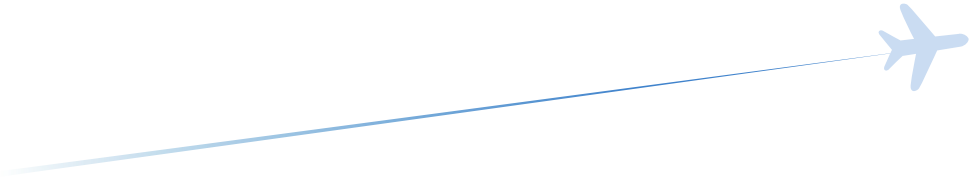

D5.1 Definition of use cases

Deliverable ID:	**5.1**
Dissemination Level:	**PU**
Project Acronym:	**Modus**
Grant:	**891166**
Call:	**H2020-SESAR-2019-2** **SESAR-ER4-10-2019**
Topic:	**ATM Role in Intermodal Transport**
Consortium Coordinator:	**BHL**
Deliverable Lead:	**BHL**
Edition date:	**23 September 2021**
Edition:	**00.01.10**
Template Edition:	**02.00.02**

Founding Members
EUROPEAN UNION
EUROCONTROL

SESAR
JOINT UNDERTAKING

Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
Annika Paul / BHL	Modus coordinator	25/06/2021
Ulrike Schmalz / BHL	Modus consortium partner	25/06/2021
Andrew Cook / UoW	Modus consortium partner	25/06/2021
Gerald Gurtner / UoW	Modus consortium partner	25/06/2021
Antonio Correas / SKY	Modus consortium partner	25/06/2021
Nadine Pilon / ECTL	Modus consortium partner	25/06/2021
Fabrice Setta / UIC	Modus consortium partner	25/06/2021

Reviewers internal to the project

Name/Beneficiary	Position/Title	Date
Annika Paul / BHL	Modus coordinator	29/06/2021
Andrew Cook / UoW	Modus consortium partner	29/06/2021
Nadine Pilon / ECTL	Modus consortium partner	29/06/2021
Kay Plötner / BHL	Modus consortium partner	29/06/2021

Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date
Annika Paul / BHL	Modus coordinator	30/06/2021

Rejected By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date

Document History

Edition	Date	Status	Author	Justification
00.01.00	30 June 2021	Submitted	Modus consortium	Submitted for review by the SJU
00.01.10	23 September	Submitted	Modus consortium	Revised version addressing comments and feedback by the SJU

Copyright Statement

Modus

MODELLING AND ASSESSING THE ROLE OF AIR TRANSPORT IN AN INTEGRATED, INTERMODAL TRANSPORT SYSTEM

This deliverable is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No. 891166 under European Union's Horizon 2020 research and innovation programme.

Abstract

Within the Modus project, one of the main goals is to analyse how the performance of the overall European transport system can be optimized by considering the entire door-to-door journey holistically and considering air transport within an integrated, multimodal approach. In this regard, it is essential to identify the main barriers in achieving European (air) mobility goals and how air transport can evolve by efficiently connecting information and services with other transport modes to achieve a seamless journey experience for passengers. For this particular purposes, a set of use cases is identified and defined within this deliverable D5.1.

As a first step, relevant mobility strategies and goals towards an integrated, intermodal transport sector are reviewed and high-level topic areas identified, including *Ticketing*, *Interoperability and data*, *Connectivity*, *Intermodal alignment* and *Environmental impact*. Based on these, four Modus use cases are defined in a second step, which represent key aspects of the door-to-door journey in Europe, ranging from the analysis and discussion of the impact of *Flexible ticketing* on re-accommodating passengers in case of disruptions, to the potential policy-incentivised replacement of *Short-haul travel* (air) on selected routes within Europe. In addition to this, the role of *Connectivity and seamless travel* is considered to be essential as well as the degree of *Personalised travel*.

The specification of these use cases enables a detailed discussion with experts from various transport domains as to how these use cases enable an integrated, multimodal transport system, and to assess the impact on available capacities or travel times across the different Modus scenarios (which are defined in deliverable D3.2) in Modus WP5.

Table of Contents

List of Tables

List of Figures

Abbreviations

ACARE	Advisory Council for Aviation Research and Innovation in Europe
D2D	Door to door
ERRAC	European Rail Research Advisory Council
G2G	Gate to gate
KPI	Key performance indicator
MaaS	Mobility as a Service
R&I	Research and innovation
SRIA	Strategic Research and Innovation Agenda
SRRIA	Strategic Rail Research and Innovation Agenda
STRIA	Strategic Transport Research and Innovation Agenda
TEN-T	Trans-European Transport Network
TRIMIS	Transport Research and Innovation Monitoring and Information System

1 Introduction

1.1 Objectives of Modus

In the context of increasing environmental awareness, regulatory measures, capacity shortages across different modes, or the need for a more seamless and hassle-free passenger journey, the future evolution of European travellers' demand for mobility is still unknown, as well as its potential impacts on the European transport system. The optimisation and alignment of multimodal transport is therefore of utmost importance for the overall performance of the (future) European transport system, especially in regard to providing a seamless and hassle-free journey for passengers as well as mitigating (air) capacity constraints. In line with this, the high-level objective of Modus is to analyse how the performance of the overall European transport system can be optimised by considering the entire door-to-door journey holistically and considering air transport within an integrated, multimodal approach. This is pursued by:

- Identifying and assessing (future) drivers for passenger demand and supply of mobility, and how these affect passenger mode choice,
- Applying and further advancing existing models to determine the demand allocation across different transport modes, especially air and rail, and the effects on the overall capacity of these modes, and
- Developing and assessing performance and connectivity indicators which facilitate the identification of gaps and barriers in meeting high-level European (air) transport goals and solutions to gaps can be addressed.

Modus wants to explore how air transport and traffic management (ATM) can better contribute to improve passengers' multimodal journeys and how this translates into an enhanced performance of the overall transport system. A multimodal journey from door to door comprises different steps. The focus of Modus within this door-to-door travel chain is on multimodal transport that includes as a main segment either rail or air transport or both in Europe. Other transport modes such as public transport are considered as access and egress modes (feeder traffic) to either the airport or the rail station.

1.2 Objectives of this deliverable

In line with these overall objectives, it is essential to identify the main barriers in achieving European (air) mobility goals and how air transport can evolve by efficiently connecting information and services with other transport modes to achieve a seamless journey experience for passengers.

For this particular purposes, a set of use cases is identified and defined within this Deliverable D5.1. They reflect a particular aspect of the transport system or the passenger journey, and are relevant to meet the goals and ambitions outlined in high-level strategic agendas from various transport domains and aspects discussed during the first Modus workshop, as well as the factors outlined in the Modus deliverable on future supply of and demand for mobility [1]. Use cases may relate to specific processes, such as passenger flows and dwell times at airports, transfer between modes, or the integration of ticketing options across various transport modes.

These use cases are developed in parallel to the scenarios in Modus deliverable D3.2 and are later assessed across these scenarios, by applying the developed key performance indicators (KPIs) in D3.2, to compare the respective impact across scenarios in WP5 (Tasks 5.2 and 5.3).

1.3 Deliverable structure and content

The following deliverable starts with a definition of the scope of use cases as they are applied within the context of the Modus project and how these are linked to the scenarios and key performance indicators outlined in the Modus Deliverable D3.2 (Section 2). In order to identify relevant high-level strategic objectives as a basis for the use cases, Section 3 outlines and details a multitude of strategic agendas from different European transport domains. Based on this, Section 4 defines the Modus use cases which will be investigated in the further course of the project. Section 5 summarises the deliverable and outlines the next steps.

2 Definition and scope of use cases

In general, a use case is defined as processes with a subset of actors performing specific actions in a well-defined environment. In Modus, a use case illustrates a representative example which relates to a specific process or element of the multimodal travel chain to achieve strategic goals for the European transport system. These strategic goals are derived from high-level political agendas from different transport domains (Section 3), and translated into achievable, measurable objectives within the Modus use cases in Section 4.

These use cases describe a range of multimodal capabilities which serve as the basis to measure and assess their contribution towards achieving the outlined strategic goals, this includes the stakeholders, key performance indicators and the scope of a use case. The use cases will be assessed and modelled within the scenarios that are being defined in Modus Deliverable D3.2, use cases thus help to understand micro scenarios or certain aspects in a scenario. The assessment will be done either qualitatively, by means of consulting various transport experts in workshops and/ or interviews, or quantitatively, measured through KPIs defined in the Modus deliverable D3.2.

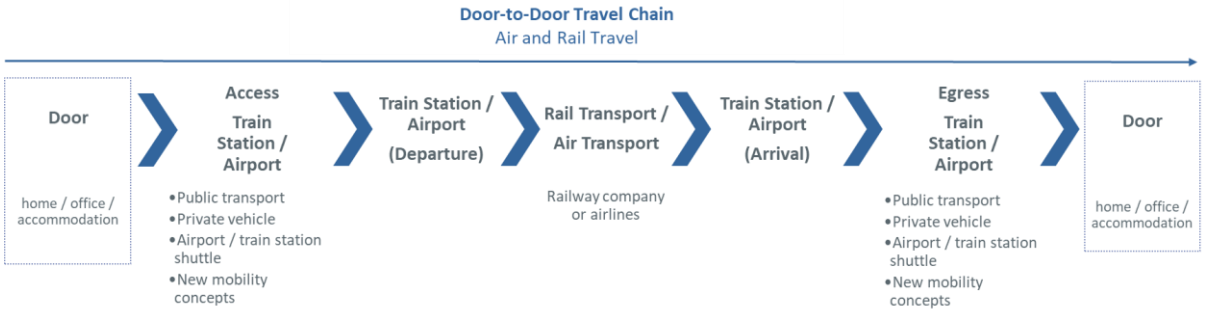

Figure 1: Modus multimodal door-to-door scope

Source: adapted from [2]

The use cases presented in this deliverable are passenger-focused and shall support multimodal travel processes along the passenger journey. A specific use case can be concerned with the entire D2D journey for rail and air travel or parts of the journey (e.g. the booking process, disruptions, need for assistance, or transfer between modes). In fact, use cases can already be applicable pre-journey, such as towards supporting the booking process and preparation phase of various passenger types. For clarification purposes, the concept of the D2D travel chain applied here is illustrated in Figure 1. From the users' perspective, various pain points can occur along this travel chain, such as long travel times, long dwell times, disruptions, and limited ticket integration. Use cases will be provided to tackle some of those pain points.

3 High-level mobility goals

The following multimodal mobility strategies and key articles (Table 1) as well as the Modus overall objectives have been consulted to define feasible use cases in Section 4, which are later on assessed either qualitatively or quantitatively in Tasks 5.3 and 5.2 (WP5, D5.2) of the Modus project.

The goals and objectives outlined within these strategies are consolidated in terms of their relevance for the Modus objectives to analyse how the performance of the overall transport system can be optimised by considering the entire door-to-door journey holistically and considering air transport within an integrated, multimodal approach.

Table 1: Overview European mobility strategies

Author	Year	Title	Short description
European Commission, [3]	2020	Sustainable and Smart Mobility Strategy	This strategy lays the foundation for how the EU transport system can achieve its green and digital transformation and become more resilient to future crises. As outlined in the European Green Deal, the result will be a 90% cut in emissions by 2050, delivered by a smart, competitive, safe, accessible and affordable transport system.
NLR and SEO, [4]	2020	Destination 2050	Destination2050 outlines a possible route toward net zero European aviation by the combination of four key measurements.
Ritchie, H., [5]	2020	Cars, planes, trains: where do transport CO_2 emissions come from?	This article provides an overview and discussion of emissions across transport modes.
European Commission, [6]	2019	The European Green Deal	The European Green Deal provides an action plan to boost the efficient use of resources by moving to a clean, circular economy, to restore biodiversity and cut pollution. The plan outlines investments needed and financing tools available. It explains how to ensure a just and inclusive transition.
European Commission, [7]	2017	Strategic Transport Research and Innovation Agenda (STRIA)	STRIA is the EU's Strategic Transport Research and Innovation Agenda. It sets out the areas where the EU needs to act in concertation with EU countries and stakeholders to radically change transport.
ACARE, [8]	2017	Strategic Research and Innovation Agenda	The Strategic Research and Innovation Agenda (SRIA) provides the strategic roadmap for aviation research, development and innovation developed by ACARE (Advisory Council for Aviation Research and Innovation in Europe) that accounts for both evolutionary and revolutionary technology.

Author	Year	Title	Short description
ERRAC, [9]	2014	Strategic Rail Research and Innovation Agenda	This Strategic Rail Research and Innovation Agenda (SRRIA) is well placed to guide and inspire future research and innovation over the coming decades. Through this SRRIA, ERRAC reaffirms Europe's need to offer a well-balanced, business-led and strong programme of research and innovation for the railway system over the next decades.
SESAR Joint Undertaking, [10]	2020	Strategic Research and Innovation Agenda – Digital European Sky	Complementing the European ATM Master Plan 2020 and the High-Level Partnership Proposal, this Strategic Research and Innovation Agenda (SRIA) details the research and innovation roadmaps to achieve the Digital European Sky, matching the ambitions of the "European Green Deal" and the "Europe fit for the digital age" initiative.
Shift2Rail, [11]	2019	Multi-Annual Action Plan	The S2R Master Plan provides a high-level view of what needs to be done; it explains why and by when. It sets the framework for the research and innovation (R&I) activities to be performed as part of and beyond the S2R Programme and the deployment activities to be carried out by all operational stakeholders, coordinated to achieve a Single European Rail Area.
Gkoumas, K. et al., [12]	2021	Rail transport research and innovation in Europe	This report provides a comprehensive analysis of research and innovation initiatives in Europe in this field. The assessment follows a structured methodology developed by the European Commission's Transport Research and Information Monitoring and Information System (TRIMIS). The report critically addresses research by thematic area and technology, highlighting recent developments and future needs. It also provides insight from the academia and the private sector by means of focused scientific literature and patent analysis.
European Commission, [13]	2011	Flightpath 2050	This document outlines the vision of the European Union for the aviation sector until 2050.
Modus project, [1]	2021	Modal choice analysis and expert assessment (Deliverable D3.1)	The Modus multimodality workshop was aimed to engage experts from various transport domains in a discussion on the enablers for a multimodal transport system, focusing on infrastructure needs, business models and passenger expectations of the future.

Author	Year	Title	Short description
EUROCONTROL Aviation Sustainability Unit, [14]	2021	Think Paper #11 - Plane and train: Getting the balance right	The paper reviews the latest literature comparing air and rail sustainability, assesses whether shifting from air to rail across Europe is a realistic option, and identifies areas where air and rail could be complementary, rather than mutually exclusive.
EEA, [15]	2020	Transport and environment report 2020 – Train or plane?	The report assesses the value of travel by train and plane. Rail travel is the best and most sensible mode of travel, apart from walking or cycling. Aviation's emission impacts are much higher on a passenger-kilometre basis. But flying is not necessarily the most harmful choice. Travel by a petrol or diesel-powered car, especially if traveling alone, can be more harmful.
European Commission, [16]	2020	TEN-T Review	The Trans-European Transport Network (TEN-T) policy supports and symbolises connectivity and accessibility for all regions of the Union. Through several revisions, the policy has coped with growing transport demand, geo-political developments (several EU enlargements) and evolving transport policy challenges (e.g. liberalisation, standardisation, technological innovation).
European Commission, [17]	2021	European Commission welcomes adoption of new rail passenger rights	The new rail passenger rights framework follows a 2017 Commission proposal and will apply as of 6 June 2023. It includes a new obligation for carriers qualifying as a 'sole undertaking' to offer their international, long-distance domestic and regional rail services as a through-ticket.
Goulding, L. and M. Morrell, [18]	2019	Future of Rail 2050	The Future of Rail 2050 takes a user's perspective and explores how rail travel might change for passengers and freight, looking at the following questions: (1) What are the megatrends that will influence the way people live, work, travel and consume information in the future? (2) How will future train infrastructure and systems cope with the rising demand for passenger and freight capacity? (3) How will rail fare in a world experiencing an increase in the frequency and intensity of extreme weather events?
ERTRAC, [19]	2017	Vision 2050 "Future Road Transport 2050"	Outlines a vision of future urban transport.
SLOCAT, [20]	2021	SLOCAT Transport and Climate Change Global	The SLOCAT Transport and Climate Change Global Status Report – 2nd edition tells the

Author	Year	Title	Short description
		Status Report – 2nd edition	global and regional stories of where we are and where we need to get to urgently on climate action in the transport sector. With contributions from more than 150 world-class experts and organisations, it is a one-stop shop for the latest available data, targets and developments on transport demand, emissions, policies and measures – showing that it is imperative to accelerate radical action for sustainable transport and climate in this time of unprecedented global change.

After the collection of the key strategies presented in Table 1, all documents have been reviewed by the Modus consortium in regard to their main goals and objectives. Furthermore, since there are manifold challenges and goals outlined in these strategies, the identification of and focus on specific topic areas is in line with both the Modus' objectives and the respective goals from European mobility strategies. The Modus objectives include:

- Consideration of the passenger door-to-door journey
- Air transport within an integrated, intermodal transport system
- Improvement of passengers' intermodal journey
- Analysis of the connection and dependence between ATM/ air transport and other transport mode
- Seamless journey experience for passengers
- Placing these objectives within the context of increasing environmental awareness, regulatory measures, capacity shortages across different modes

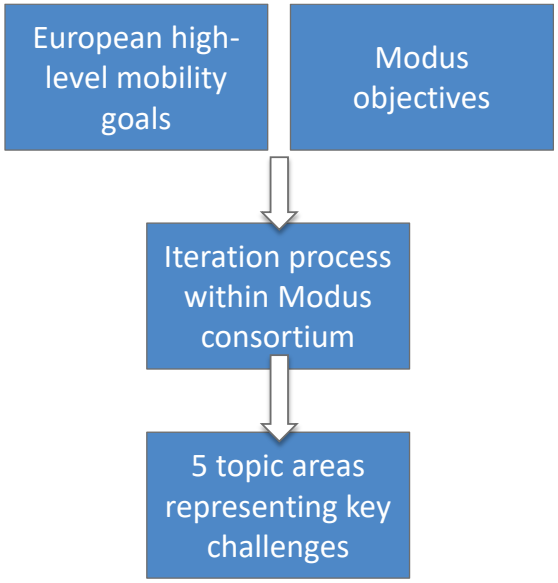

Figure 2: Approach to identify topic areas

Based on the high-level European strategies and the objectives of the Modus project, five distinct topic areas have been defined which build the basis for the establishment of Modus use cases (Figure 2). This has been accomplished within an internal iteration process and related discussions within the Modus consortium. The topic areas are as follows:

Ticketing: This topic area is important to consider in order to realise a seamless passenger door-to-door journey, which potentially includes multimodal connections across the different trip segments, by providing passengers with single, flexible and integrated ticketing.

Interoperability and data: This topic area emphasises the importance of data sharing, interoperability standards and reliability across transport modes and providers in order to facilitate a seamless door-to-door journey for passengers, and to foster a more efficient exchange and alignment across modes.

Connectivity: Improving the connectivity of European regions is high on the agenda of European transport strategies and part of the objectives of the Modus project; improving connectivity by improving intermodal journeys from door-to-door is therefore another topic area within Modus.

Intermodal alignment: One very important aspect to realise a multimodal European transport system is the establishment of a respective framework which sets out rules and regulations for cooperation, interoperability, or liabilities. Particular emphasis is placed on these aspects within this topic area.

Environmental impact: The decarbonisation of the transport sector is of highest priority and therefore included in this specific topic area. It focuses on the effects and impact of multimodal cooperation and competition on emissions reduction.

In Table 2 these topic areas and their matching with the strategies from Table 1 are outlined. For each topic area, specific aspects are highlighted which are discussed in various European transport strategies.

Table 2: Modus topic areas and European mobility strategies

Topic area and key words	Description (examples)	European mobility strategies (Table 1)
Ticketing		
Innovative and flexible ticketing	Seamless multimodal passenger transport will be facilitated by integrated electronic ticketing [3] Legal framework to support multimodal travel information, booking and ticketing services [3] Provide the customer with simple means such as a single ticket for an entire journey [8]	[3] [8]
Single / integrated ticketing across modes	Delivery of tailored, on demand integrated end-to-end mobility solutions [18] Fully multimodal trip planning, pricing, payment [19]	[3] [8] [7] [1] [18] [19]
Booking and ticketing (tools)	Offering one ticket for the multimodal trip, enabled by the application of relevant tools and services [1]	[1]
Interoperability and data		
(Real time) data availability	Provision of real-time data for the passengers and transport providers in order to plan and conduct a seamless journey, and address potential disruptions in time and facilitate journey re-planning.	[3] [10] [17]
Information/ data sharing, multimodal information system	Collaboration between different modes of transport, a detailed analysis of existing data and processes for their integration, and the specification of needs for additional data collection and analysis [10] International standards for data exchange [19] Real time, user-friendly, accessible and accurate information would improve passenger experience before and during the trip. Transfer time, development of intermodal hubs between modes of transport and information in case of disruptions are some key elements on the subject [1] By 2020, establish the framework for a European multimodal transport information, management and payment system [10]	[7][1] [19] [10] [9] [11]
Collaborative processing across modes	Collaborative mechanisms to enforce mobility plans under disruptive events [8] Innovative, collaborative decision-making, built upon total node (airport) management is required to create seamless passenger and cargo concepts, technologies and procedures [8] Optimisation of airport infrastructure use through advanced collaborative operations and planning services [10] Enable more collaborative decision-making between stakeholders, thus improving predictability and the network performance as a whole [10]	[8][1] [10]

Topic area and key words	Description (examples)	European mobility strategies (Table 1)
Provision of travel process management, travel management tools	Travel information that is unbiased, robust, relevant and complete must be available both before and during the journey [8] Integrated, customer-preference based door-to-door journey planning, booking, ticketing and payment [8]	[8]
Operational reliability	Significant improvements in operational reliability, the cost of rail travel and appreciation of the security of the railway system contribute to the overall attractiveness of the system [9] The operational reliability of trains benefits from targeted technical development, so there is less travel disruption, passengers arrive at their destinations on time and the overall better service enhancing rail's attractiveness for passengers [9] Real-time information exchange giving stakeholders (including mobility providers) an increased knowledge of the entire multimodal journey will enhance the reliability of multimodal journey planning [10]	[10] [9]
Secured privacy for passengers	Focus on passenger data protection [19]	[19]
Connectivity		
Reduction of door-to-door (D2D) travel time	A customer-centric, integrated European transport system underpinned by common standards, innovative business models and smooth processes is essential for seamless, door-to-door journeys [8] 90% of travellers within Europe are able to complete their journey, door-to- door within 4 hours [8], [13] Reducing D2D travel time, seamless travel, travel costs, multimodal offers [1]	[8][1] [13]
Connection of remote regions	Mobility is available and affordable for all, that rural and remote regions are better connected, accessible for persons with reduced mobility and persons with disabilities [3] The comprehensive network should be a Europe-wide transport network ensuring the accessibility and connectivity of all regions in the Union, including the remote, insular and outermost regions [16]	[3] [14] [15] [16]
Intermodal transfer accessibility and efficiency	Efficient and barrier-free interchanges between transport modes [18] The rail system is accessible and attractive to all passengers, whatever their social category, age and life characteristics and their possible physical impairment including disabled persons and persons with temporal or permanent reduced mobility [9]	[8][7][1] [18] [9] [15]
Fair and accessible transport solutions	Providing access to mobility services for every European individuals [18] The rail system is accessible and attractive to all passengers, whatever their social category, age and life characteristics and their possible physical impairment including disabled persons and persons with temporal or permanent reduced mobility [9]	[18] [10] [17] [9] [11]

Topic area and key words	Description (examples)	European mobility strategies (Table 1)
	Passengers will have access to personalised mobility services from multimodal mobility providers [10]	
Intermodal alignment		
Regulation to ensure level playing field for service providers	Conducive framework for EU-wide, integrated, multimodal information, ticketing and payment services (overcoming insufficient availability and accessibility of data, sub-optimal cooperation between suppliers and vendors, the absence of digital tickets in some cases, inadequate payment system interoperability, and existence of different licencing and distribution agreements) [3] The integrated, intermodal transport system will not become a reality without overarching regulation setting the framework conditions for design, implementation and operation [8] The role of standardisation, regulation environment, ticketing [1] Provide robust governance, regulatory and standardisation frameworks to enable scaling and effective integration of smart mobility services as a public good [7]	[3][7][1] [10] [4] [8]
Development of multimodal hubs	Aviation ground nodes must evolve into intermodal hubs for easy transition between surface and air transport, this is essential if overall transport performance needs are to be met [8] The Trans-European Transport Network (TEN-T) Regulation — Regulation (EU) No 1315/2013 — stipulates that until 2030 the most important core network components, including urban nodes and airports, are expected to have multimodal links, as long as they are economically viable, environmentally sustainable and feasible [15] Develop intermodal hubs in cities [7]	[8][7] [11] [15] [12]
Airport and rail station access and egress	Airport access must be efficient with frequent, comfortable and stress-free transport options available [8] Improved aviation ground node design & ground node landside access [8] As fundamental interfaces within the transport system, stations and terminals are designed to meet the needs of the future customer and are the cornerstone for the provision of quality, accessible and reliable rail services and sector competitiveness [9]	[8][10] [9]
Mobility as a Service	Demand for new and innovative solutions, with various transport services being integrated into a service accessible on demand, following the Mobility as a Service (MaaS) concept [3] Become the backbone of current and future mobility concepts (e.g. MaaS) and on-demand future logistics [11] Customer demand-driven services lead the railway to provide excellent service within the overall mobility chain. Connections between rail and the other modes are seamless, making mode interchange as simple and as efficient as possible. Information is permanently available to	[3] [11]

Topic area and key words	Description (examples)	European mobility strategies (Table 1)
	make travel safe and efficient along the travel chain, including at stations. All customers and potential customers are connected to mobility services [11]	
Passenger-centric infrastructure	Design a passenger-centric infrastructure along the entire transport system [1]	[1]
Environmental impact		
Reduction of CO_2 emissions	Energy efficiency, decarbonisation and air quality [19] Reduce transport's reliance on fossil fuels without delay and in synergy with zero pollution efforts [3] Incentives for more sustainable choices: carbon pricing, taxation, and infrastructure charging, complemented by improved information to users [3] CO_2 emissions per passenger kilometre need to be reduced by 75%, NO_x by 90% and perceived noise by 65% all relative to the year 2000 [8], [13] Increase energy savings towards minimising fossil energy utilisation [7] Net zero CO_2 emissions from all flights within and departing from the EU can be achieved by 2050 through joint, coordinated and decisive industry and government efforts. The European aviation industry is committed to reaching this target and contribute to the goals set in the European Green Deal and the Paris Agreement [4]	[3][1][7] [19] [10] [11] [13] [14] [15] [4] [12] [5] [6] [20] [8]
Transparency across transport modes	Internalisation of external costs (implementing the 'polluter pays' and 'user pays' principles, carbon pricing and infrastructure charging mechanism) [3]	[3] [15] [20]

Following, Table 3 outlines how the overall objectives of the Modus project are represented across these five topic areas.

Table 3: Matching Modus' objectives and topic areas

	Topic areas				
Modus objectives	**Ticketing**	**Interoperability and data**	**Connectivity**	**Intermodal alignment**	**Environmental impact**
Consideration of the passenger door-to-door journey	x	x	x	x	
Air transport within an integrated, intermodal transport system	x	x		x	x
Improvement of passengers' intermodal journey	x	x	x	x	
Analysis of the connection and dependence between ATM/ air transport and other transport mode		x		x	
Seamless journey experience for passengers	x	x		x	
Placing these objectives within the context of increasing environmental awareness, regulatory measures, capacity shortages across different modes				x	x

The identified topic areas in the table above are translated into Modus use cases in the following Section 4.

4 Modus use cases

4.1 Introduction

Based on the analysis of the high-level strategic agendas, Modus objectives and the identified topic areas relevant for Modus (Section 3), this section now focuses on the establishment and definition of use cases for further assessment in the Modus project.

The Modus use cases will be subject to qualitative and/ or quantitative assessment in the further course of the project. The qualitative assessment will include the consultation of various transport experts in workshops and/ or interviews in order to discuss the potential impact of a use case on the future performance of the European transport system (Task 5.3 in WP5). The quantitative assessment focuses on the evaluation of use cases across the different Modus scenarios defined in Deliverable D3.2, and by applying respective key performance indicators. Hence, some of the outlined use cases can be applied in the models developed in WP4 of the Modus project (Task 5.2 in WP5), such as *Flexible ticketing*, whereas other use cases, such as *Personalised travel*, provide a valuable application to be discussed and evaluated during further Modus workshops or by consulting transport experts (from the Modus Industry Board).

First, in order to obtain a comprehensive and manageable set of use cases for the further analysis in the Modus project, internal collaboration and discussion in the consortium led to the establishment of four different use cases: (1) *Flexible ticketing*, (2) *Personalised travel*, (3) *Connectivity and seamless travel*, and (4) *Short-haul travel*, which are further elaborated below.

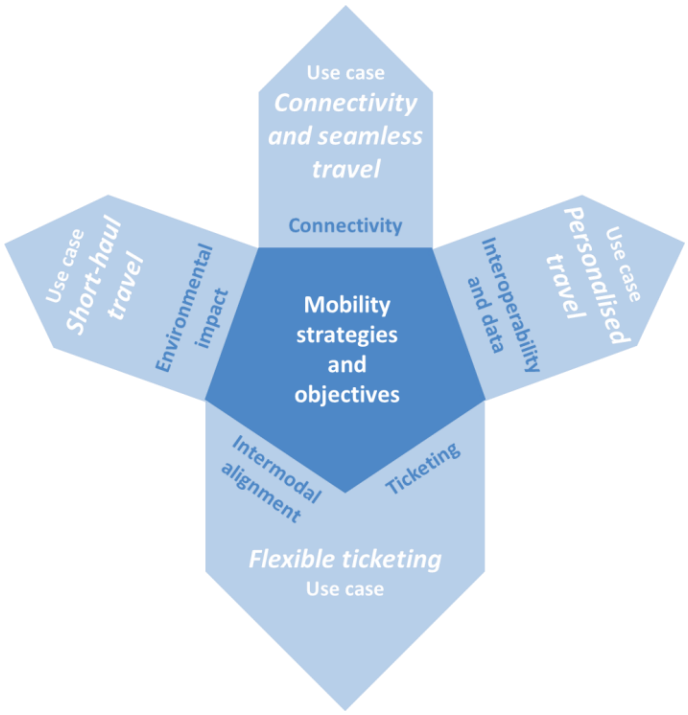

Figure 3: Modus topic areas and use cases

Second, use cases are required to represent the different topic areas and hence the Modus objectives as well as European mobility strategies. Figure 3 shows the topic areas and the corresponding use case. Each use case hence represents a particular development or goal from a specific topic area. The selected goals and developments, and thus use cases, have been carefully identified and discussed within the consortium in order to depict a shift towards a seamless, connected, multimodal transport system with a focus on its environmental impact[1].

In line with these priorities, each use case is described according to the following categories and specifications:

1. Name of the use case: This category depicts the main topic of the use case.
2. Description and application in the quantitative/ qualitative assessment: This category gives further insight into the objective and scope of the use case. It provides an initial specification of how the use case will be assessed quantitatively and/or qualitatively.
3. Topic area: This specification relates to the different topic areas relevant for Modus in Section 3.
4. Example of (an) indicator(s) to reflect topic area's goal(s): This category outlines a range of example indicators which may be applied in order to measure the impact of a particular use case across scenarios.
5. Involved stakeholders: This specification outlines those stakeholders that are affected by this use case. The stakeholder categories are defined in Table 4.

[1] The topic areas *Intermodal alignment* and *Ticketing* have been combined within the use case *Flexible ticketing* since the provision of flexible ticketing for passengers combines the objectives of aligning different modes by better data sharing, data exchange platforms, or collaborative processing and management (see Table 2), which are essential for a single ticketing approach across modes and the flexibility for passengers to switch between modes in case of disruptions, for example.

Table 4: Definition of stakeholder categories

Stakeholder category	Definition
Traveller(s)	A person or group travelling from A to B, either via train or plane.
Access & egress modes	These transport modes cover the first and last mile of the intermodal journey, for instance to access the airport and reach the final destination. Examples are buses, undergrounds, taxi services or other novel mobility concepts.
Rail stations & airports	Multimodal transport infrastructure that allows travellers to transit, take connection flights and trains or connecting transport to the final destination (access and egress modes).
Operators	These are stakeholders offering mobility services along the entire travel chain, such as airlines, public transport providers, airports or train station shuttle operators or providers of novel mobility concepts.
Distributors	These are third parties that consolidate schedules and fares and provide one-stop-shops for travellers for searching and booking itineraries.
Digital travel platforms and assistants	A digital travel companion that shall support the traveller pre-, during-, and post journey.
Policy makers	Policy makers define the regulations and frameworks for the entire European mobility system, both on national and European level. Examples are data protection rules, passenger rights or environmental requirements.

4.2 Flexible ticketing

In the identified topic area *Ticketing* the different mobility strategies highlight and propose aspects such as moving towards a more flexible, innovative and integrated ticketing across different transport modes. Travellers should also be eligible to re-schedule their journey in case of disruptions, for example, using the same ticket and re-book between rail and air. In close alignment with the first topic area is the one concerning *Intermodal alignment*. When offering flexible tickets to passengers which allow them to re-schedule their journey, one requirement is the availability of different transport modes along a passenger journey as well as in a modal hub, for example, which allows passengers to easily transition between different modes of transport. In line with these two topic areas and the respective goals, the first use case focuses on *Flexible Ticketing*, and is further described according to the pre-defined specifications.

Flexible ticketing

Description and application in the quantitative/ qualitative assessment:

Passengers shall be re-booked between air and rail during disruption, subject to capacity constraints;

Potentially introducing some type of prioritisation based e.g. on ticket type and final destination;

Consideration of a specific transport hub perspective, how many different transport modes can be accessed;

Flexible ticketing will be introduced to selected scenarios from D3.2 and assessed in WP5.

Stakeholders

- Travellers
- Access & egress modes
- Rail stations & airports
- Operators
- Distributors (to consolidate operators and act as price aggregators)

Topic area: Ticketing | Intermodal alignment

Indicators (examples)

- Number of re-accommodated (re-booked) travellers
- Passenger journey times
- Delays at various legs of the journey, all during disruption

Figure 4: Use case *Flexible ticketing*

4.3 Personalised travel

The topic area *Interoperability and data* contains a variety of goals and objectives which are considered to be essential in the future European transport system, such as the availability of real-time data across transport modes, or the collaboration between transport modes in sharing data and aligning operations. In order to translate these objectives into a measurable use case, this area is represented by the implementation of *Personalised travel*, which requires the collaboration of transport modes in terms of data sharing and focuses on providing travellers with individualised information for their journey as well as real-time updates. Personalised travel services and information can be offered via a digital travel assistant, for example, as theoretically discussed in the paper by Höser and Schmalz [21], and as developed as a first prototype in the DORA project [22], or in the PASSME application, which constitutes a trial use case for Amsterdam Schiphol airport. The latter project designed a personalised device and smartphone application to provide an individual experience to travellers [23][2]. In order for these applications to provide real-time information and individualised services along the travel chain a high degree of cooperation between different transport operators and service providers is required [24], as outlined in this Modus use case, which may be facilitated by data infrastructure and frameworks such as Gaia-X [25].

[2] Although concepts and prototypes already exist, many challenges have to be tackled before a rollout within Europe. For instance, the protection of personal data needs to be ensured. Providers' digital infrastructure needs to be aligned. Personal travel assistants are discussed in the Modus project as they have the potential to tackle many pain points of multimodal travel and improve the journey experience. The use case is not meant to invent a new approach to personalised travel but rather to be applied across the different scenarios in order to evaluate the impact of such.

Personalised travel

Description and application in the quantitative/ qualitative assessment:

Digital travel platforms, applications and services allow a highly personalised and tailored D2D passenger journey according to passengers' personal preferences supported by a digital travel companion;

Personalisation: Ability to integrate personalised information to fulfil the needs of diverse users will increasingly demand personalisation throughout their travel chain [21];

Purchase of tickets and services: Enabling a payment process for purchasing mobility and other journey related services [21].

Topic area: Interoperability and data

Stakeholders

- Travellers
- Digital travel platforms and assistants
- Operators
- Distributors

Indicators (examples)

- Number of transport providers and service companies collaborating on a platform
- Number of functions and services offered to passengers along the journey

Figure 5: Use case *Personalised travel*

4.4 Connectivity and seamless travel

The topic area *Connectivity* includes the realisation of a seamless travel experience for travellers and the inclusion of different regions, urban and remote, into a well-connected European transport system. The mobility strategies postulate that a journey from door to door shall be attainable within a certain time, such as four hours as in the Flightpath 2050 [13], for example. In the current transport system however, the flying time from gate to gate (G2G), the time spent at the airport and to get to and/or from a destination (i.e. D2D time) often accrue to more than these envisaged four hours [26]. These aspects are represented in the use case *Connectivity and seamless travel* in which the travel time from door to door is considered. Since a main focus in the different mobility strategies outlined in Section 3 is placed on providing connectivity of remote regions, this particular use case will focus on longer journeys and those to more geographically remote regions. Furthermore, one of the main objectives of the Modus project is the multimodal availability of air-rail choices, the connectivity supplied by such air-high-speed-rail complementarity and how it might be used by passengers, this is also reflected in this particular use case.

Connectivity and seamless travel

Description and application in the quantitative/ qualitative assessment:

Passengers making longer journeys could be given priority during missed connections and/ or disruptions;

Example: A passenger in London making 3 connections to Lulea in Sweden may be given priority over a passenger going to Paris.

Seamless travel will be introduced to selected scenarios from D3.2 and assessed in WP5.

Topic area: Connectivity

Stakeholders

- Travellers
- Access & egress modes
- Operators
- Rail stations & airports

Indicators (examples)

- Number of passengers travelling on a connection
- (Average) travel time from door to door on selected city (airport) connections
- Reachable population (e.g. 4 hours, 7 hours 30 or 9 hours)
- Number of air/ rail mobility operators on a connection
- Connection options per day/ week

Figure 6: Use case *Connectivity and seamless travel*

4.5 Short-haul travel

Reducing the environmental footprint of the European transport sector is one of the main challenges in the years to come, and firmly established in all mobility strategies, as highlighted in the topic area *Environmental impact* (see Section 3). Next to technological innovations and the use of alternative fuel options, operational changes are considered to reduce emissions to a significant amount. One lever relating to this, which is currently being discussed in different European countries [14, 15, 27, 28], is the reduction and shift of certain short-haul flights to the high-speed rail network. In line with this, a specific use case is dedicated to *Short-haul travel* and comprises policy makers setting incentives that lead to the reduction of short-haul flights on specific distance segments or routes[3]. Within this use case, this includes the consideration of a potential ban of certain short-haul flights in order to discuss and assess how this would be enforced and implemented on particular connections, and the resulting impact.

[3] This Modus use case represent a reduced complexity application of current developments or measures which are being discussed in terms of the environmental impact of the transport sector. When comparing different transport modes there are other dimensions such as noise, land use, the impact on biodiversity, or required infrastructure construction which need to be taken into account holistically. In the case of the Modus use case, we would like to assess and discuss a particular aspect to gain an initial understanding of the impacts as well as highlight further research in this area.

Short-haul travel

Description and application in the quantitative/ qualitative assessment:

Policy incentives are set up in such way that short-haul flights are reduced or banned on routes with a feasible alternative connection, such as high-speed rail;

Passengers booking a journey are offered the transport mode with the least environmental impact (subject to a certain overall travel time benchmark and modal capacity considerations).

Stakeholders

- Policy makers
- Travellers
- Operators

Topic area: Environmental impact

Indicators (examples)

- CO_2 per passenger kilometre travelled (D2D)
- Total CO_2 emissions for D2D journey

Figure 7: Use case *Short-haul travel*

4.6 Outlook: Application across Modus scenarios

The use cases defined within this deliverable are to be discussed and assessed across the different scenarios (developed in Modus D3.2), in order to evaluate their impact in a future European transport system.

Depending on the level of air traffic volume in each scenario the use case *Short-haul travel* may have a very different impact on air transport or rail capacities, for example. Moving more short-haul flights to high-speed rail connections may lead to alleviation of congestion at major European hubs. By applying these use cases across the Modus scenarios with the application of defined KPIs, we are thus able to gain a better and detailed understanding of the impact of specific measures in the future transport sector.

Furthermore, the use case *Flexible ticketing* might be implemented in selected scenarios in order to investigate the impact in comparison to other scenarios. Considering the perspective of a particular modal hub, such as an airport or a railway station, the modelling of this use case provides insight into the degree of recovery or re-scheduling and rebooking which is possible and the effect on available capacities or travel times.

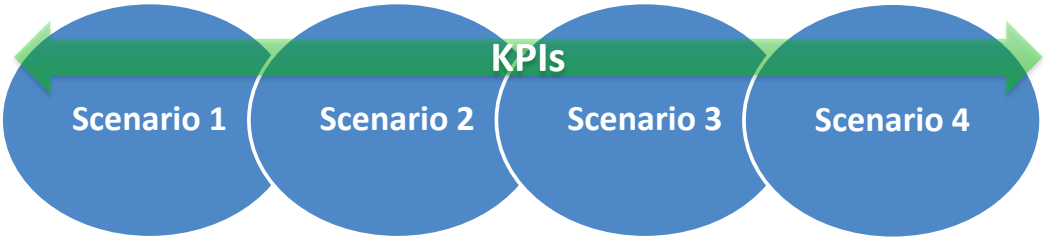

Figure 8: Scenarios and key performance indicators developed in Modus D3.2

5 Synthesis, discussion and next steps

This deliverable focused on the definition of use cases which reflect the objectives of high-level European mobility strategies as well as factors identified within the Modus project that are essential for the establishment of a multimodal European transport system, with a particular emphasis on the relationship between air and rail.

As a first step, relevant mobility strategies and goals towards an integrated, intermodal transport sector were reviewed and high-level topic areas identified, including *Ticketing*, *Interoperability and data*, *Connectivity*, *Intermodal alignment* and *Environmental impact*.

Based on these, four Modus use cases have been defined in a second step, which represent particular aspects of the identified topic areas and which are considered as having a significant impact on mobility processes, capacities and/ or journey times, for example.

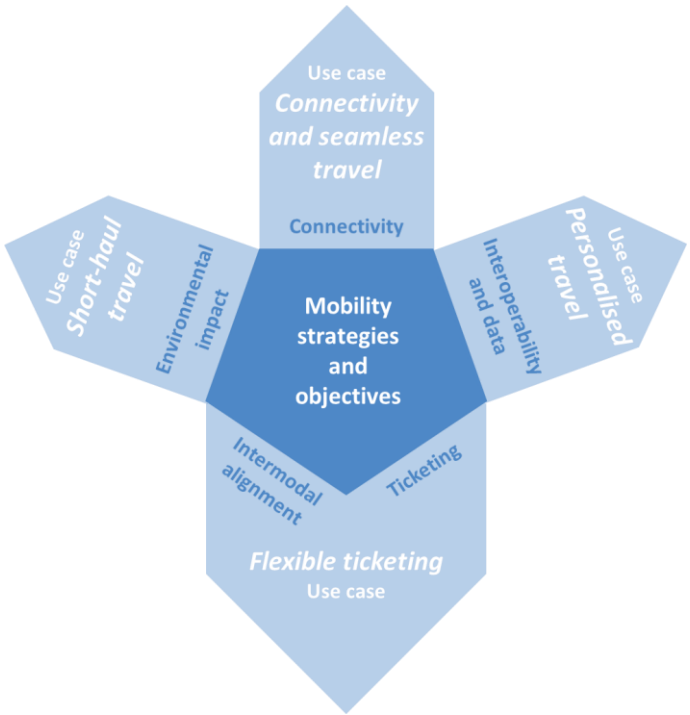

Figure 9: Mobility objectives and Modus use cases

These represent key aspects of the door-to-door journey in Europe, ranging from the analysis and discussion of the impact of *Flexible ticketing* on re-accommodating passengers in case of disruptions, to the potential policy-incentivised replacement of *Short-haul travel* on selected routes within Europe. In addition to this, the role of *Connectivity and seamless travel* is considered to be essential as well as the degree of *Personalised travel*, hence constituting the remaining two use cases (see Figure 9).

The specification of the use cases enables a detailed discussion with experts from various transport domains as to how these use cases enable an integrated, multimodal transport system, and to assess the impact on available capacities or travel times across the different Modus scenarios (which are defined in deliverable D3.2) in Modus WP5. Here, KPIs and use cases are applied across the different

scenarios in order to model the impact of a particular use case on certain aspects of the transport system.

6 References

[1] Modus project, “Modal choice analysis and expert assessment,” https://modus-project.eu/2021/06/25/modus-d3-1-modal-choice-analysis-and-expert-assessment-report-already-available-for-download/.

[2] Schmalz, U., Ringbeck, J., and Spinler, S., “Door-to-door air travel: Exploring trends in corporate reports using text classification models,” *Technological Forecasting and Social Change*; Vol. 170, No. 4, 2021, p. 120865. doi: 10.1016/j.techfore.2021.120865.

[3] European Commission, “Sustainable and Smart Mobility Strategy: Putting European transport on track for the future,” https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789.

[4] NLR, and SEO, “Destination 2050,” 2021, https://www.destination2050.eu/wp-content/uploads/2021/03/Destination2050_Report.pdf, [retrieved 11 March 2021].

[5] Ritchie, H., “Cars, planes, trains: where do transport CO2 emissions come from?,” https://www.weforum.org/agenda/2020/10/cars-planes-trains-aviation-co2-emissions-transport/.

[6] European Commission, “The European Green Deal,” https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en, [retrieved 27 August 2021].

[7] European Commission, “Strategic Transport Research and Innovation Agenda (STRIA): STRIA priority areas, roadmaps and related links.,” https://ec.europa.eu/info/research-and-innovation/research-area/transport/stria_en.

[8] ACARE, “Strategic Research and Innovation Agenda - 2017 update,” Advisory Council for Aviation Research and Innovation in Europe, 2017, https://www.acare4europe.org/sites/acare4europe.org/files/document/ACARE-Strategic-Research-Innovation-Volume-1.pdf.

[9] ERRAC, “Strategic Rail Research and Innovation Agenda: A step change in rail research and innovation,” https://errac.org/publications/strategic-rail-research-and-innovation-agenda/.

[10] SESAR Joint Undertaking, “Strategic Research and Innovation Agenda: Digital European Sky,” https://www.sesarju.eu/sites/default/files/documents/reports/SRIA%20Final.pdf.

[11] Shift2Rail, “Multi-Annual Action Plan,” https://shift2rail.org/publications/multi-annual-action-plan/.

[12] Gkoumas, K., Marques dos Santos, F., Stępniak, M., Ortega Hortelano, A., Grosso, M., Tsakalidis, A., and Pekár, F., *Rail transport research and innovation in Europe. An assessment based on the Transport Research and Innovation Monitoring and Information System (TRIMIS)*, Publications Office of the European Union, Luxembourg, 2021.

[13] European Commission, *Flightpath 2050. Europe's Vision for Aviation*, Publ. Off. of the Europ. Union, Luxembourg, 2011.

[14] EUROCONTROL Aviation Sustainability Unit, “Plane and train: Getting the balance right,” https://www.eurocontrol.int/sites/default/files/2021-06/eurocontrol-think-paper-11-plane-train.pdf.

[15] European Environment Agency, “Transport and environment report 2020: Train or plane?,” https://www.eea.europa.eu/publications/transport-and-environment-report-2020.

[16] European Commission, “Trans-European Transport Network (TEN-T) Review,” https://ec.europa.eu/transport/themes/infrastructure/ten-t/review_en .

[17] European Commission, “Passenger rights: European Commission welcomes adoption of new rail passenger rights,” https://ec.europa.eu/transport/themes/passengers/news/2021-04-29-new-rail-passenger-rights_en.

[18] Goulding, L., and Morrell, M., “Future of Rail 2050,” https://www.arup.com/perspectives/publications/research/section/future-of-rail-2050.

[19] European Road Transport Research Advisory Council (ERTRAC), “ERTRAC Vision: Future Road Transport 2050,” https://www.ertrac.org/uploads/images/1.%20ERTRAC%20Vision%202050_ERTRAC%202017.pdf.

[20] SLOCAT, “Transport and Climate Change Global Status Report,” https://tcc-gsr.com/.

[21] Höser, M., and Schmalz, U., “Supporting Door-to-Door Air Travel: Towards a Privacy Preserving Virtual Assistant for Passengers,” *(Manuscript submitted for publication)*, 2021.

[22] DORA, “Door to Door Information for Airports and Airlines,” 2018, https://cordis.europa.eu/project/id/635885.

[23] PASSME, “PASSME - Fast airports. Stress-free journeys.,” https://passme.eu/wp-content/uploads/2018/10/180701-PASSME-NAG-presentatie-2-juli.pdf.

[24] SYN+AIR project, “Synergies between transport modes and air transport: Data sharing and access to travelers' data as a facilitators of multimodality,” https://www.eurocontrol.int/event/art-workshop-passenger-centred-mobility.

[25] Gaia-X, “Gaia-X: A Federated Secure Data Infrastructure,” https://www.gaia-x.eu/.

[26] DATASET2050 project, “Mobility Assessment: Deliverable D5.1,” 2017.

[27] Loh, C., “France Moves Closer To Barring Short-Haul Domestic Flights,” *Simple Flying* [online], 12.04.2021, https://simpleflying.com/france-short-haul-domestic-ban-closer/.

[28] Martinez Garbuno, D., “Could Spain Follow France With A Domestic Flight Ban?,” *Simple Flying* [online], 20.05.2021, https://simpleflying.com/spain-domestic-flight-ban/.