

MultiModX

White Paper

Towards passenger-centric multimodality in Europe:
Insights, Solutions and policy directions from the
MultiModX project

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Abstract

Europe's transport policy promotes multimodality as a driver of decarbonisation, resilience and passenger-centric mobility, yet air–rail integration remains fragmented due to limited coordination, data interoperability and passenger protection. This document presents policy recommendations based on the MultiModX project, which develops and validates three complementary Solutions for multimodal performance evaluation, air–rail schedule coordination and cross-modal disruption management. Using real-world data and stakeholder input, MultiModX shows that modest timetable adjustments can significantly improve connectivity and that coordinated disruption management substantially reduces stranded passengers and delays. Building on this evidence, the document proposes targeted policy actions on performance frameworks, pre-regulatory modelling, timetable coordination, disruption recovery and enabling conditions. Together, these recommendations provide an evidence-based pathway to translate Europe's multimodal ambition into reliable door-to-door mobility.

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1 Executive summary

1.1 Europe's multimodal ambition and the implementation gap

Europe is committed to delivering a more connected, sustainable and passenger-centric mobility system. Multimodality lies at the heart of this ambition, supporting decarbonisation, resilience, and accessibility objectives under the European Green Deal, Flightpath 2050 and the Sustainable and Smart Mobility Strategy. In particular, air–rail integration is expected to play a central role in reducing emissions and congestion by offering more sustainable door-to-door travel solutions, often resulting in a shift in demand away from short-haul flights, while strengthening regional connectivity and improving door-to-door performance.

Despite strong political ambition and an expanding regulatory agenda, air–rail multimodality remains fragmented in practice. It remains difficult for passengers to plan and book seamless multimodal journeys due to limited impartial information across platforms, insufficient schedule coordination and the absence of guarantees for through-tickets. Responsibilities during disruptions remain unclear, data interoperability is incomplete, and recovery actions are largely managed independently within each mode. As a result, many travellers actively avoid multimodal journeys due to the perceived risk of being stranded or left without assistance.

This persistent gap between policy ambition and operational reality prevents Europe from fully realising the vision of fast, resilient and low-carbon door-to-door mobility, as articulated in its strategic roadmaps.

1.2 The MultiModX contribution

The MultiModX project contributes directly to closing this gap by providing evidence, analytical tools and policy-relevant insights for air–rail multimodal integration. MultiModX demonstrates what becomes possible when coordination, data availability and regulatory enablers are in place.

Through three integrated SESAR Solutions, the project establishes a coherent methodological foundation for future European multimodal mobility governance:

- **Solution 399 – Multimodal Performance Evaluation** measures door-to-door passenger outcomes using a structured catalogue of passenger-centric indicators, extending existing aviation performance frameworks to multimodal journeys and providing open-source tools for evaluating multimodal networks.
- **Solution 400 – Multimodal Schedule Design** improves planned connectivity by optimising air and rail timetables within operational constraints, increasing feasible connections and reducing transfer times.
- **Solution 401 – Multimodal Disruption Management** protects passengers during disruptions through coordinated, cross-modal recovery strategies that minimise stranded passenger numbers and preserve journey continuity.

Each Solution plays a distinct and complementary role: one measures, one improves, and one protects. Together, they form an integrated package that supports evidence-based policymaking across the full journey lifecycle: from planning and booking to execution and disruption recovery.

All Solutions have been validated using real-world data through an intra-Spain case study and refined through extensive stakeholder engagement involving airlines, railway operators, airports, global distribution platforms, and policymakers.

1.3 Key results and evidence

The MultiModX results demonstrate that coordinated air–rail multimodality delivers measurable benefits for passengers and for the transport system as a whole.

At the planning stage, modest air–rail timetable adjustments ($\pm 10\text{--}20$ minutes) significantly improve connectivity at multimodal hubs. In the case study, **door-to-door travel times were reduced by up to 20%**, and the number of feasible connecting itineraries increased by 5–7%, without negative impacts on other services or the need for new infrastructure. These findings **confirm timetable coordination as a high-impact, low-cost policy lever**. The full cost impacts on the supply-side remain to be evaluated.

During operational disruptions, the benefits of multimodal cooperation are even more pronounced. **Coordinated air–rail disruption management reduced the number of stranded passengers by approximately 17%, average journey times by 20% and service delays by up to 50%. Flexible rebooking across modes proved critical to containing the propagation of disruptions, even when disruptions affected only one mode.**

From a passenger perspective, the stakeholder’s feedback showed that reliability, transparency and guaranteed connections deliver more than marginal time savings. Passengers value clear responsibility, credible recovery options and timely information. **Multimodal integration, therefore, succeeds only when it is designed around passenger confidence and protection, not solely around infrastructure or capacity.**

1.4 From evidence to policy: key recommendations

Building on this evidence, the document proposes seven targeted policy recommendations addressing performance evaluation, schedule coordination and ticketing, disruption management, capacity, and enabling conditions for deployment.

1. The document calls for the establishment of a **common European catalogue of passenger-centric multimodal performance indicators**, building on the MultiModX framework. This would extend existing SESAR performance governance beyond mode-specific metrics to capture door-to-door reliability, missed connections, resilience and stranded passengers. Such indicators would enable consistent benchmarking across projects, guide data standardisation priorities, and align regulation more closely with actual passenger outcomes.

2. The recommendations propose **standardising modelling-based assessment as a standard for pre-regulatory policy evaluation**. MultiModX demonstrates that modelling can assess passenger, operational and capacity impacts of policies such as short-haul flight bans, CO₂ pricing, timetable changes or disruption-management obligations before implementation. Embedding such tools into EU impact assessments would strengthen evidence-based policymaking and reduce regulatory risk - often including negative unforeseen consequences.
 3. The document recommends **enabling and incentivising air–rail timetable coordination**, particularly at TEN-T airports. Regulatory support for limited schedule flexibility, combined with monitoring of multimodal connection performance, would unlock connectivity gains that cannot be achieved through infrastructure investment alone.
 4. The recommendations emphasise the need to **strengthen cross-modal disruption management and promote appropriate journey alternatives across modes**. Evidence from MultiModX shows that coordinated recovery significantly improves passenger-centric outcomes. Translating this into policy would require incentives for cooperation, real-time data sharing and cross-modal rebooking, and would support the evolution of multimodal passenger rights toward genuine door-to-door service.
 5. The document highlights the importance of **aligning air and rail capacity planning**. Multimodal strategies deliver their intended benefits only if sufficient rail capacity is available, particularly during disruptions. Capacity misalignment, therefore, represents a structural risk that must be addressed through coordinated planning.
 6. The recommendations propose **defining EU-level multimodal connectivity targets**, such as regarding population access to multimodal hubs, the quality of rail–airport links, and the availability of optimised air–rail connections. Such targets would make progress toward multimodality, measurable and comparable across regions.
 7. The document emphasises the need to **sustain long-term applied research and structured cross-sector cooperation**. While analytical tools are mature, operational deployment remains constrained by institutional fragmentation and limited mutual understanding between sectors. Continued research, joint training and operational pilots are essential to translate multimodal concepts into practice.
- Together, these recommendations provide a coherent, evidence-based pathway for translating Europe's multimodal ambition into operational reality.

MultiModX confirms that air–rail multimodal integration is not a theoretical aspiration but an operationally viable and high-impact strategy. Passenger-centric performance evaluation coordinated schedule planning and joint disruption management together form a robust foundation for a resilient and sustainable European mobility system.

The key question is no longer whether Europe should pursue multimodality, but how quickly it can deploy the regulatory, technical and governance conditions required to make multimodal journeys reliable and attractive for passengers. The MultiModX Solutions offer not only evidence of what works, but also a practical roadmap for embedding passenger-centric multimodality into European transport policy and regulation.

2 The European need for multimodal integration

Although multimodality has become a cornerstone of European transport policy, significant barriers still prevent seamless integration in practice. Passengers continue to struggle with end-to-end journey planning and booking due to the limited availability of neutral multimodal information, poorly coordinated timetables, and unclear responsibilities during disruptions (European Parliament, 2024). The absence of through-ticketing forces travellers to assemble journeys themselves, leaving them unprotected when connections are missed. This is reflected in passenger behaviour: according to the 2024 Flash Eurobarometer, many travellers actively avoid multimodal or multi-operator journeys due to the perceived risk of being stranded (European Commission, 2024a).

Operational and regulatory fragmentation reinforces these challenges. Aviation and rail operate under different data standards, passenger-rights frameworks and governance structures, while real-time operational data remain inconsistently available despite progress under Multimodal Travel Information Services (MMTIS) (European Commission, 2024b). As a result, Europe's ambitions for sustainable modal shift, resilience and door-to-door performance, as articulated in the Sustainable and Smart Mobility Strategy (SSMS), cannot be fully realised without tools and frameworks that bridge analytical, operational and regulatory gaps (European Commission, 2020b).

MultiModX responds to these challenges by providing data-based evidence, with insights into the effects of multimodal coordination, schedule integration, and disruption management. It develops robust modelling and optimisation tools, validated with real-world data and stakeholder feedback, that help align multimodal planning with actual passenger needs.

2.1 The current European regulatory landscape

The European transport network currently operates with overlapping but not yet fully integrated layers that cover passenger rights, multimodal data, digital booking, and network infrastructure. The absence of a unified regulatory and operational framework for real-time, door-to-door multimodal journeys remains a central systemic gap with many different stakeholders with complementary and, at times, misaligned views. As a result, multimodality remains dependent on voluntary cooperation rather than being supported by a consistent regulatory and operational framework.

2.1.1 Strategic roadmaps overview

Strategic roadmaps shaping the future of multimodal coordination across aviation, rail, and digital mobility aim to address the identified gaps. Initiatives from the European Smart Mobility Strategy, DG MOVE, SESAR, and Europe's Rail increasingly align research, innovation and regulation, supporting harmonisation and more seamless door-to-door journeys. DG

MOVE's 2023 Annual Activity Report further situates these efforts within a unified EU digital mobility strategy, prioritising multimodal ticketing, data spaces and passenger-centric regulation.

2.1.1.1 European high-level roadmap – European Green Deal and Sustainable and Smart Mobility Strategy

The EU is committed to becoming climate-neutral by 2050 (United Nations, 2015), and through the European Green Deal, it aims to reduce overall emissions by at least 55% by 2030¹, and by 90% by 2040² (European Commission, 2020a). Transport accounts for one quarter of EU greenhouse gas emissions, with aviation accounting for 14.4% and rail for 0.5% of transport-related emissions³ (European Parliament and Council, 2021a). Emission reduction objectives led to the development of the European Sustainable and Smart Mobility Strategy (SSMS), which outlines the European vision for mobility within the framework of 2030 and 2050 (European Commission, 2020b; European Commission, 2020c).

The SSMS identifies multimodality as a key enabler of efficiency, resilience and sustainability, notably through initiatives on integrated information, ticketing and payment services (through the Flagship on *Making connected and automated multimodal mobility a reality*), passenger rights, data, taxation and infrastructure. These policy objectives are defined in the Mobility Strategy with ambitions and milestones for the 2030, 2035 and 2050 periods.

2.1.1.2 Aviation roadmap – Single European Sky

Within aviation, the Single European Sky (SES) and its technological pillar, SESAR, aim to enhance the performance, efficiency, and sustainability of air traffic management (European Parliament and Council, 2024a; European Commission, 2024c). The development and subsequent deployment of technology are planned through the European ATM Master Plan, which outlines the vision and priorities for the Digital European Sky (SESAR JU, 2024a; SESAR JU, 2020). The SESAR Performance Framework provides a common framework and an evaluation tool for innovations in air traffic management. These initiatives consider the aviation ecosystem with an increasing interest in passenger-centric and multimodal approaches to develop the European Vision for Aviation outlined in the Flightpath 2050 report (European Commission, 2011).

In recent years, SESAR has explicitly positioned multimodality and passenger experience as core innovation priorities (SESAR JU, 2025). The Strategic Research and Innovation Agenda for

¹ Compared to 1990 levels.

² The European Green Deal – Striving to be the first climate-neutral continent.

https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (Accessed 22 December 2025)

³ Explainers – Clean and sustainable mobility. <https://www.consilium.europa.eu/en/policies/clean-and-sustainable-mobility/> (Accessed 22 December 2025)

the Digital European Sky (SRIA) sets a 2030 vision in which air–rail multimodality is supported by common metrics, processes and tools for door-to-door mobility intelligence, real-time information, collaborative decision-making and integrated disruption and crisis management (SESAR JU, 2020). The ATM Master Plan includes multimodality under “Smart airports as multimodal nodes and the passenger experience”, while the SESAR Multimodal Flagship has evolved into a broader Passenger Experience focus. The consideration of multimodality within the SESAR framework is evolving, acquiring a transversal nature and an objective to be reached in deployment.

2.1.1.3 Rail roadmap

In rail, Europe’s Rail Joint Undertaking (EU-Rail), aims to deliver a high-capacity, flexible, multimodal, sustainable, reliable, and integrated European railway network for passengers and cargo (Europe’s Rail JU, 2025).

EU-Rail defines a detailed multi-annual roadmap for digitalisation, interoperability, and integrated passenger services within its Work Programme 2025–2026, providing structured steps towards a more connected and multimodal rail system (Europe’s Rail JU, 2025). EU-Rail’s System Pillar further outlines the long-term framework for harmonised digital architecture and operational models across European railways, directly supporting cross-modal integration⁴ (Europe’s Rail JU, 2024).

⁴ Europe’s Rail Joint Undertaking – System Pillar: TSI and Standards. https://rail-research.europa.eu/system_pillar/system-pillar-tsi-and-standards/ (Accessed 22 December 2025)

3 Regulatory elements on passenger mobility and multimodal aspects

This section provides an overview of the regulatory elements covering passenger rights, multimodal data, digital booking, and network infrastructure, along with an indication of their current planned and expected evolution.

3.1 Passenger rights

From a legal perspective, the European framework for passenger mobility rights remains largely structured along monomodal lines:

- In aviation, Regulation (EC) No 261/2004 defines compensation and assistance (European Parliament and Council, 2004). It is currently under inter-institutional negotiation for revision (European Commission, 2025; European Council, 2025a) with a proposal to enhance the enforcement of passenger rights, providing updates on the right to be rerouted, assistance, and compensation for cancellations and delays (European Council, 2025b). Regulation (EC) No 1107/2006 establishes specific rights for persons with reduced mobility in air transport (European Parliament and Council, 2006).
- In rail, Regulation (EU) 2021/782 on rail passengers' rights and obligations governs information, assistance, compensation and through-ticketing within the railway system (European Parliament and Council, 2021b). In July 2025, the Commission launched a targeted public consultation for a possible revision of this framework, specifically aimed at addressing missed connections, multi-operator journeys, and interfaces with other modes in multimodal travel contexts (European Commission, 2025).

Certain gaps have been identified that undermine the effectiveness of individual monomodal passenger rights Regulations (air, rail, waterborne and coach) (European Commission, 2020c). For this reason, there is a proposal to amend these regulations, aiming to simplify, consolidate, and harmonise them (European Commission, 2023).

While these instruments provide solid monomodal protection, they were not designed to govern door-to-door multimodal journeys or to allocate responsibilities across air–rail travel chains. For the first time, the EU is advancing a dedicated legislative proposal on passenger rights in the context of multimodal journeys under the ordinary legislative procedure (European Commission proposal COM(2023) 752; 2023/0436) (European Commission, 2023b)). As of late 2025, this proposal remains under discussion and has not yet been translated into enforceable door-to-door multimodal rights.

Additional persistent barriers to seamless multimodal travel concern baggage, passenger assistance and real-time communication: luggage handling remains largely confined within

modal silos, no unified multimodal framework governs physical passenger assistance during transfers – with Regulation (EC) No 1107/2006 on the rights of persons with reduced mobility when travelling by air (European Parliament and Council, 2006) and Regulation (EU) No 2021/782 on rail passengers' rights and obligation (European Parliament and Council, 2021b) – nor is there a single “journey owner” responsible for providing consistent, real-time end-to-end information, guidance and rebooking instructions across the full travel chain.

3.2 Multimodal data integration

At the data level, multimodal journey information is governed by Commission Delegated Regulation (EU) 2017/1926 on EU-wide Multimodal Travel Information Services (MMTIS), as amended in 2024 (European Commission, 2024b). MMTIS establishes the legal framework for EU-wide multimodal travel information by obliging Member States to operate National Access Points and by requiring transport operators and public authorities to make static and dynamic travel data available in harmonised formats. MMTIS remains focused on data access and interoperability and does not, in itself, establish integrated ticketing, operational coordination or multimodal passenger rights.

The SESAR JU and Europe's Rail JU European jointly funded the Travel Wise project to foster the evolution and adoption of a common European mobility data space⁵.

3.3 Digital mobility services

Beyond data, the European Union is developing additional regulatory layers for digital mobility integration. The Multimodal Digital Mobility Services (MDMS) initiative aims to establish common rules for digital mobility platforms that provide multimodal information, comparison, booking, and payment, with the goal of ensuring fair access to data, interoperability between operators and intermediaries, and transparent information for passengers (European Parliament, 2025). In parallel, the proposed Single Digital Booking & Ticketing Regulation (SDBTR) aims to facilitate the purchase of single digital tickets for multimodal journeys and enhance contractual continuity across modes (European Economic and Social Committee, 2025).

Together, these instruments address complementary layers of multimodal integration: MMTIS focuses on data availability and interoperability, MDMS regulates the behaviour of digital mobility platforms, and SDBTR aims to establish contractual and ticketing continuity for passengers.

Beyond these passenger-facing gaps, the practical implementation of EU regulation and technical standardisation continues to face structural barriers at the operator level, linked to differences in commercial models, legacy IT systems, data ownership strategies, liability

⁵ Travel Wise project - <https://travelwise-project.eu/> (Accessed 22 December 2025)

allocation and competitive concerns, which still limit the effective uptake of common standards by both airlines and railway undertakings. At the same time, both the air and rail sectors are actively engaged in ongoing efforts to progressively align their digital, operational and contractual frameworks within the context of European initiatives on ticketing, data sharing and multimodal integration. Stakeholders still express concerns that regulatory approaches are insufficiently aligned with operational and economic realities. Addressing these structural barriers will require targeted investment and additional operational costs, which must be carefully assessed and controlled to ensure proportional and sustainable implementation.

SESAR JU's SIGN-AIR project focused on legal and contractual aspects of air–rail cooperation, including data sharing, liability allocation and revenue distribution (SESAR JU, 2024b).

3.4 Network infrastructure

From an infrastructure perspective, the revised TEN-T (Trans-European Transport Network) Regulation provides the physical backbone for European multimodality by strengthening the role of multimodal nodes, such as airports, high-speed rail stations, and urban nodes, and by guiding investment priorities for cross-border connectivity (European Parliament and Council, 2024b). It plays a central role in structuring the European multimodal network; however, the regulatory alignment between infrastructure planning, digital integration, and passenger protection is still evolving.

4 The MultiModX Project

The MultiModX project develops three Solutions designed to model, optimise, and protect multimodal mobility. The methodology depends on three shared analytical building blocks: passenger archetypes, regional archetypes, and multimodal policy packages.

- **Passenger archetypes** capture behavioural differences such as willingness to pay, tolerance for transfer time, frequency of travel, and preference for specific modes.
- **Regional archetypes** reflect socioeconomic and infrastructure differences across Europe.
- **Policy packages** introduce measures such as short-haul flight bans, CO₂ taxation, improvements in access to rail stations, or changes in ticketing integration.

MultiModX evaluates the integration of air and rail operations from a mobility perspective; the project assumes that the required governance and technological enablers (e.g. data exchange infrastructure, integrated ticketing) are already in place. The Solutions are therefore able to assess what-if situations, enabling the evaluation of changes to the system at the infrastructure (e.g., improved connectivity between modes), policy (e.g., short-haul flight bans), and business model levels (e.g., integrated ticketing between air and rail operators, coordinated operations to deal with disruptions). The experiments developed in the project considered the intra-Spain mobility (MultiModX Consortium, 2025a).

MultiModX also integrated stakeholder knowledge through workshops, consultations, and an Industry Board representing airlines, rail operators, airports, GDSs, global distribution platforms, and policymakers (MultiModX Consortium, 2024; 2025). These exchanges helped refine assumptions, validate the scenario designs, and ensure that modelling outcomes reflect operational constraints and governance realities.

4.1 MultiModX Solutions

Solution 399 – Multimodal Evaluation Framework

MultiModX provides a digital catalogue of indicators (available at <https://multimodx.eu/>) that complements and extends the SESAR Performance Framework to include passenger-centric aspects capturing door-to-door multimodal itineraries.

Additionally, a set of models for evaluating planned, replanned (due to disruptions), and executed mobility networks have been released. These provide a framework for assessing 'what if' scenarios, enabling changes to infrastructure, schedules, policies, and other relevant factors (MultiModX Consortium, 2025b).

Solution 400 – Multimodal Schedule Optimiser

The Multimodal Schedule Optimiser improves multimodal connectivity by adjusting air and rail schedules during the planning phase. Using passenger demand and individual itineraries, it re-times selected services within operational limits to increase feasible connections and reduce transfer times, while respecting infrastructure constraints. The Solution quantifies connectivity and passenger benefits resulting from improved schedule coordination across modes (MultiModX Consortium, 2025c).

Solution 401 – Multimodal Disruption Management

The Multimodal Disruption Management Solution is a network-wide disruption management tool for integrated air-rail systems, aimed at minimising passenger impact. It coordinates recovery actions across modes in the event of disruptions to minimise the number of passengers being stranded. The optimiser considers retiming (delays), cancellations, rerouting, and passenger rebooking in a coordinated and centralised manner or with a distributed approach. The Solution enables assessment of decentralised versus cooperative recovery strategies and provides passenger-centric resilience indicators, supporting evidence-based evaluation of multimodal disruption management policies (MultiModX Consortium, 2025d).

4.2 Key results and evidence

The MultiModX tools demonstrate that multimodal coordination can significantly improve network efficiency, passenger satisfaction, and systemic resilience during all phases of the journey: from planning to execution (including dealing with disruptions). Individual relevant results are summarised, when adequate, along with the policy recommendations.

Analysis shows that better timetable alignment leads to substantial reductions in travel time across many origin–destination pairs, making rail a more viable alternative than short-haul flights. Connectivity improves without negatively affecting other services, and the system accommodates more passengers without requiring new physical infrastructure.

Disruption scenarios reveal even greater value from multimodal cooperation. When air and rail operators coordinate their responses, far fewer passengers become stranded, delays no longer propagate uncontrollably, and replacement routings become feasible.

Stakeholder feedback gathered during the MultiModX Industry Board meetings highlights that, while technical tools exist, full deployment requires regulatory clarity, data interoperability, and trust-based governance frameworks across all modes. Discussions also revealed a persistent mutual lack of familiarity with regulatory frameworks, operational realities and terminology between the air and rail sectors, even among experienced professionals, which continues to hinder effective cooperation. Passengers consistently prioritise reliability, transparency, guaranteed connections, and simple recovery options; thus indicating that multimodal integration must be built around these expectations.

5 Remaining challenges: Regulation, data, and passenger experience

Despite important policy momentum, several obstacles continue to hinder the practical implementation of multimodal integration. Regulatory fragmentation across modes still creates uncertainty for multimodal travellers. Responsibilities are often unclear when journeys involve multiple operators or intermediaries, and current passenger-rights frameworks do not adequately address door-to-door, cross-modal journeys. This results in gaps in protection and complicates the management of disruptions. There is a scope for introducing tools that evaluate policies through modelling, enabling the assessment of their potential impact before deployment and opening the door for evidence-based policy definition.

At the same time, data exchange remains heterogeneous, with clear opportunities to advance harmonisation and adopt interoperable solutions that can deliver effective short-term improvements while keeping implementation costs under control. Essential information — such as real-time timetables, capacity data, disruption alerts, or passenger details — is still not consistently available or provided in aligned or, at least, interoperable formats. Additionally, operators may be reluctant to share commercially sensitive data without a clear legal framework, which limits the sector's ability to plan, coordinate, and recover effectively in a multimodal context.

Finally, the passenger experience remains a significant barrier. Many travellers still perceive multimodal journeys as complex and unpredictable. They lack confidence that missed connections will be protected, that luggage will be handled seamlessly, or that reliable recovery options will be available across modes. Without transparent responsibilities, interoperable data, and credible continuity guarantees, passenger confidence in multimodal travel will remain limited, regardless of the progress in infrastructure or technology.

6 Policy recommendations

These recommendations stem from the analytical results of the MultiModX project and extensive stakeholder feedback collected via Industry Board meetings and consultations (MultiModX Consortium, 2024; 2025). They are structured around four thematic areas:

- **performance evaluation**
 - 1. Develop and maintain a common European catalogue of multimodal performance indicators
 - 2. Use of modelling techniques for pre-regulatory policy assessment
- **schedule coordination and ticketing**
 - 3. Establish a legal framework to facilitate air-rail timetable coordination
- **disruption management**
 - 4. Strengthen cross-modal disruption management and recovery
- **enabling conditions for deployment.**
 - 5. Address capacity requirements for multimodal services
 - 6 Introduce EU-level multimodal connectivity targets
 - 7 Support long-term research and cross-sector professional cooperation

6.1 Policy recommendations description

1. Develop and maintain a common European catalogue of multimodal performance indicators

- **Rationale from MultiModX:**

Assessing the performance of Europe's multimodal transport system requires a shared set of indicators with common definitions. In a multimodal context, multiple stakeholders apply different evaluation frameworks, making it difficult to compare results across projects, regions, and modes.

MultiModX developed an open digital catalogue of passenger-centric indicators extending existing aviation performance frameworks to capture door-to-door air–rail journeys, taking into account the input from the Industry Board, and other research projects within the SESAR Multimodal and Passenger Experience Flagship.

Passenger-centric and door-to-door indicators are more effective at capturing the benefits of multimodality (e.g., transfer waiting times, journey continuity), but they are more challenging to compute due to fragmented data ownership, GDPR constraints, and commercial sensitivities. MultiModX demonstrates that model-based approaches and post-processing of aggregated datasets can address these limitations, provided methodologies are standardised and transparent. Finally, it is likely that indicators present variants to account for stakeholders' needs or data and modelling limitations. This could hinder their compatibility across projects

and other initiatives. For this reason, MultiModX's catalogue of indicators accounts for variants of the indicators, documenting how they are calculated.

To reflect varying levels of maturity, indicators are classified into three deployability levels:

- Level 1: Indicators already included in the SESAR Performance Framework;
- Level 2: Indicators modelled by research projects;
- Level 3: Advanced door-to-door indicators that are currently constrained by data availability.

Note how, in some cases, variants of the same indicator might be at different levels, or an indicator might only be computable at a given level for a particular geographical or operational scope where data are available.

Recommendation	Impact
<ul style="list-style-type: none"> ○ Introduce a common European multimodal catalogue of performance indicators, building on the MultiModX catalogue. ○ Establish a governance framework (e.g. under the SESAR Passenger Experience Flagship) to ensure consistent definitions and use across EU-funded projects. ○ Maintain and regularly update indicator maturity levels based on data availability and methodological readiness. ○ Allow the use of model-based and post-processed datasets, provided methodologies are fully documented and reproducible 	<ul style="list-style-type: none"> ○ Enables consistent benchmarking of multimodal Solutions across projects and regions. ○ Supports the prioritisation of data standardisation efforts at the EU, national, and operational levels. ○ Accelerates the development and deployment of passenger-centric multimodal Solutions.
Alignment with the current regulatory framework	
<p>The catalogue complements and extends the SESAR Performance Framework (SESAR JU, 2023) and supports the Strategic Research and Innovation Agenda for the Digital European Sky objective of developing multimodal performance metrics by 2030 (SESAR JU, 2020). It can also inform data prioritisation under EU-wide Multimodal Travel Information Services (MMTIS) (European Commission, 2024b).</p>	

2. Use of modelling techniques for pre-regulatory policy assessment

- **Rationale from MultiModX:**

A common performance framework must be supported by evaluation tools based on standardised assumptions. MultiModX modelling tools demonstrate the ability to assess policy impacts across planning, pre-tactical and execution phases, including mode choice, disruption recovery, passenger rebooking flexibility and compensation liabilities.

These tools enable quantitative assessment of both encouraging and discouraging policies, such as CO₂ taxation, short-haul flight restrictions, integrated disruption management and the quantification of passenger duty-of-care obligations. All MultiModX models have been released as open-source and already function as a common evaluation framework for multimodal Solutions, mechanisms, and policy scenarios, including flight bans, capacity constraints, and timetable changes, even though they are currently applied only within research contexts.

Recommendation	Impact
<ul style="list-style-type: none"> ○ Extend the use of modelling techniques, such as those developed in MultiModX, to support ex-ante evaluation of EU mobility legislation and policy options. 	<ul style="list-style-type: none"> ○ Ensures transparent, consistent and evidence-based policymaking. ○ Enables assessment of multiple policy alternatives and unintended consequences. ○ Improves understanding of impacts on passengers, operators and infrastructure. ○ Reduces regulatory risk by identifying unintended passenger and network effects before implementation.
Alignment with the current regulatory framework	
<p>Pre-regulatory modelling supports implementation of the Sustainable and Smart Mobility Strategy (European Commission, 2020c), emissions pricing mechanisms under the “Fit for 55” package (European Parliament and Council, 2023c), multimodal passenger rights proposals (European Commission, 2023b) and national measures such as short-haul flight restrictions (Convention Citoyenne pour le Climat, 2021).</p>	

3. Establish a legal framework to facilitate air-rail timetable coordination

- **Rationale from MultiModX:**

MultiModX shows that small schedule adjustments ($\pm 10\text{--}20$ minutes) can significantly improve air–rail connectivity. In the intra-Spain case study, total travel time was reduced by up to 20% and the number of connecting passengers increased by 5–7%, without negative

impacts on other services. Results show that timetable optimisation delivers its strongest benefits in environments with a high proportion of connecting itineraries and integrated air–rail hubs, such as major TEN-T airports. The cost impacts on the supply-side remain to be evaluated.

Schedule definition and ticketing remain primarily commercial decisions by operators. Regulatory frameworks should therefore enable and incentivise coordination.

Recommendation	Impacts
<ul style="list-style-type: none"> ○ Require major airports and associated rail hubs to analyse inter-modal connectivity performance. ○ Enable operators to re-time services within predefined flexibility windows, subject to operational constraints. ○ Introduce monitoring of multimodal minimum connection times and define indicative targets at major hubs. 	<ul style="list-style-type: none"> ○ Improves accessibility and supports the modal shift to rail. ○ Expands airport catchment areas and regional connectivity. ○ Frees airport capacity by replacing short-haul flights with rail where feasible.
Alignment with the current regulatory framework	
<p>The Sustainable and Smart Mobility Strategy aims to double high-speed rail traffic by 2030 and triple it by 2050 (European Commission, 2020c). Effective timetable coordination relies on integrated ticketing and multimodal passenger rights (European Commission, 2023b), supported by digital mobility services and data integration initiatives.</p>	

4. Strengthen cross-modal disruption management and recovery

- **Rationale from MultiModX:**

MultiModX demonstrates that coordinated air–rail disruption management, in a centralised manner, significantly reduces the impact on passengers. Experimental results show reductions of:

- stranded passengers: –17%.
- average journey time: –20%.
- service delays: –50%.

Greater flexibility to rebook passengers across modes during disruptions further enhances resilience (reducing the number of stranded passengers significantly), even when disruptions occur in only one mode.

Results confirm that the indicators most positively impacted by coordinated multimodal disruption management are passenger-centric, including stranded passengers, replanned passengers and resilience. This provides an empirical foundation for transforming the concept

of an “equivalent journey alternative” from a voluntary operational practice into a legally guaranteed passenger right, independent of transport mode.

Recommendation	Impacts
<ul style="list-style-type: none"> ○ Strengthen cross-modal cooperation during disruptions. ○ Establish a Multimodal Crisis Coordination Protocol enabling: <ul style="list-style-type: none"> ▪ cross-carrier rebooking; ▪ air–rail alternative routing; ▪ joint capacity allocation; ▪ shared use of replacement services. ○ Promote real-time sharing of timetables and available capacity. ○ Enable passengers to access an “equivalent journey alternative” across modes where feasible. 	<ul style="list-style-type: none"> ○ Enhances system resilience and continuity in the event of disruptions. ○ Reduces the number of stranded passengers. ○ Increases passenger confidence and uptake of multimodal tickets as it reduces the risk of being stranded.
Alignment with the current regulatory framework	
<p>Multimodal disruption management is a priority identified in the Strategic Research and Innovation Agenda for the Digital European Sky. The vision is to develop and implement key metrics, processes and tools for system and journey resilience (disruption avoidance and management) (SESAR JU, 2020). This will also inform the definition of multimodal passenger right regulations (European Commission, 2023b).</p>	

5. Address capacity requirements for multimodal services

- **Rationale from MultiModX:**

Schedule optimisation and disruption recovery analyses highlight capacity constraints on key high-speed rail corridors. Insufficient rail capacity limits both timetable synchronisation and effective disruption recovery, as constrained networks reduce the availability of feasible rebooking and alternative routings during disruptions. Capacity misalignment, therefore, undermines not only planned multimodal connectivity but also the credibility of passenger protection and recovery strategies.

Recommendation	Impact
<ul style="list-style-type: none"> ○ Prioritise rail services that provide multimodal connectivity in terms of capacity and slot allocation. ○ Increase rail capacity on high-demand corridors critical for multimodal operations. ○ Incentivise services that ensure sufficient multimodal capacity. 	<ul style="list-style-type: none"> ○ Ensures the feasibility and reliability of modal-shift policies. ○ Strengthens the robustness of multimodal networks.
Alignment with the current regulatory framework	
<p>The revised TEN-T Regulation provides the infrastructure backbone for multimodal connectivity and guides investment priorities for cross-border corridors and multimodal nodes (European Parliament and Council, 2024b)</p>	

6. Introduce EU-level multimodal connectivity targets

- Rationale from MultiModX:

Schedule synchronisation reshapes catchment areas, strengthens regional connectivity and enhances the role of secondary airports.

Recommendation	Impact
<ul style="list-style-type: none"> ○ Define and monitor multimodal connectivity targets, such as: <ul style="list-style-type: none"> ▪ share of population within 120 minutes of a multimodal airport; ▪ number of OD pairs with optimised air–rail connections; ▪ quality and frequency of rail–airport connectivity 	<ul style="list-style-type: none"> ○ Provides measurable benchmarks for tracking progress. ○ Supports evidence-based monitoring of EU mobility objectives.
Alignment with the current regulatory framework	
<p>These targets align with the Strategic Research and Innovation Agenda for the Digital European Sky objective of developing door-to-door mobility intelligence and integrated performance cockpits (SESAR JU, 2020); and with the overall objectives of the Smart Mobility Strategy (European Commission, 2020b).</p>	

7. Support long-term research and cross-sector professional cooperation

- **Rationale from MultiModX:**

While analytical tools and data frameworks are mature, operational uptake is constrained by fragmented institutional cultures and limited mutual understanding between aviation and rail stakeholders. Sustained applied research and structured cooperation are essential to translate multimodal concepts into practice.

Recommendation	Impact
<ul style="list-style-type: none"> ○ Support continued investment in applied research and structured cooperation, including: <ul style="list-style-type: none"> ▪ joint training programmes; ▪ knowledge-exchange initiatives; ▪ operational pilot projects. 	<ul style="list-style-type: none"> ○ Accelerates deployment of multimodal Solutions. ○ Strengthens trust and alignment between air and rail sectors. ○ Sustains Europe's innovation capacity.
Alignment with the current regulatory framework:	
<p>This recommendation complements existing EU research frameworks under SESAR, Europe's Rail and DG MOVE by strengthening long-term, operationally anchored cooperation.</p>	

7 Conclusions

MultiModX confirms that air–rail multimodal integration is not a theoretical aspiration but an operationally viable and high-impact strategy. Passenger-centric performance evaluation, coordinated schedule planning, and joint disruption management together form a robust foundation for a resilient and sustainable European mobility system.

The key question is no longer whether Europe should pursue multimodality, but how quickly it can translate ambition into enforceable, operational conditions that make multimodal journeys reliable and attractive for passengers. The MultiModX Solutions offer not only evidence but also a practical roadmap for delivering a resilient, efficient, and truly passenger-centric mobility network across Europe.

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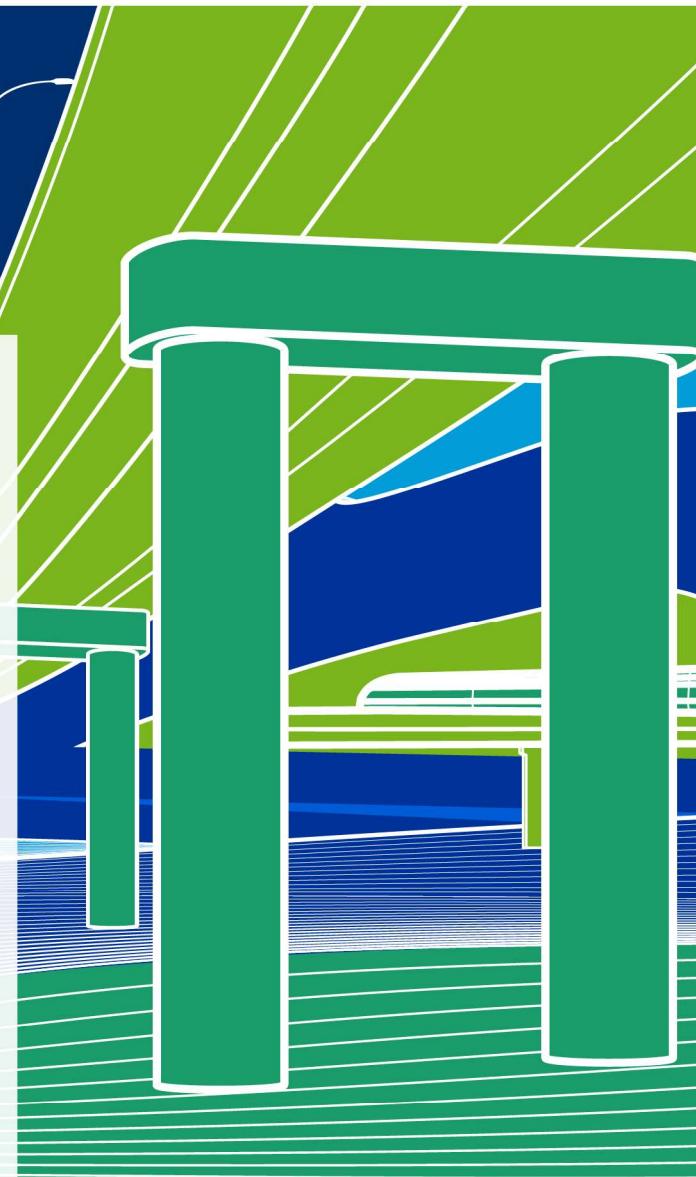
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MultiModX official website:
<https://multimodx.eu/>

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