create an integrated planning solution for air and rail networks to optimise transfer and connection times, which will result in more viable and efficient travel options for passengers.

Approach and Methodology:

- The project works with a multi-layer network that currently includes air and rail. In the future, this could expand to other networks, like buses.
- The solution uses a combination of mixed integer linear programming and graph-based models to perform timetable coordination and optimisation.
- Incremental modifications are the starting focus. This is based on the understanding that there are many operational constraints impacting timetable development. The approach will assess whether small adjustments to current schedules can enhance passenger-centric outcomes. Other modifications, such as adding new services, may be considered in future stages.

Objectives and Flexibility:

- The solution is designed to be flexible, allowing different objectives to be prioritised, such as passenger-centric goals (e.g., minimising travel or waiting time, maximising reliability, reducing unserved demand) or operator-centric goals (e.g., minimising costs). A combination of these objectives is also possible.
- Stakeholders often have varying interests, so the framework aims to accommodate different objectives, enabling them to be integrated and analysed according to specific needs.

Operational Workflow:

- The initial phase starts with a baseline path assignment and an initial schedule using existing models. This is followed by applying the timetable coordination solution to adjust the schedules for air and rail services. The updated schedules are then fed into the performance evaluation system.
- The iterative process continues until a stable equilibrium is reached, marked by the fulfillment of predefined conditions. At this point, various indicators can be assessed to measure performance.

Constraints and Customisation:

- The solution considers several constraints, such as operational limits (e.g., train headways and dwelling times). While airport capacities are not currently included, they could be integrated in future updates.
- Passenger-related constraints are also part of the model, such as setting maximum or minimum transfer times. This customisation allows the exploration of different approaches to meet passenger and operator needs.

Objective Function and Output:

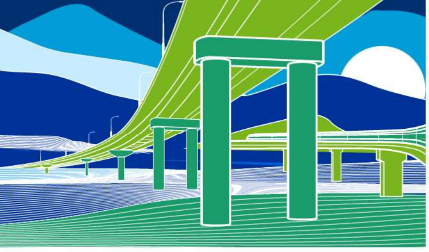
- The model can generate a cost function that minimises transfer times while also considering timetable deviations, or it can weigh these criteria differently to create a balanced output. This results in an optimised schedule that aligns air and rail connections effectively.
- The final outcome is a synchronised timetable that will be analysed through the performance evaluator to gauge the impact on key performance indicators.

Expected Benefits:

- The project aims to reduce passenger waiting and travel times, thus improving the overall passenger experience.
- It will also assess broader impacts, such as door-to-door travel time reduction, which contributes to cost savings and more efficient travel.
- A significant potential benefit is the reduction in CO_2 emissions by shifting travel from air to rail where possible, thanks to making multimodal connections more attractive.
- From a societal perspective, the project seeks to increase the number of connections available between specific destinations, enhancing network resilience and accessibility, particularly in the context of the Spain-Germany corridor.

Conclusion:

- The project is expected to produce a synchronised timetable that optimises travel connections, provides various benefits for passengers and operators, and contributes to more sustainable travel solutions. The detailed technical aspects of this solution will be further presented in the following sections.



Bing Liu

Schedule design

Concept of Time Shift Strategy

1. Definition: The time shift strategy involves adjusting the departure and arrival times of train and flight services within an initial timetable to create a more synchronised schedule.
2. Objective: By shifting the times of certain services, the goal is to improve connections between different modes of transport, like trains and flights, making travel more efficient for passengers.
3. Better and More Connections:
    - Better connections refer to reducing transfer times between services that already exist in the initial timetable but were not optimal (e.g., long waiting periods).
    - More connections involve creating new transfer possibilities that did not exist in the original timetable.

Passenger Considerations

1. Passenger path and Itinerary:
    - Passenger path: The route a passenger plans to take, e.g., traveling from one city to another (e.g., Girona to Barcelona, then to Malaga), but not specifying which specific services (trains/flights) they will use.
    - Passenger Itinerary: The actual selection of services (specific train and flight timings) chosen to fulfill the passenger's journey.
2. Impact of Time Shift: When services are shifted, passengers may reconsider their travel itineraries based on improved connections, which leads to better travel experiences.
3. **Model Overview**

1. Inputs:
    - Initial timetable.
    - Passenger itinerary.
2. Decision Variables:
    - Departure and arrival times of services are adjusted as part of the time shift strategy.
    - Itinerary choice for passengers is determined to see which services are selected for optimal connections.
3. Constraints:
    - Operational limits, such as minimal and maximal running times for trains and flights, and minimum connection times for transfers.
    - Passenger assignment constraints, including capacity and transfer time.
    - Time shift range constraints, where services cannot be shifted beyond a certain limit (e.g., no shift to the next day).

Objective Functions

1. Passenger Side:
   - Minimise unserved demand, ensuring as many passengers as possible are accommodated.
   - Optimise transfer times, which is often a primary focus for improving passenger convenience.
2. Operator Side:
   - Minimise timetable deviation to avoid excessive changes in the schedule.
3. Trade-off among multiple objectives
   - The trade-off among multiple objectives is considered, such as transfer time reduction versus timetable deviation, using a parameter (lambda) to adjust priorities.

Preliminary Results and Case Study

1. Network and Scenario:
   - The model was applied to the Spanish air and rail network, involving over 100 origin-destination pairs, more than 50 trains, and over 100 flights.
   - Three scenarios were tested: a benchmark (initial timetable without changes), static demand (fixed passenger itineraries), and dynamic demand (optimised timetable and itinerary shifts).
2. Findings:
   - Transfer Time Reduction: The synchronised timetable improved transfer times for passengers, with some itineraries showing improvements of up to 45 minutes.
   - Time Shift Only vs. Time Shift + Itinerary Shift: Some improvements were solely due to time shifts, while others also involved itinerary changes.
3. Operator Perspective:
   - Timetable deviation was analysed, showing that most services approached the maximum allowed time shift.
   - A sensitivity analysis revealed that increasing the time shift range could lead to more itinerary shifts, reducing transfer times without significantly increasing timetable deviation.
   - Interestingly, a larger time shift for one service might offset the need for other shifts, leading to an overall more efficient schedule.

Key Takeaways and Future Considerations

1. Application of Time Shift Strategy: This strategy effectively improves passenger transfer times and creates more travel options.
2. Future Work:
   - Testing more realistic and larger networks with updated data.
   - Considering the impact of additional services and rerouting.
   - Iterating between timetable shifts and passenger behavior to refine the model further.

Conclusion

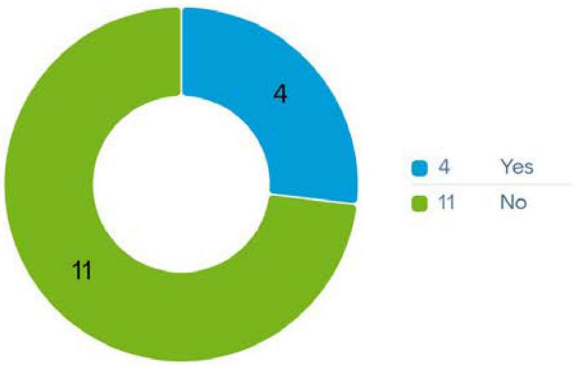
The time shift strategy, combined with itinerary adjustments, offers significant potential for optimising timetables, enhancing passenger experience, and potentially saving costs and $CO2$ emissions. Future enhancements could explore more complex network interactions and passenger behavior modeling to maximise the benefits.

Question Session 1

Welcome to Questions Session 1!

MultiModX

Q1.1: Should MMX consider an addtional passenger archetype?



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Q1.1.1. In case we missed a passenger archetype, which are the main characterisitics to capture/model?

Test 1	People with accessibility issues and groups (i.e. educational travel)	Reduced mobility	Change of behavior after pandemicsEnvironmental attitudes
Businesstravellers and Commuters (in a wider range)	car ownership	Business vs leisure	Pass holders

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MultiModX

Q1.1.1. In case we missed a passenger archetype, which are the main characterisitics to capture/model?

Travellers with special equipment or pets	Group size	travelling alone vs as a family, group

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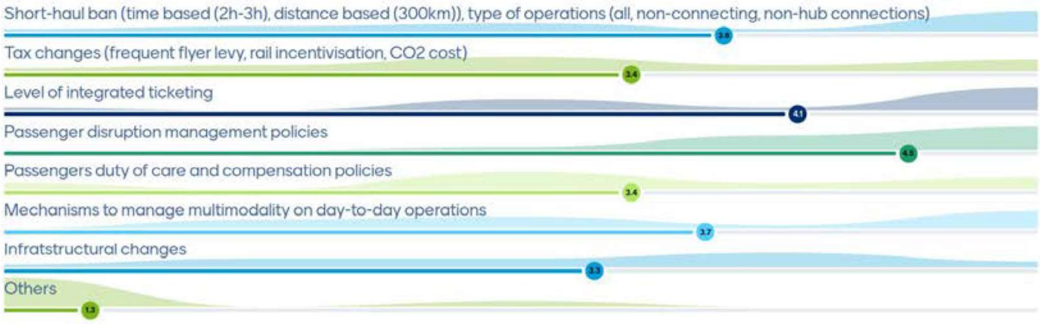
Q1.2: How relevant to evaluate are the following:



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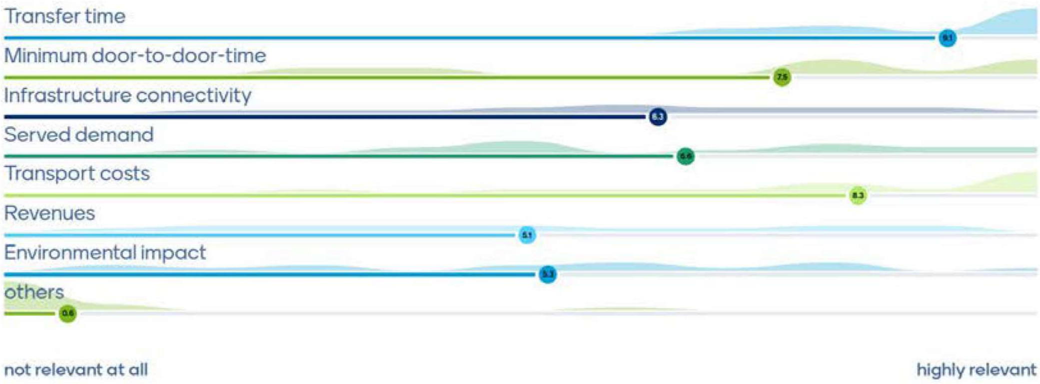
Q1.3 When evaluating schedules, how relevant are the following parameters?



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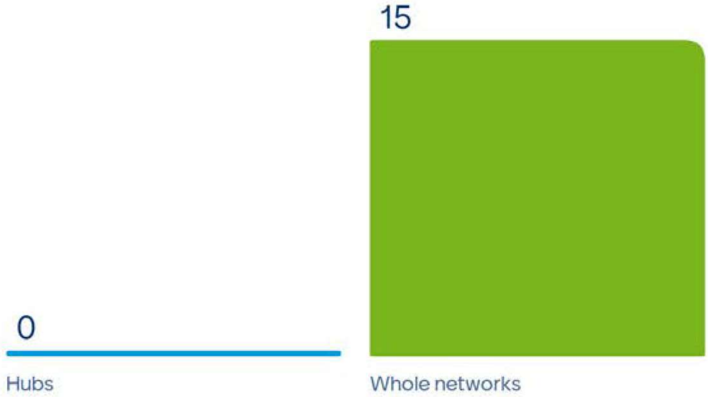
Q1.4: Should we focus more on single hubs (on one operator level) or on the whole networks (cross-operator adjustments)?



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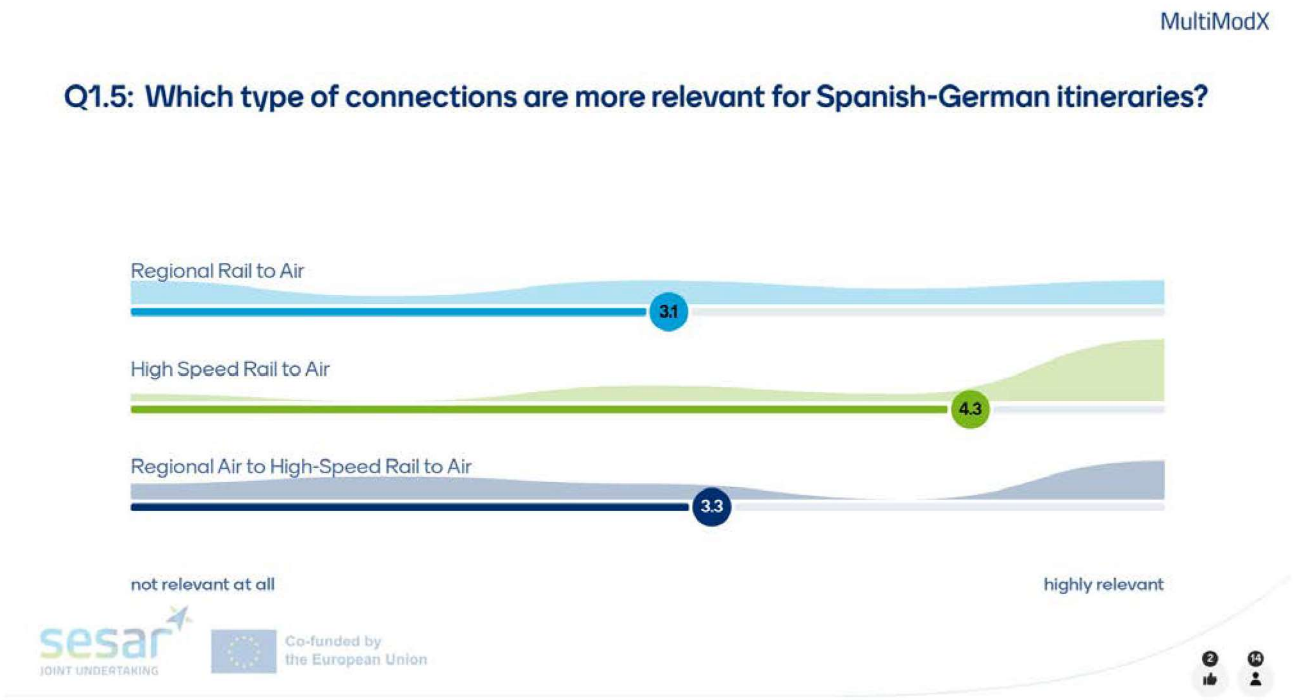
MultiModX
Q1.5: Which type of connections are more relevant for Spanish-German itineraries?
Regional Rail to Air
3.1
High Speed Rail to Air
4.3
Regional Air to High-Speed Rail to Air
3.3
not relevant at all
highly relevant
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Session 2

Welcome to Questions Session 2!

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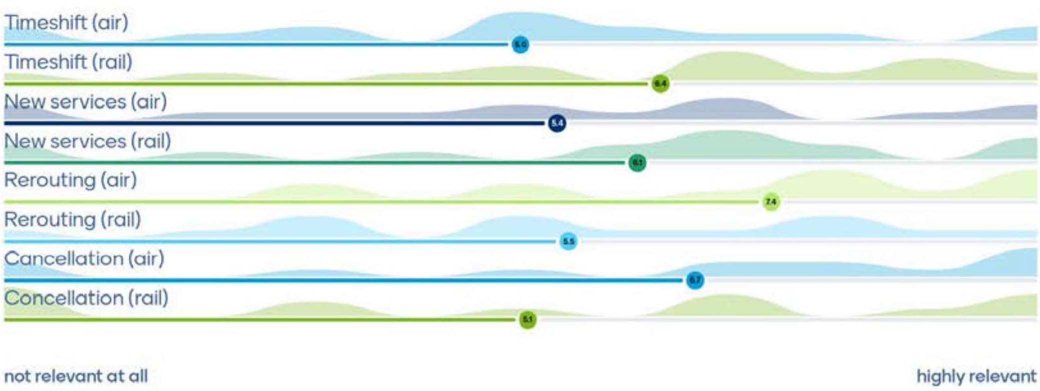
Q2.1: How relevant are the follwoing adjustment strategies?



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Q2.2: What are missed important constraints?

Airport capacity (per time window)
1 Popular

Timeslots at airports are sometimes very valuable for airlines which can hinder timeshifting
1 Popular

Connecting flights. resources personnel. airport and track capacity.
1 Popular

Aircraft rotation

Capacities

Hub Airlines connecting pax based on flights

Capacity, rotation

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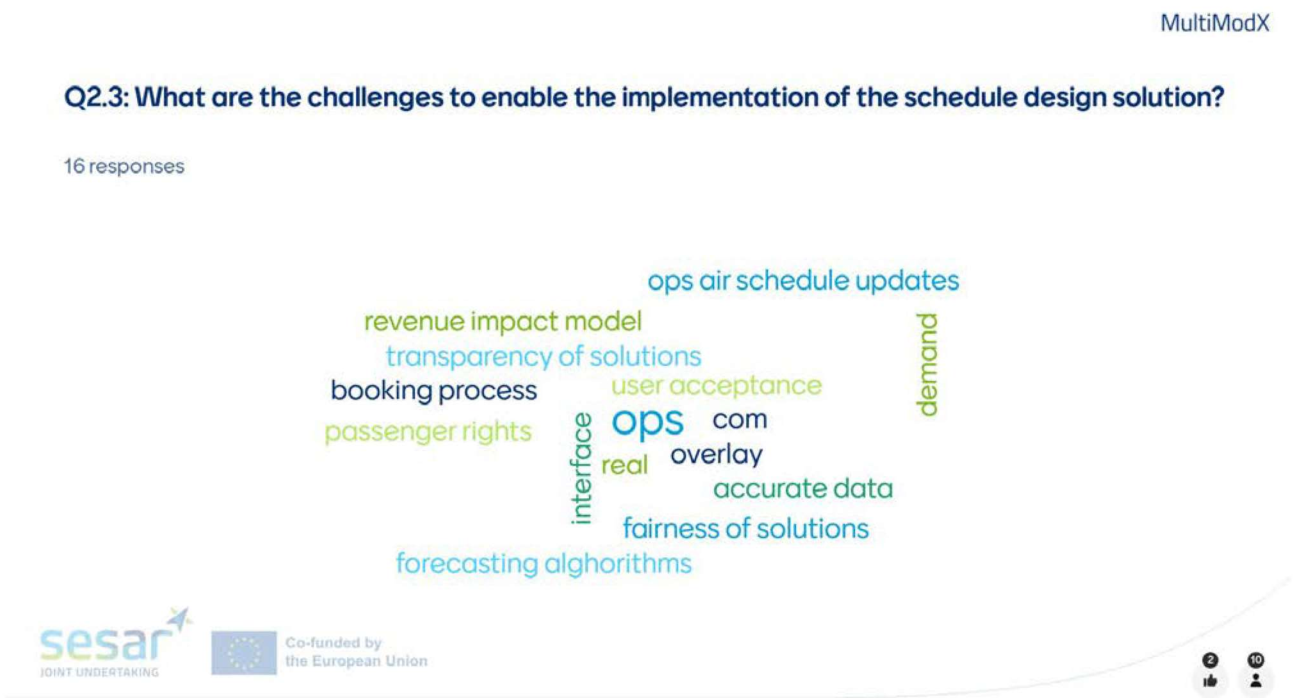
MultiModX
Q2.3: What are the challenges to enable the implementation of the schedule design solution?
16 responses
ops air schedule updates
revenue impact model
transparency of solutions
booking process
user acceptance
demand
passenger rights
ops
com
interface
real
overlay
accurate data
fairness of solutions
forecasting alghorithms
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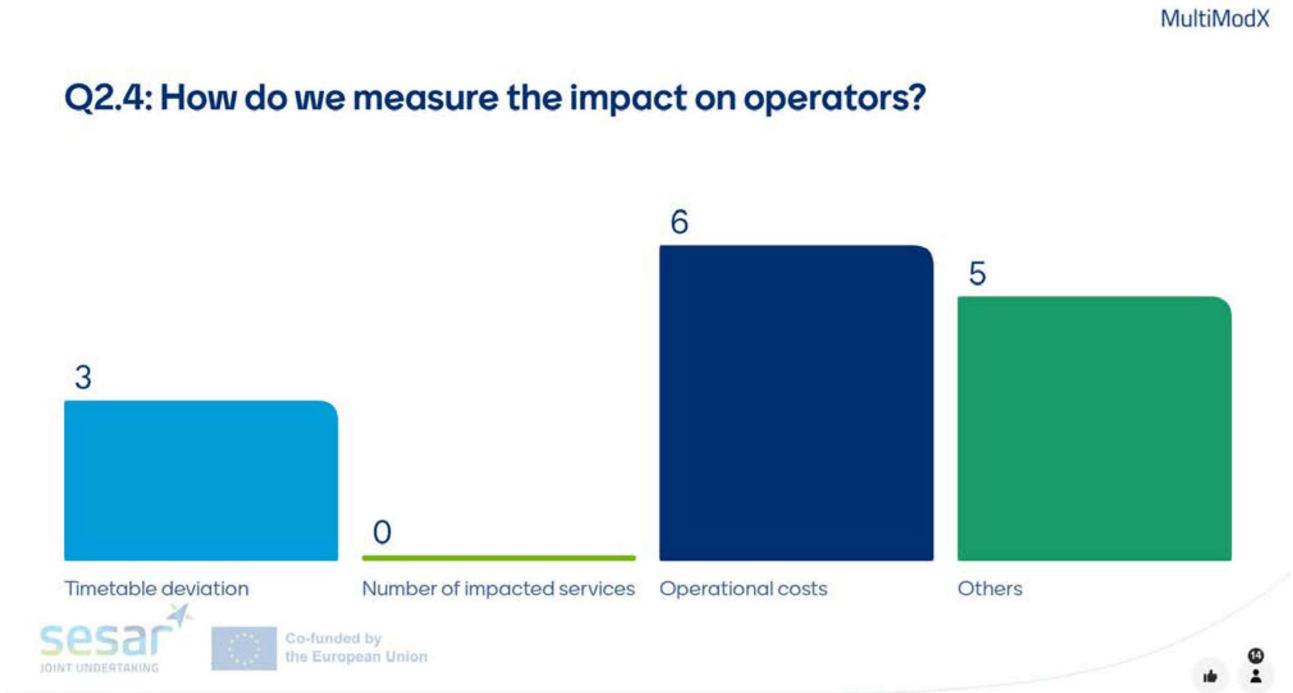
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Q2.4: How do we measure the impact on operators?
3
Timetable deviation
0
Number of impacted services
6
Operational costs
5
Others
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Air-Rail Disruption Management & Tactical Performance Assessment

Christopher Szymula
Luis Delgado

Intro Tactical evaluator, disruption evaluation

MultiModX consortium has extended the capabilities of the detailed open-source simulation model Mercury (https://github.com/UoW-ATM/Mercury) to evaluate how disruptions impact a detailed simulation model designed to evaluate how disruptions impact multimodal travel – specifically, connections between air travel and rail. And how this advanced simulation can help airports, transport operators, and policymakers better plan for and respond to disruptions, improve operational strategies, and enhance the passenger experience.

The main goal of this research is to model and analyse scenarios where travel experiences disturbances and disruptions, such as delays and missed connections, and to test solutions that might mitigate these issues.

1. Simulation of Disruptions: The model simulates various real-world travel scenarios at an airport and between different modes of transport (e.g., air to rail connections). It considers potential delays at different stages of travel, such as train delays, and assesses the impact on passenger connections.
2. Tactical Evaluation: The model focuses on tactical-level simulations, aiming to check whether current travel schedules are too tight or resilient enough under certain conditions, like unexpected delays. It assesses what happens if a connection is missed and how passengers adapt.

3. Agent-Based Modeling: The research uses an open-source agent-based model developed over 10 years in Westminster, Mercury, which has been extended to include train operations and interactions between air and rail travel. The agents represent elements like flights, trains, and passengers. For example, a «passenger handler» agent decides how to react when a passenger might miss their connection, such as rebooking them on the next available flight or train.

4. Real-World Example - Madrid: The simulation focuses on Madrid, illustrating how passengers travel from different train stations (Atocha and Chamartín) to the airport and their potential connections. It explores scenarios involving delays in ground mobility (e.g., taking a bus or metro between the station and the airport) and assesses how these delays influence whether passengers make their connections.

5. Mitigation Strategies: Increasing bus frequency or offering faster processing through the airport (e.g., a security fast-lane) for passengers who are late. These adjustments can reduce the number of passengers missing connections, but their impact varies.

6. Quantitative Analysis and Indicators: The model tracks individual elements, such as specific flights, trains, and passengers. It produces data that can be used to calculate aggregate outcomes like the number of people missing connections, delays, and costs associated with compensations.

7. Open-Source Tool: The model is part of an open-source tool called Mercury (https://github.com/UoW-ATM/Mercury), which allows researchers to modify and experiment with different parameters, simulate disruptions, and test various operational strategies.

Disruption Management in Multimodal Systems

The Core Challenge:

The primary focus of the project is to explore whether the impact of disruptions can be more effectively managed using multimodal systems. These systems, which integrate various modes of transportation (e.g., trains, buses, airplanes) that have distinct characteristics, offer new opportunities for enhanced disruption response.

Causes and Types of Disruptions:

Disruptions in transportation can stem from multiple sources. These include:

- Natural events such as severe weather conditions.
- Technical issues related to rolling stock (e.g., train breakdowns or bus malfunctions).
- Infrastructure failures, including track damage or technical problems with terminals and stations.

While disruptions may look similar across different modes, such as delays due to adverse weather or equipment issues, the characteristics of each mode – whether airside or rail – present unique challenges that must be addressed differently.

The Impact on Passengers:

While understanding the causes of disruptions is important, it is equally vital to consider their impact on passengers. Passengers are often the most affected by disruptions, facing delays, detours or even non-reachable destinations, often resulting in confusion and frustration. Addressing these challenges is essential to maintaining a positive passenger experience and ensuring that they reach their destinations with minimal inconvenience.

Objectives of the Project:

The goal is to identify how passengers are affected during disruptions and to determine strategies that can mitigate these impacts. The aim is to adapt services effectively so that, even under operational constraints, passenger needs are prioritised and service continuity is maintained.

Disruption Management Model:

To achieve these objectives, a disruption management model has been developed. This model simulates the behavior of transportation networks when disruptions occur and helps in understanding how different strategies can be employed to maintain service delivery during such events. The model is essential for assessing how various elements within a multimodal network can respond, ensuring that capacity is available to meet passenger demands and meet passenger demands and maintain operational feasibility.

Key Results and Conclusions:

- Improved Response with Multimodal Coordination: The research indicates that employing multimodal systems can lead to more effective disruption management. By leveraging different transportation options that complement each other, operators can better accommodate passengers during periods of disruption.
- Enhanced Passenger Experience: When disruptions are managed effectively through multimodal coordination, passengers experience fewer delays and greater flexibility in their travel plans. This contributes to maintaining trust in the transportation system and overall satisfaction.
- Operational Strategies for Capacity Management: The project highlights that disruptions can be mitigated by multimodal capacity management, ensuring that resources are allocated where they are most needed by passengers. The disruption management model provides insights into optimal strategies for maintaining service even under challenging conditions.
- Resilience and Adaptability: The use of multimodal systems enhances the resilience of transportation networks, allowing for more adaptable responses to unforeseen events. This flexibility ensures that operators can continue to provide service, albeit sometimes with modifications, to accommodate the affected passenger flow.

Session 3

Welcome to Questions Session 3!

MultiModX

Q3.1: How does our approach capture the actual real-life disruption management? (-:diferences | +:similarities)

It is a model with abstraction levels which will hardly ever reflect reality. But it might help to raise understanding (and find them at all) on factors which are more relevant than other.
6 Popular

A solid foundation for further refinement to better reflect the reality
5

There is consequential impact on other modes of disruption leading to systemic and unpredictable failures. The model assumes an overly simplified but understandable approach
5

-cascade effects - capacity -behavior of passengers
4

The challenge is real world satisfaction and journey achievement the model reflects departure to arrival. So does not reflect actual on time journeys
4

Add strikes in the major source of disruption
3

- agreement between stakeholders
3

Total travel time D2D
3

MultiModX

Q3.1: How does our approach capture the actual real-life disruption management? (-:diferences | +:similarities)

Are you calculating with historic Data? - forecast data should be used in Open Systems
3

Systems to communicate and shed passengers at the rate to allow the model to work do not exist currently at scale
1

Decisions driven by costs
1

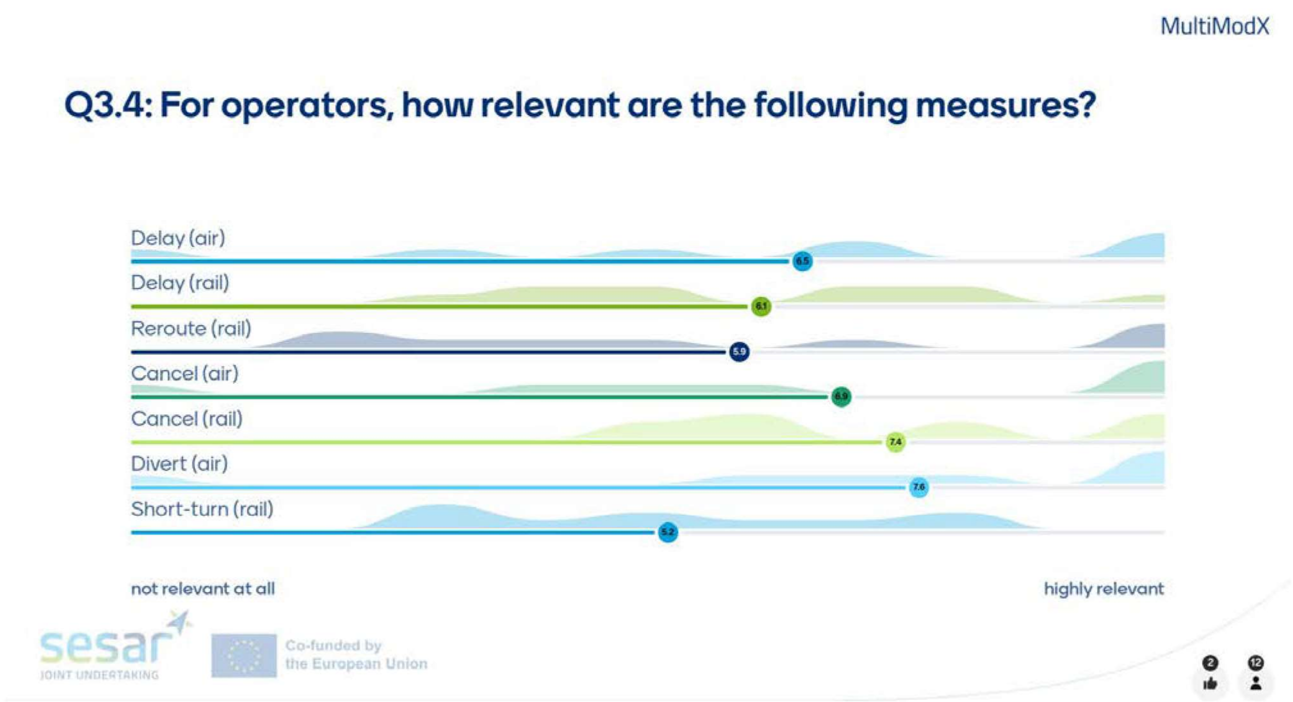
H

Decisions driven by costs

Q3.3.1: In case of disruptions, what time horizon ahead for network-wide replanning of operations should MMX consider for rail?

MultiModX

Q3.3.2: In case of disruptions, what time horizon ahead for network-wide replanning of operations should MMX consider for aviation?


MultiModX
Q3.4: For operators, how relevant are the following measures?
Delay (air)
6.5
Delay (rail)
6.1
Reroute (rail)
5.9
Cancel (air)
6.9
Cancel (rail)
7.4
Divert (air)
7.6
Short-turn (rail)
5.2
not relevant at all
highly relevant
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2
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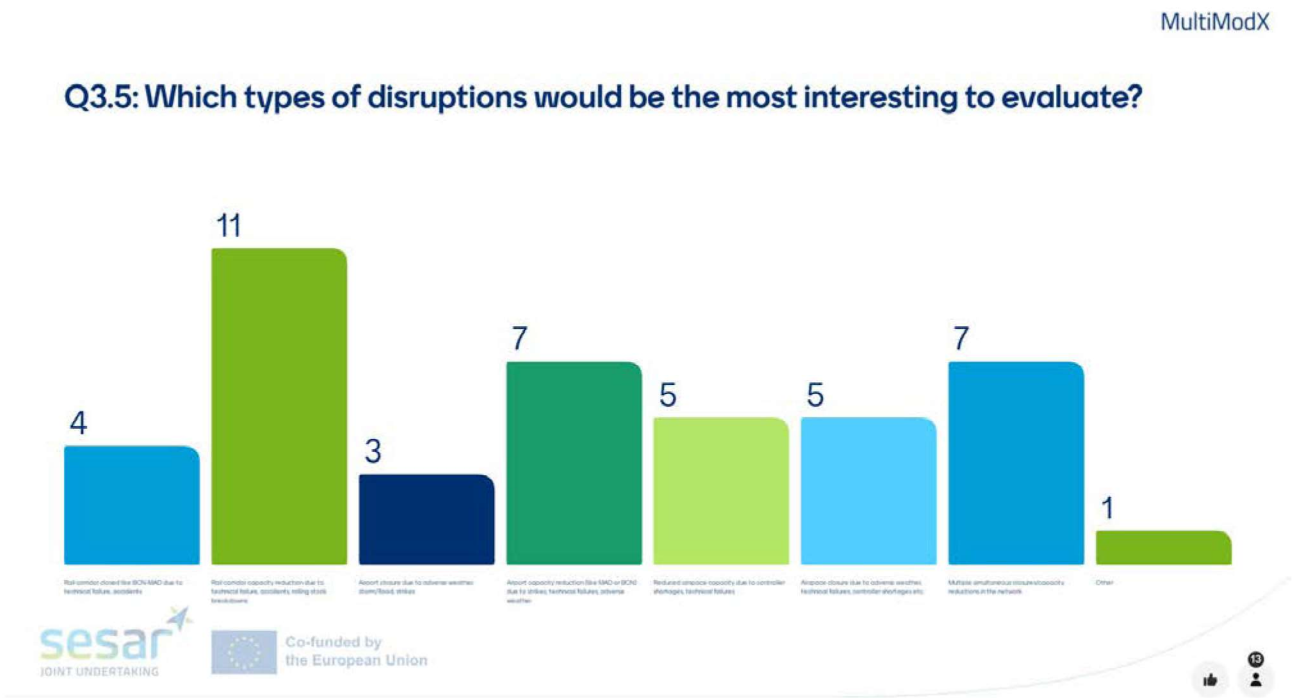
MultiModX
Q3.5: Which types of disruptions would be the most interesting to evaluate?
4
11
3
7
5
5
7
1
Other
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Q3.6: What are the challenges to enable the implementation of the disruption management solution?

- Confidence the plan will work and takes into account the practicalities of operation
- Total cost to operator
- Cooperation between industry players
- Before implementing an overall DM you should implement the MMX solution first...Based on the overall future solution the challenges might be different
- Complexity, Volume and Variety of data; real life Challenges Like different Customer behavoiur
- OPS-Time to propose passenger new solutions / passenger decision
- SoI-Network, stakeholders clear systems boundaries, type of events
- Agreement among operators for sharing the disruption cost

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Q3.6: What are the challenges to enable the implementation of the disruption management solution?

- Cooperation between stakeholders (operators of rail and air and operators of railways/stations and airports)
- Real time monitoring
- Needs collaborative decision making process
- Communicate to passengers how they can proceed (incl those who booked via intermediaries)

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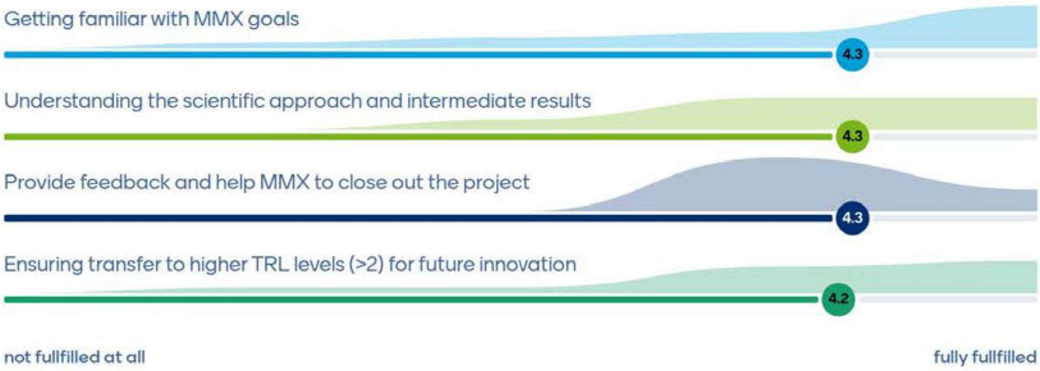
Have we achieved our 4 workshop goals?



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Where we are: MMX Timeline

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Kay Ploetner

Closing remarks & way forward

The workshop concluded with a review of the initial goals: understanding the objectives of MultimodX, evaluating the scientific approach, assessing intermediate results, and ensuring readiness for higher technology readiness levels. It was acknowledged that while progress was made, transitioning these strategies into higher readiness levels will require continued refinement and real-world application.

MultiModX

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The Aviation Think Tank

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