D2.2 – Standardisation (STAND) - Initial

Deliverable ID:	**D2.2**
Project Acronym:	**SIGN-AIR**
Grant:	**101114845**
Call:	**HORIZON-SESAR-2022-DES-IR-01**
Topic:	**HORIZON-SESAR-2022-DES-IR-01-WA5-3**
Consortium Coordinator:	**Universitat Politècnica de Catalunya**
Edition date:	**29 August 2023**
Edition:	**00.01**
Status:	**Submitted**
Classification:	**PU**

Abstract

D2.2 "Standardisation (STAND) - Initial" is the first iteration of a series of reports aiming to capture the standardisation needs of the SIGN-AIR SESAR solution. This initial iteration of STAND provides all standardisation contextual information existing at the beginning of the development activities. D2.2 captures the overall status of the most widely available and used data standards per transportation mode.

Authoring & Approval

Author(s) of the document

Company Name	Date
AETHON	24/08/2023

Reviewed by

Company Name		Date
SPA	Ismini Stroumpou	25/08/2023
UPC	Josep Lluis Larriba Pey	25/08/2023

Approved for submission to the SESAR 3 JU by

Company Name	Date
SPA	29/08/2023
UPC	29/08/2023
UB-FTTE	31/08/2023
AETHON	31/08/2023
ENAC	31/08/2023
EPF	31/08/2023
CARNET	31/08/2023
TIMELEX	31/08/2023
ATM	31/08/2023
STA	31/08/2023
BLQ	31/08/2023
TPER	31/08/2023
AMTU	31/08/2023
FD	31/08/2023
HSP	31/08/2023

Rejected by

Company Name	Date

Document History

Edition	Date	Status	Company Author	Justification
00.00.01	17/7/2023	Draft	AETHON	First Draft
00.00.02	25/07/2023	Draft	STA, UB-FTTE, EPF	Contribution to Background
00.00.03	24/08/2023	Draft	AETHON	Incorporation of partners contribution and comments
00.00.04	25/08/2023	Draft	SPA & UPC	Review & Comments
00.00.05	28/08/2023	Draft	AETHON	Incorporation of Review Comments and Final Formatting
00.01.00	31/08/2023	Release	SPA	New document for review by the S3JU

Copyright Statement

SIGN-AIR

[IMPLEMENTED SYNERGIES, DATA SHARING CONTRACTS AND GOALS BETWEEN TRANSPORT MODES AND AIR TANSPORTATION]

SIGN-AIR

This document is part of a project that has received funding from the Connecting Europe Facility programme under grant agreement No 101114845 under CINEA.

Table of Contents

List of Tables

1 Executive summary

This document is the Standard Deliverable of the SIGN-AIR SESAR Solution dealing with the development and piloting of a new platform, the SIGN-AIR platform, for an orchestrated sharing of data in multimodal traveling. D2.2 "Standardisation (STAND) - Initial" is the first iteration of a series of reports aiming to capture the standardisation needs of the SIGN-AIR SESAR solution. The standardisation need documents provide information to support industrialisation activities and assist the entry into operations of the corresponding SESAR solution, namely the SIGN-AIR platform. The STAND documents in tandem will cover all standardisation contextual information existing at the beginning of the development activities but will also identify the needs for amendments of the existing standardisation documents to support the scope of the new SESAR solution.

The SIGN-AIR platform will provide the means for Transport Service Providers (TSPs) to register, reach Data Sharing Agreements and Smart Contracts with other TSPs and manage their contractual relationships. The SIGN-AIR platform will only manage the contractual aspects through the types of data offered by the TSPs. As an added value, the SIGN-AIR platform will provide a number of services to the stakeholders of multimodal travel through the analysis and exploitation of the contracts: (i) templates for contracts to simplify the legal management, (ii) electronic management and information provision about each specific contract, (iii) routing information for Travel Companions (TCs) with enriched information about the specific contracts for their traveller customers, and (iv) facilitation of single ticketing through the comprehensive understanding of the contracts and the data managed, among others.

For the SIGN-AIR platform to effectively leverage standardised data in its Monitoring Dashboard and as a means of communication with Travel Companions (TCs), it is imperative to achieve a profound understanding and technical examination of each pertinent data standard. This report endeavours to comprehensively evaluate the landscape of data standards within the realm of multimodal passenger scenarios and emphasis on IATA SSIM standardization, association of non-standardised to standardised data, and the harmonization of NeTEx/SIRI and IATA SSIM.

2 Introduction

2.1 Purpose of the document

In order to be able to successfully capture the current situation in the area of data standards of various multimodal passenger scenarios, one must first capture the overall status of the most widely available and used data standards in each mode of transportation. The successful completion of this task will lead to a clear understanding on how to proceed regarding the amendment of an existing data standard or the need for definition of a new data standard.

For SIGN-AIR to be able to utilize standardised data and use it in its Monitoring Dashboard as well as the medium of communication with the TCs, a clear understanding and technical examination for each of the data standards – European standards (EN), technical specifications (TS) or TR (technical reports) - must be reached. Followingly, a successful understanding of the data standards and management of those will provide a source input to the National Access Points (NAPs) whose purpose [1] is to provide a single interface through which transport-related data from various data providers are made accessible to the public. Datasets are accompanied by a standardized set of metadata in order to facilitate their exchange and reuse.

The most adopted set of data standards in the aviation industry regarding the exchange of airline time schedules is the IATA Standard Schedules Information Manual (SSIM). [2] It is the official set of standards, guiding the industry with recommended practices, messaging formats and data processing procedures that are to be used by all IATA member airlines and their business partners for the exchange of airline schedules, communication of airport coordination information and minimum connect time data. For that purpose, the project will develop a standardisation mechanism for IATA SSIM that would then be connected to the SIGN-AIR platform for data retrieval and sending. The IATA SSIM tool for standardisation will involve the creation of the UI (map where the user can insert the information) and the database components (conversion from SCR and other formats to a Relational Database Management System). Especially for the case of the IATA SSIM data standard further investigation has been conducting regarding the cost of accessing the documentation of the standard and other aspects as well.

Moreover, the tool to be created will be able to associate non-standardised to standardised data. This tool will be implemented in the SIGN-AIR platform when the user (TSP) registers information to create his data attributes Catalogue.

Furthermore, another task to research is the aspect of data harmonization. As it has already successfully been conducted by the Transmodel consortium[1] which has executed a study on harmonizing the industry standard and the EU - approved standard (NeTEx and GTFS) regarding public transport, the SIGN-AIR project aims to generate a study in the similar direction regarding NeTEx/SIRI and IATA SSIM harmonisation which will be possible after a successful mapping of all relevant data standards.

[1] https://netex-cen.eu/faq/how-does-netex-compare-with-gtfs/

Finally, it is important to mention that this deliverable is focusing on the data standardization and leaves a great part of the identification of standardization need(s) required for the deployment of the SIGN-AIR platform for its next version. The main reason is that the design and the architecture of the platform needs to be more advanced to allow us to be able to perform such type of standardising needs identification. The secondary reason is that the relation of the SIGN-AIR platform with the ATM system is not clear yet as SIGN-AIR platform is targeting multimodality and not only air transport.

2.2 Intended readership

This section outlines the specific audience for whom the insights and recommendations presented in this report are intended. The primary readership for this deliverable encompasses the European Air Traffic Management (ATM) community, prominently the European Air Traffic Management Master Plan (ATM MP) Stakeholder Consultation Group (EASCG). Additionally, this report holds relevance to other stakeholders, including the European Union's Single European Sky Coordination Group (EUSCG), and the European Standardization Coordination Group (ESCG). The collaborative input and consideration of these key stakeholders are pivotal in advancing SESAR's contributions to standardization activities, particularly in collaboration with organizations such as EUROCAE.

2.3 Background

The literature review presented in this chapter firstly identified and provided a complete summary of each of the available and mostly used data standards focusing on the region of Europe for each of the transport sectors that SIGN-AIR is involved. Following that, additional data standards are analysed similarly that are indirectly involved in a passenger trip. Finally, the last sub-chapter encapsulates the sense of data harmonization in terms of defining it, providing its goals, the benefits, several examples, and the overall progress in the area so far.

2.3.1 Overview of relevant standards

When attempting to harmonize commercial airline data standards, the starting point of the research should be an assessment of existing industry standards and best practices. This involves conducting a comprehensive review of relevant documentation, guidelines, and frameworks established by regulatory bodies, industry organizations, and standardization bodies. All the following modes of transport which were found to be part of a multi-legged trip are therefore proved necessary to analyse. The main categories of passenger transport can be broadly classified into the following categories: Public, Air, Rail, Road, Maritime transport as well as micro mobility.

2.3.1.1 Public Transit

Public transit specifically refers to transportation services that are publicly available and accessible to the general population. Public transport (also known as public transportation, public transit, mass transit, or simply transit) is defined as a system of transport for passengers by group travel systems available for use by the general public which unlike private transport, is typically managed on a schedule, operated on established routes, and that charge a posted fee for each trip. There is no rigid definition of which kinds of transport are included, and air travel is often not thought of when discussing public transport[2]. Planes count as public transport if they are operated by an airline that carries fare-paying passengers.[3] It includes modes such as buses, trains, trams, subways, and light rail systems that operate on fixed routes and schedules. Public transit is typically managed and operated by government agencies or authorized entities with the goal of providing affordable and efficient transportation options for the public.

2.3.1.1.1 Transmodel - Public Transport Reference Data Model

Name	Transmodel - Public Transport Reference Data Model
Official Website	https://www.transmodel-cen.eu/
Managing Organisation	CEN-CENELEC
Standard Type	Technical Specification
Exchange Data File	None; Transmodel is a Conceptual model
Introduction	Transmodel serves as the foundation for establishing exchange standards that facilitate the sharing and dissemination of accurate and harmonious public transport information, transcending organizational and system boundaries. When formulating legislations and regulations, procuring technical systems, or integrating such systems, having access to a precise and standardized language confers a significant advantage. Transmodel offers precisely such a unified language that comprehensively addresses various facets of public transport. It has been meticulously developed and improved over several decades by public transport experts from diverse European countries. Much like the consensus achieved in adopting uniform symbols for road signs across numerous countries, Transmodel provides the groundwork for a shared language in the realm of public transport.[4]
Overview	Transmodel presents an abstract representation of fundamental concepts and data frameworks pertaining to public transportation. This framework is versatile and can be employed to construct a diverse array of public transport information systems, encompassing functions such as scheduling, fare management, operational oversight, real-time data provision, and journey planning, among others. Transmodel enhances various aspects of public transport information and service management. Notably, it fosters seamless compatibility between the

[2] https://en.wikipedia.org/wiki/Public_transport

[3] https://aviationinfo.net/do-planes-count-as-public-transport/

[4] https://www.transmodel-cen.eu/transmodel-at-a-glance/

	information processing systems employed by transport operators and agencies. This is achieved by employing consistent definitions, structures, and interpretations for the data used in the constituent systems. This harmonization is applicable both within an organization, linking disparate applications, and in the interaction between collaborating entities, such as a public authority and a transport operator.[5]
Benefits	The Transmodel standard establishes a framework for delineating and concurring upon data models, encompassing the entire scope of public transport operations. Through adoption of this European Standard and its resultant data models, operators, authorities, and software providers can collaborate more effectively to create integrated systems. Furthermore, the comprehensive nature of the standard ensures that forthcoming advancements in system development can be accommodated with minimal complications.
Common Data Elements	Service Journey, Line, Transport mode, Vehicles, Stop places, Accessibility Assessment, Scheduled Stop Point, Quay, Journey Pattern, Vehicle Journey , Operating day, Service journey, Block, Driver, Duty, Operator, Agency

Table 1: Transmodel Data Standard

2.3.1.1.2 GTFS - General Transit Feed Specification

Name	GTFS - General Transit Feed Specification
Official Website	https:// www.gtfs.org/
Managing Organisation	Google
Standard Type	Technical Specification
Exchange Data File	Comma-separated values (CSV)
Introduction	The General Transit Feed Specification (GTFS) is an Open Standard used to distribute relevant information about transit systems to riders. It allows public transit agencies to publish their transit data in a format that can be consumed by a wide variety of software applications. Today, the GTFS data format is used by thousands of public transport providers.[6]
Overview	GTFS is split into a schedule component that contains schedule, fare, and geographic transit information and a real-time component that contains arrival

[5] https://www.transmodel-cen.eu/purpose-of-the-transmodel/

[6] https://gtfs.org/

	predictions, vehicle positions and service advisories. Information about routes, schedules, and fares are represented in basic text files, which means it can be created and maintained without the use of complicated or proprietary software. [7]
Benefits	Interoperability: GTFS allows transit data to be easily exchanged and integrated with various software applications, including trip planners, mapping services, and mobile apps. This interoperability enhances the accessibility of transit information for users and enables the development of innovative tools and services. Real-Time Updates: GTFS can be extended to include real-time data, such as vehicle locations, arrival predictions, and service alerts. By incorporating real-time updates, transit agencies can provide more accurate and up-to-date information to passengers, improving their overall transit experience. Trip Planning and Navigation: GTFS enables the development of trip planning applications that can generate optimal routes and schedules based on transit data. Users can access comprehensive information about transit services, including routes, stops, and timetables, helping them plan their journeys more efficiently. Multi-Modal Integration: GTFS supports the integration of multiple modes of transportation, such as buses, trains, subways, ferries, and more. This allows users to plan and navigate through a combination of different transit options, facilitating seamless transfers and promoting the use of public transportation. Open Data: GTFS promotes the availability of open data, allowing transit agencies to share their data with the public and developers. This openness fosters transparency, encourages innovation, and enables third-party developers to build new applications and services using the provided data.
Common Data Elements	Agency, Route, Stop, Trip, Calendar and calendar dates, stop_times, transfers

Table 2: GTFS Data standard

2.3.1.1.3 NeTEx - Network Timetable Exchange (PARTS 1, 2, 3, 4)

Name	NeTEx - Network Timetable Exchange
Official Website	https:// www.netex-cen.eu/

[7] https://gtfs.org/

Managing Organisation	CEN-CENELEC
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	NeTEx serves as a means for seamless sharing of public transport passenger data between various systems, facilitating the integration of multiple modes of transportation such as rail, bus, coach, and metro. This technology aims to become a widely adopted XML standard across Europe.[8]
Overview	NeTEx establishes a standardized approach for exchanging public transport passenger data in XML format. It is divided into three parts, each aligned with specific functional aspects of the CEN Transmodel conceptual model for Public Transport Information, namely [T1], [T2], and [T3]. Part 1 [N1] outlines the fixed Network components, including stops, routes, and lines. Part 2 [N2] focuses on Timetables, while Part 3 [N3] is primarily dedicated to Fare data (which is the main focus of this paper). All three parts utilize the same framework of reusable components, versioning mechanisms, and validity conditions, ensuring the unique identification of data elements on a global scale, as defined in Part 1. NeTEx also incorporates "VERSION FRAMES," which are container elements designed to group data into coherent sets for efficient exchange. The deliverables of NeTEx consist of (i) a CEN Specification document presented in three parts, (ii) a data model represented in the standard UML modeling language [U1], and (iii) an accompanying XML schema, providing a formal electronic description that can be used by data processing software. Data formatted in NeTEx adheres to XML documents that must precisely follow the schema. Standard XML validator tools can automatically check for conformance. Moreover, the schema enables the creation of bindings to various programming languages, streamlining the implementation process for software supporting NeTEx formats. To aid comprehension, sample XML documents that encode different data sets and exchange functions are provided alongside the schema.
Benefits	Reducing development and support costs Increasing function and design quality Reducing complexity

[8] https://www.netex-cen.eu/wp-content/uploads/2015/12/01.NeTEx-Introduction-WhitePaper_1.03.pdf

	Protection of investment[9]
Common Data Elements	Public Transport schedules including stops, routes, departures times / frequencies, operational notes, and map coordinates, Routes, Connections, days of operation, composite journeys such as train journeys that merge or split trains, agency information, positioning runs, garages, layovers, duty crews, useful for AVL and on-board ticketing systems, accessibility information, Fare structures, Fare products and vehicle data.

Table 3: NeTEx Data Standard

2.3.1.1.4 SIRI - Service Interface for Real-time Information

Name	SIRI - Service Interface for Real-time Information
Official Website	https://www.siri-cen.eu/
Managing Organisation	CEN-CENELEC
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	SIRI is a CEN Technical Standard that specifies a European interface standard for exchanging information about the planned, current or projected performance of real-time public transport operations between different computer systems.
Overview	The SIRI Situation Exchange service (EN 15531-5) covers the exchange of information describing an incident, typically an unplanned event such as a disruption, but also planned events that affect public transport or its use, such as engineering works, or major public events that will affect the use or availability of transport. The SIRI-SX service was originally designed to be, as far as possible, consistent with the DATEX II and TPEG standards, which also include situation and public event representations. The SIRI Facility Monitoring service (EN 15531-4) covers the exchange of information concerning the current status of facilities (corresponding to kind of Transmodel EQUIPMENT). It provides a short description of the facility itself, the availability status and specifically the impact of the availability status for various categories of disabled or incapacitated people.

[9] https://netex-cen.eu/faq/what-are-the-advantages-of-using-netex/

	SIRI is a natural complement to NeTEx, NeTEx providing the scheduled information and SIRI the realtime one. Both SIRI and NeTEx share a common conceptual model provided by Transmodel. The information provided by SIRI can be used for many different purposes, for example: • To provide real time-departure from stop information for display on stops, internet and mobile delivery systems • To provide real-time progress information about individual vehicles • To manage the movement of buses roaming between areas covered by different servers • To manage the synchronisation of guaranteed connections between fetcher and feeder services • To exchange planned and real-time timetable updates • To distribute status messages about the operation of the services • To provide performance information to operational history and other management systems.[10]
Benefits	Real-Time Updates: SIRI enables the delivery of real-time information about public transport services, including vehicle locations, arrival predictions, and service alerts. This information allows passengers to stay informed about the current status of their journeys, reducing uncertainty and improving their travel experience. Enhanced Passenger Experience: By leveraging SIRI, transit agencies and application developers can create passenger-facing applications that provide accurate and up-to-date information. Passengers can access real-time arrival times, service disruptions, and alternative routes, enabling them to make informed decisions and plan their trips more efficiently. Multi-Modal Integration: SIRI supports the integration of real-time information across different modes of transportation, such as buses, trains, trams, and ferries. This integration allows passengers to view and plan their journeys seamlessly, even when using multiple modes of transport, promoting the use of public transportation as part of a connected transportation network. Standardization and Interoperability: SIRI establishes a common standard for real-time information exchange, ensuring compatibility and interoperability between different systems and stakeholders. It simplifies the integration of real-time data from various sources, making it easier for transit agencies, application developers, and other stakeholders to collaborate and share information. Dynamic Service Management: SIRI facilitates dynamic service management by allowing transit agencies to send service updates, notifications, and alerts to

[10] https://siri-cen.eu/Page.aspx?CAT=STANDARD&IdPage=2fb18063-5ae9-4553-a931-d0296d5b4315

	both passengers and operational staff. This capability enables proactive management of service disruptions, changes in schedules, or other operational issues, leading to better service reliability and responsiveness. Efficient Resource Utilization: SIRI enables transit agencies to monitor and manage their fleets more effectively. By having real-time visibility into vehicle locations and operational data, agencies can optimize their resources, improve dispatching, and respond more efficiently to changing conditions, ultimately leading to more reliable and efficient public transport services.
Common Data Elements	Production Timetable Service, Estimated Timetable Service, Stop Timetable Service, Stop Monitoring Service, Vehicle Monitoring Service, Connection Timetable Service, Connection Monitoring Service, General Message Service, Situation Exchange Service, Facility Monitoring service

Table 4: SIRI Data Standard

2.3.1.1.5 OSDM - Open Sales and Distribution Model

Name	OSDM - Open Sales and Distribution Model
Official Website	https://osdm.io/
Managing Organisation	UIC - International union of railways
Exchange Data File	Extensible Markup Language (XML)
Standard Type	Technical Specification
Introduction	The aims of the Open Sales and Distribution Model (OSDM) are twofold: (1) to substantially simplify and improve the booking process for customers of public transport trips and, (2) to lower complexity and distribution costs for retailers, distributor and carriers. The OSDM strengthens rail and public transport as a convenient and ecological means of transportation by simplifying distribution. Finally, it lays a solid fundament which can be extended to the distribution of other means of transportation.
Overview	The standard is defined in IRS 90918-10 and provides a new open sales and distribution interface for the passenger transport sector as follows: • Can be used for all fares, including domestic (offline and online) • Interface for (multimodal) trip search (online), including bus or local transport ticketing • Interface for booking/reservations (online) • After-sales for booking/ticket reservations and ancillary services (offline and online)

	• Graphical seat reservation (online) OSDM results from the fusion of the new Tariff Model (nTM) and the Full Service Model (FSM) specifications. The new Tariff Model (nTM) is a UIC project launched in April 2019 to develop a new tool based on new UIC harmonised tariff terms and conditions in order to offer customer-friendly and competitive prices for international travel, based on timetables. The Full Service Model (FSM) is a rail distribution sector industry initiative launched in 2013 to develop an Open IT Specification between rail service providers and international distributors, including third party retailers in order to complement individual bilateral IT solutions between distributors and rail service providers. FSM develops online interface specifications between rail distribution players (B2B) to improve travellers' access to rail tickets. Following a commitment made by Passenger CEOs in 2019 to demonstrate tangible improvements for customers by establishing EU-wide through-ticketing systems, a decision was made in October 2019 to provide a common roadmap for the integration and development of two complementary distribution solutions (new Tariff Model and Full Service Model), taking into account through-ticketing and multimodality in April 2020. UIC and FSM signed a technical agreement to develop a single/integrated specification for complementary FSM and UIC nTM functional parts. Railway operators, Global Distribution Systems (GDS), Online Travel Agencies (OTA), Airline industry and Other public transport modes are all possible actors of interest of the OSDM data standard.[11] During the revision of the TAP TSI specification, the ODDM data standard has been taken into account. Currently, the OSDM specifications are undergoing further evaluation to ensure seamless integration and data exchange with other established standards, such as the European CEN/TS 16614 (NeTEx) standards. To achieve this goal, ERA is collaborating with CEN, UIC, and CER to align OSDM with the NeTEx standard, thereby enabling interoperability between the two[12].
Benefits	Enhanced Ticket Purchase: Railway customers will have easier access to rail and multimodal transport tickets across Europe, enabling them to purchase tickets at the most beneficial prices and tariff conditions. OSDM facilitates combining fares, including existing and new fare combinations, providing customers with more flexibility and options. Improved Services and Customer Attraction: Railway operators can offer better services and attract new customers by leveraging technical innovation and smart mobility solutions. These solutions contribute to seamless travel experiences, enhancing customer satisfaction and increasing the competitiveness of railway services.

[11] https://uic.org/IMG/pdf/uic-passenger-open-sales-and-distribution-model.pdf

[12]https://www.era.europa.eu/system/files/2022-10/TAF%20and%20TAP%20TSI%20Bulletin%20September%202022.pdf

	Reduced Costs: By streamlining the distribution process, the railway sector can benefit from reduced development and distribution costs. OSDM's capabilities help optimize and simplify the ticket distribution process, leading to cost savings for the industry as a whole. Improved Connectivity for Ticket Vendors: Ticket vendors will benefit from improved connectivity in railway ticket distribution. OSDM enables a simpler distribution model, making it easier for vendors to sell tickets. This improved connectivity enhances efficiency and convenience for ticket vendors, improving their overall distribution operations. One-Stop-Shop Distribution Services: OSDM meets the market demand for one-stop-shop distribution services. It provides a centralized platform that integrates various ticketing options, enabling seamless and sustainable travel across Europe. This meets passenger expectations for through-ticketing, allowing them to travel more easily and efficiently throughout the continent.[13]
Common Data Elements	

Table 5: OSDM Data Standard

2.3.1.2 Air Transport

Air transport involves the movement of passengers by airplanes and helicopters. It includes commercial airlines, chartered flights, and general aviation. Air transport offers both domestic and international travel options, connecting cities and countries across the globe.

2.3.1.2.1 SSIM - Standard Schedules Information Manual

Name	SSIM - Standard Schedules Information Manual
Official Website	https://guides.developer.iata.org/docs
Managing Organisation	IATA
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	The International Air Transport Association (IATA) publishes the Standard Schedules Information Manual (SSIM), which serves as a comprehensive guide

[13] https://uic.org/IMG/pdf/uic-passenger-open-sales-and-distribution-model.pdf

	outlining the global standards and protocols for the exchange of airline schedules and various data, including aircraft types, airports, terminals, and time zones.
Overview	Enabling a smooth and effective sharing of flight details within the aviation sector necessitates the establishment and adoption of uniform methods, regulations, and fundamentals. To simplify the process of sharing data and to establish uniform procedures for managing schedule and slot information, the Standard Schedules Information Manual (SSIM) is released on a yearly basis. It included the official set of standards, guiding the industry with recommended practices, messaging formats and data processing procedures that are to be used by all IATA member airlines and their business partners for the exchange of airline schedules, communication of airport coordination information and minimum connect time data.[14] Airlines utilize the SSIM format to exchange schedule and route data with Global Distribution Systems (GDSs) and other entities involved in the aviation industry. GDSs rely on this standard to facilitate tasks such as assigning airline tags, updating flight schedules, and managing inventory. Furthermore, the SSIM format is also employed to update location and air traffic control systems with the most up-to-date flight information.[15]
Benefits	The SSIM format guarantees uniform and consistent data across multiple airlines and systems, leading to a decrease in errors and an increase in automation. It enables automated data synchronization between airlines and GDSs, resulting in reduced time and effort required for technical data entry. It enables faster and more precise updates to flight schedules, thereby improving reliability and enhancing customer satisfaction. [2]
Common Data Elements	Flight number, Departure airport code, Arrival airport code, Departure time, Arrival time, Aircraft type, Flight duration, Operating carrier code, Marketing carrier code, Codeshare information, Frequency, Flight status, Aircraft registration number, Block time, Stopover information, Connecting flight details, Flight restrictions, Terminal and gate information, Baggage allowance, Special service requests (SSRs), Fare class codes, Ticketing and reservation information, Schedule change effective dates

Table 6: SSIM Data Standard

2.3.1.2.2 PADIS - Passenger and Airport Data Interchange Standards

Name	PADIS - Passenger and Airport Data Interchange Standards

[14] https://www.iata.org/en/publications/store/standard-schedules-information

15

Official Website	https://www.iata.org/contentassets/18a5fdb2dc144d619a8c10dc1472ae80/pnrgov20xml20implementation20guide2016_1.pdf
Managing Organisation	IATA
Standard Type	Technical Specification
Exchange Data File	Extensible Mark-up Language (PNRGOV XML)
Overview	PADIS is created by IATA as a standardised means (new standards, harmonised regulations and adequate infrastructure) for sharing passenger information between airlines, airports, governments and others in the aviation industry. It aims to simplify the passenger process towards a more seamless, inclusive and secure passenger experience while improving efficiency and reducing industry costs. The shared data encompasses Advance Passenger Information (API) and Passenger Name Records (PNR) data. It is a subset of electronic data interchange (EDI) messages designed for use with both EDIFACT and XML syntaxes. It enables airlines to facilitate the exchange of data relevant to government requirements on PNR data and Airlines reservation systems. PADIS covers all standard passenger interactions, such as flight check-in updates, boarding pass reprints, baggage transfers, itinerary pricing requests and ticketing control requests, among others. It uses EDIFACT messages in booking, departing, and ticketing to communicate with other airlines and GDSs. The format of individual EDIFACT messages is defined by PADIS.
Benefits	PADIS allows airlines to share passenger sensitive data (API and PNR) with other airlines, airline service suppliers and States, seamlessly and safely. These data can be a useful tool for governments' border control or security processing as it can help them pre-identify travellers and patterns.
Common Data Elements	Advance Passenger Information (API): full name, date of birth and nationality. Passenger Name Records (PNR): passenger name, contact details, payment information (credit card numbers), an itinerary (or a group of passengers travelling together), passport details, email addresses, IP addresses, telephone numbers and a ticketing/ticketed indicator

Table 7: PADIS Data Standard

2.3.1.2.3 NDC - New Distribution Capacity

Name	NDC - New Distribution Capacity
Official Website	https://www.iata.org/en/programs/airline-distribution/retailing/ndc/
Managing Organisation	IATA
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	NDC (New Distribution Capability) stands as an initiative endorsed by the travel sector, established by IATA (International Air Transport Association), with the purpose of creating and fostering the acceptance of a fresh data transmission standard rooted in XML (Extensible Markup Language). This standard, known as the NDC Standard, amplifies the potential for interactions between airlines and travel agents. Furthermore, it is accessible to all external parties, intermediaries, IT service providers, and entities beyond the IATA membership, enabling them to integrate and employ this standard.[16]
Overview	NDC represents the modernization of outdated data exchange standards that were established for ticket distribution over 40 years ago, a time predating the invention of the Internet. This initiative emerged within a swiftly changing airline industry environment in response to three primary trends, with the goal of harmonizing distribution channels and ensuring transparency. (1) The current industry caters to a significantly transformed passenger base with heightened demands regarding their air retail experiences. (2) Airlines have made substantial technological investments and are preparing to efficiently manage their own offers and their distribution. These newfound capabilities within airline distribution are placing pressure on the realm of indirect sales, potentially disrupting the equilibrium of the customer experience. This situation necessitates the integration and interaction with a multitude of innovative technologies. (3) Travel agencies employ a varied assortment of channels to arrange flights for their clients. As airlines have redefined both their offerings and sales strategies, travel agents have adapted accordingly. The travel agency community is also undergoing a transformation to accommodate these changes.[17]
Benefits	• Provide comprehensive airline product and service details to corporate buyers, minimizing the need for bookings that don't comply with company policies. • Display and compare all available air travel choices and their associated fares.

[16] https://www.iata.org/en/programs/airline-distribution/retailing/ndc/#tab-2

[17] https://www.iata.org/contentassets/6de4dce5f38b45ce82b0db42acd23d1c/get-started-ndc.pdf

	• Choose the most suitable travel option based on preferences such as quality, service level, schedule, and price. • Receive personalized offers from preferred sellers based on individual travel history and preferences. • Gain access to the complete range of airline products, including add-ons and special fares. • Work with real-time information on offers, products, and policies. • Enhance the ability to compare offerings for customers based on product and service features, not just price. • Provide tailored service by considering customers' complete travel history and preferences if they opt for recognition. • Distribute the entirety of the airline's product range, along with ancillary services and promotional fares. • Present airline products in an engaging manner using visually appealing formats like photos and videos. • Increase the depth of information available for each product, covering attributes, facilities, policies, and passenger reviews. • Introduce value-added products and services where relevant. • Achieve more efficient and quicker implementations, leading to cost savings.[18]
Common Data Elements	Offer Data, Passenger Data, Flight Information Availability, Data Fare Families, NDC Standard Messages, Payment and Billing Information, Booking References Passenger Loyalty, Profile Data, Travel Agency and Intermediary Data Travel Documents Itinerary Details

Table 8: NDC Data Standard

2.3.1.2.4 AIRIMP - Reservations Interline Message Procedures

Name	AIRIMP - Airline Industry Reservations Interline Message Procedures
Official Website	https://www.iata.org/en/publications/store/airline-industry-reservations-interline-message-procedures-airimp/
Managing Organisation	IATA
Standard Type	Technical Specification
Exchange Data File	Teletype (Type-B) messages

[18] https://www.iata.org/contentassets/6de4dce5f38b45ce82b0db42acd23d1c/get-started-ndc.pdf

Overview	AIRIMP refers to standards developed by IATA for the handling of Passenger Reservations Interline Messages. The AIRIMP standards are used in transactions between travel agency and airline systems, and by airline to airline systems, when making interline reservations, whether by manual, mechanical or computerised reservations systems (CRS) in order to ensure uniformity, understanding, accuracy and economy. After a passenger books an itinerary, the airline, the travel agent or travel website user creates a PNR in the CRS (e.g., Amadeus, Sabre, or Travelport - Apollo, Galileo, and Worldspan). This is the Master PNR for the passenger and the associated itinerary. The PNR is identified in the particular database by a record locator. In the case when part of the journey is not provided by the holder of the Master PNR, then copies of the PNR information are sent to the CRSs of the airlines that will be providing transport. These CRSs will open copies of the original PNR in their own database to manage the portion of the itinerary for which they are responsible. The record locators of the copied PNRs are communicated back to the CRS that owns the Master PNR, so all records remain tied together. This allows exchanging updates of the PNR when the status of trip changes in any of the CRSs. Nowadays, airline systems can now also be used for bookings of hotels, car rental, airport transfers, and train trips, so this will be part of PNR.
Benefits	Easy exchange of reservation information in case passengers required flights of multiple airlines to reach their destination; Facilitates communication between IATA/ATA members and CRS suppliers, between the applicable CRS Suppliers and, where permitted, either directly or via a CRS Supplier, with auxiliary service operators
Common Data Elements	Passenger Name Records (PNR): passenger name, contact details, payment information (credit card numbers), an itinerary (or a group of passengers travelling together), passport details, email addresses, IP addresses, telephone numbers and a ticketing/ticketed indicator

Table 9: AIRIMP Data Standard

2.3.1.2.5 AIDM - Airline Industry Data Model

Name	AIDM - Airline Industry Data Model
Official Website	https://guides.developer.iata.org/docs
Managing Organisation	IATA
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)

Overview	IATA's Airline Industry Data Model (AIDM) is an infrastructure that see the upgrade of the current messaging standards development capability. It aims to become a single point of access to store structured information that includes industry-agreed vocabulary, data definitions and their relationships and related business requirements. Each message development project can easily leverage existing models developed by other standards groups to generate interoperable messaging standards faster and with higher quality. The standards are developed under the conference as a result of collaboration between a business sponsoring Board and the Architecture and Technology Strategy Board in accordance with Resolution 009 in their pursuit of modern data exchange standards.[19] All new data exchange standards must follow the AIDM methodology and leverage industry agreed data definitions in the AIDM repository.
Benefits	• Enhanced uniformity in defining and formatting data exchanges enhances cross-industry compatibility. • Accelerated introduction of new or revised data exchange standards to the market. • Swifter implementation of industry standards driven by their quality and prominence[20].
Common Data Elements	Flight Identification, Codeshare, Line of Work, Operational Times, Disruption Detail, Status and Remarks, Airport Resource Requirement, Passenger, Baggage, Fuel, Cargo, Aircraft Detail.[21]

Table 10: AIDM Data Standard

2.3.1.2.6 AIDX - Airline Industry Data Exchange

Name	AIDX - Aviation Information Data Exchange
Official Website	https://www.iata.org/en/publications/info-data-exchange/
Managing Organisation	IATA

[19] https://guides.developer.iata.org/v221/docs

[20] https://www.iata.org/en/about/corporate-structure/passenger-standards-conference/architecture-technology-strategy/industry-data-model/

[21] https://www.aixm.aero/sites/aixm.aero/files/imce/library/ATIEC_2015/34_day3_aviation_information_data_exchange_aidx.pdf

Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Overview	Aviation Information Data Exchange (AIDX) is the global XML messaging standard for exchanging flight data between airlines, airports, and any third party consuming operational data. AIDX is generally used in the operational window of a flight, but there are implementations that have extended AIDX messaging considerably beyond this temporal scope. It is endorsed as a standard by IATA Recommended Practice 1797A, ACI Recommended Practice 501A07, ATA Recommended Practice 30.201A.[22]
Benefits	Adoption of the AIDX industry standard delivers substantial benefits to airlines, operational partners responsible for updating operational flight information and industry stakeholders consuming operational flight data. Some of the benefits include: ● Cost savings through the use of a single, common, authorized standard ● Utilizes common IATA code sets and XML schemas ● Fewer costly data feed changes will be needed as systems evolve and standardize on AIDX ● Faster time to market ● Use of a mature standard ● Support from product vendors ● XML technology allows AIDX to join other XML-crafted standards such as: TypeX (as the delivery envelope), BCBP (Passenger Data Exchange), SIDX – Schedule Information Data Exchange (SSM/SSIM/ASM), XML for Slot processes (Chapter 6 in SSIM manual), EDI/XML for PNR Push/AQQ/API Numerous airlines, airports and vendors have deployed AIDX, are planning AIDX efforts or are waiting on others to spur their developments in the future.[23]
Common Data Elements	Flight Identification, Codeshare, Line of Work, Operational Times, Disruption Detail, Status and Remarks, Airport Resource Requirement, Passenger, Baggage, Fuel, Cargo, Aircraft Detail.[24]

Table 11: AIDX Data Standard

2.3.1.2.7 FIXM - Flight Information Exchange Model

[22] https://www.iata.org/en/publications/info-data-exchange/#tab-1

[23] https://www.iata.org/contentassets/cfe998bcf9214859afda9c8bf4ff75c3/aidx-xml-imp-guide-v22.1.pdf page 9

[24] https://www.aixm.aero/sites/aixm.aero/files/imce/library/ATIEC_2015/34_day3_aviation_information_data_exchange_aidx.pdf

Name	FIXM - Flight Information Exchange Model
Official Website	https://www.fixm.aero/
Managing Organisation	ICAO, ATMRPP
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Overview	The FIXM is a global exchange standard capturing Flight information. FIXM is implemented in Unified Modeling Language and XML and fully supports the data exchange requirements for the FF-ICE concept, as defined by the ICAO ATM Requirements and Performance Panel (ATMRPP).[25] The Flight Information Exchange Model (FIXM) is an exchange model capturing Flight and Flow information that is globally standardised. FIXM is the equivalent, for the Flight domain, of AIXM (Aeronautical Information Exchange Model) and WXXM (Weather Information Exchange Model) both of which were developed in order to achieve global interoperability for, respectively, AIS and MET information exchange. FIXM is therefore part of a family of technology independent, harmonized and interoperable information exchange models designed to cover the information needs of Air Traffic Management. According to the ICAO SWIM concept[26], FIXM is one of the models that belong to the "Information Exchange Models" layer of the ICAO SWIM Global Interoperability framework. FIXM contains flight information items that satisfy, and are traceable to, ICAO requirements for Flight information exchanges.[27]
Benefits	• FIXM offers standardized data formats for flight information within the FF-ICE scope. • This encompasses detailed flight plan data, including more comprehensive route and trajectory descriptions.[28]

[25] http://icscc.org.cn/upload/file/20221215/20221215154028_65581.pdf

[26] Manual On System Wide Information Management (SWIM) Concept, (Advanced Edition – 2015), ICAO Doc 10039

[27] https://www.fixm.aero/releases/FIXM-4.1.0/FIXM_Core_v4_1_0_Primer.pdf

[28]https://www.eurocontrol.int/model/flight-information-exchange-model#:~:text=FIXM%20provides%20harmonized%20data%20structures,with%20richer%20route%2Ftrajectory%20descriptions.

Common Data Elements	Flight Identification, Flight Information, Aircraft Information, Weather Conditions, Airspace Information, Flight Plans, Operational Status, Airport Resources, Air Traffic Control Information, Performance Monitoring.

Table 12: FIXM Data Standard

2.3.1.2.8 AIXM - Aeronautical Information Exchange Model

Name	AIXM - Aeronautical Information Exchange Model
Official Website	https://www.aixm.aero/
Managing Organisation	EUROCONTROL in coordination with FAA
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	The Aeronautical Information Exchange Model (AIXM) is crafted to facilitate the digital handling and dissemination of Aeronautical Information Services (AIS) data. AIXM employs the Geography Markup Language (GML) and serves as a specific GML Application Schema tailored for the aeronautical sector. It emerged through collaboration among the US Federal Aviation Administration (FAA), the US National Geospatial Intelligence Agency (NGA), and the European Organisation for the Safety of Air Navigation (EUROCONTROL). The present iteration stands as AIXM 5.1.1.[29]
Overview	AIXM enables the provision in digital format of the aeronautical information that is in the scope of aeronautical information services (AIS). The AIS information/data flows that are increasingly complex and made up of interconnected systems. They involve many actors including multiple suppliers and consumers. There is also a growing need in the global air traffic management (ATM) system for high data quality and for cost efficiency.[30] In order to meet the requirements of this increasingly automated environment, AIS is moving from the provision of paper products and messages to the collection and provision of digital data. AIXM supports this transition by enabling the collection, verification, dissemination, and transformation of digital aeronautical data throughout the data chain, in particular in the segment that connects AIS with the next intended user.

[29] https://en.wikipedia.org/wiki/AIXM

[30] https://www.aixm.aero/

Benefits	To overcome these drawbacks of textual NOTAMs a joint project between EUROCONTROL and the Federal Aviation Administration (FAA) was launched in 2010 (EUROCONTROL & Federal Aviation Administration, 2011b). The aim was to replace textual NOTAMs with digital NOTAMs. Digital NOTAMs represent structured data sets which can be read and interpreted by automated systems. In order to provide an encoding for digital NOTAMs, the existing Aeronautical Information Exchange Model (AIXM) was used and extended (Geospatial Intelligence TWG, 2006). AIXM allows to represent ATM elements such as event scenarios or features like airports, airspaces or routes. The machine-interpretable data structure allows filtering of NOTAMs without the need of human interpretation. Thus CHAPTER 1. INTRODUCTION 3 the flood of NOTAMs retrieved by flight crews and other flight personnel can be minimized using this automated filtering capabilities. This reduces the information overload and stress of the crew which positively affects their situation awareness.[31]
Common Data Elements	Aerodrome/Heliport including movement areas, services, facilities, etc., Airspace structures, Organisations and units, including services, Points and Navaids, Procedures, Routes, Flying restrictions

Table 13: AIXM Data Standard

2.3.1.2.9 AMXM - Aerodrome Mapping Exchange Model

Name	AMXM - Aerodrome Mapping Exchange Model
Official Website	https://www.amxm.aero/
Managing Organisation	EUROCAE WG-44/RTCA SC-217 committee
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	The AMXM stands as an openly accessible technical asset managed by EUROCAE / RTCA. Its purpose is to assist with AMDB data interchange. Various user categories gain advantages from employing AMDBs, including pilots, air traffic controllers, aerodrome administrators, and emergency/security personnel stationed at aerodromes[32].
Overview	It is developed under the support of the joint aeronautical databases committee EUROCAE WG-44/RTCA SC-217 as an open technical resource for

[31] http://www.dke.jku.at/rest/dke_web_res/publications/theses/MT1505/MT1505_copy.pdf page 9

[32] https://www.amxm.aero/

	supporting Aerodrome Mapping Databases (AMDB) data exchange. AMDBs are produced and exchanged as datasets using global standards and tools of mainstream Geographic Information System (GIS) technology. The AMXM is based on the ISO19100 series of standards maintained by the ISO TC211. An AMDB dataset describes the spatial layout of an aerodrome in terms of features (e.g., runways, taxiways, parking stands) with geometry described as points, lines or polygons, and with attributes (e.g., surface type) providing further information. AMDBs use pilots, controllers, aerodrome managers, and aerodrome emergency/security personnel as a format to exchange data.
Benefits	• promotes interoperability • improve the pilot's situational awareness for surface navigation • increasing safety increasing operational efficiency
Common Data Elements	the spatial layout of an airport, the geometry of features (e.g., runways, taxiways, buildings) described as points, lines and polygons, further information characterizing the features and their functions which are stored as attributes (e.g., surface type, name/object identifier, runway slope)

Table 14: AMXM Data Standard

2.3.1.2.10 BIX - Baggage Information Exchange

Name	BIX - Baggage Information Exchange
Official Website	https://www.iata.org/en/programs/ops-infra/baggage/baggagemessaging/#tab-2
Managing Organisation	IATA
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	Baggage management is undergoing rapid advancements, with ongoing introductions of new processes. However, the existing messaging standards, established since 1985, do not adequately facilitate baggage system integration and innovation. The current standards contribute to baggage mishandling due to message failures or rejections. To address these issues, new baggage messaging standards based on the IATA Airline Industry Data Model (AIDM) are being implemented. These updated standards aim to enhance clarity in communicating baggage information, making it easier for airlines, airports, and

	baggage handling vendors within the industry to understand and exchange relevant data.[33]
Overview	Baggage Information Exchange (BIX), the new messaging standard, uses the AIDM as a basis for constructing Baggage Messages using a business capability language, e.g., XML (Extensible Markup Language), JSON (JavaScript Object Notation) or other equivalent languages. The new messaging standard is also used in other areas outside the Baggage world, e.g., NDC and Cargo. BIX also defines the mode of communication for exchanging messages in a more secured and standard way to keep up with current and evolving IT systems.
Benefits	Cost reduction: The updated messaging standard allows the utilization of cost-effective cloud-based infrastructure, resulting in lower transaction costs. Additionally, it offers a simpler, human-readable data structure compared to its predecessor. Enhanced data content: The new messaging standard enables the inclusion of more data content, opening doors to new passenger services and functions. It facilitates the introduction of new data through experimental evaluation and sharing of pros and cons with the BWG committee for approval. Simplified complexity: The updated messaging standard significantly reduces the variety of message formats, providing a much simpler method for determining the format. This leads to connected systems that are more reliable, cost-effective to maintain, and easier to enhance. Improved resilience: The new messaging standard enhances the resilience of baggage messaging by localizing failures to the affected system, allowing for easy recovery with minimal impact on dependent systems. This is achieved through communication via multiple point-to-point connections instead of relying on a central authority. Enhanced security: Unlike the current messaging system that lacks data security, the new standard ensures end-to-end encryption and data exchange signature, guaranteeing the security and authenticity of the information. Enablement of new product offerings: The updated messaging standard introduces additional features and attributes for comprehensive end-to-end bag journey solutions. Examples include arrival tracking, baggage pre-clearance, mishandled bag image recognition, and passenger applications. Backward compatibility: The new standard accommodates the introduction of new fields and formats while allowing for flexibility in retaining current and old

[33] https://www.iata.org/contentassets/6bb095b194bc4ebf851ed73c83266c20/bix-guidance-document.pdf

	formats. Systems can selectively produce and process messages without affecting new or modified fields.[34]
Common Data Elements	Aerodrome/Heliport including movement areas, services, facilities, etc., Airspace structures, Organisations and units, including services, Points and Navaids, Procedures, Routes, Flying restrictions

Table 15: BIX Data Standard

2.3.1.3 Rail Transport

Rail transport involves the movement of passengers by trains on railways. It includes various types of trains, such as commuter trains, regional trains, and long-distance trains. Rail transport can be part of public transit systems, like commuter trains and subways that serve urban areas, or it can also include private trains or luxury trains designed for specific purposes, such as tourism or business travel.

2.3.1.3.1 RailML - Railway Markup Language

Name	RailML - Railway Markup Language
Official Website	https://www.railml.org/en/
Managing Organisation	railML.org
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	RailML (railway mark-up language) is a common exchange format, which employs the systematic use of XML for the description of rail-specific data. RailML enables the exchange of railway data between internal and external railway applications. RailML is developed within the so-called “RailML consortium” from railML.org. It is an open source exchange format under creative commons license (A free registration on RailML is mandatory for the usage and download of RailML schemes). The model language of RailML is UML and the documentation language is English. Every RailML developer and user is invited to contribute or propose scheme extensions.
Overview	RailML, on the other hand, is a data standard specifically designed for the railway industry. It focuses solely on rail transport and provides a standardized format for exchanging railway-related data. RailML covers various aspects of rail infrastructure, timetables, rolling stock, signalling, and operational details. It aims to enable interoperability between different railway systems and

[34] https://www.iata.org/contentassets/6bb095b194bc4ebf851ed73c83266c20/bix-guidance-document.pdf

	facilitate the exchange of data within the rail domain. RailML provides a more specialised and detailed approach to rail transport data, taking into account specific railway infrastructure elements and operational requirements.
Benefits	
Common Data Elements	railway infrastructure elements, track network elements, Geometry, the track geometry can be described in terms of radius and gradient, railway infrastructure elements (balises, platform edges, and level crossings), speed profiles and track conditions, rollinstock elements (railway vehicle including locomotives, multiple units, passenger and freight wagons), Timetable and Rostering elements(Operating Periods, Train Parts, Trains, Connections, Rostering[35]

Table 16: RailML Data Standard

2.3.1.4 Road Transport

Road Transport: Road transport refers to passenger travel by road using vehicles such as cars, motorcycles, buses, and taxis. While public buses and some forms of shared transportation services like ride-sharing or carpooling can be considered part of public transit, road transport also encompasses private vehicles that individuals use for personal transportation.

2.3.1.4.1 DATEX II - Data Exchange for Traffic Telematics

Name	DATEX II - Data Exchange for Traffic Telematics
Official Website	https://www.datex2.eu/
Managing Organisation	DATEX II Forum
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	DATEX II is a standard for the exchange of traffic and travel-related data in road transport. It covers real-time traffic information, traffic events, travel times, and road network data.
Overview	DATEX II serves as the electronic medium utilized across Europe to facilitate the exchange of both traffic data and traffic-related information. Its inception traces back to the early 1990s, arising from the necessity to share data between motorway operator traffic centers. This demand subsequently expanded to

[35] https://wiki2.railml.org/wiki/Main_Page

	encompass service providers, revealing the limitations of the original DATEX I due to its reliance on outdated technical principles. This led to the development of DATEX II in the early 2000s. The essence of DATEX II lies in its capacity to disseminate traffic management and traffic information devoid of language and presentation format constraints. This eradicates the potential for misinterpretations and translation errors by recipients. Instead, recipients have the freedom to select options such as spoken text, map-based visuals, or integration into navigation computations. In many ways, it mirrors natural language, possessing a grammar framework and a lexicon. At its core, DATEX II establishes a standard for the traffic and travel information sector, enabling data sharing that culminates in a comprehensive end-user information service. The impetus for DATEX II's creation emerged from a European task force that aimed to standardize the interface between traffic control and information centers. In practice, DATEX II equips road operators and data providers with a suite of resources including documentation, a Unified Modeling Language (UML) model, and tools based on the eXtensible Markup Language (XML). This framework guarantees the uniform exchange of road data across diverse entities.[36]
Benefits	Enabling the direct exchange of traffic information among operational systems in control rooms significantly enhances the safety and efficiency of transportation networks. This approach ensures that exchanges occur at the level of systems, leading to instantaneous data transfer without operator intervention. This results in quicker and more responsive management of road networks, exemplifying the core concept of Intelligent Transport Systems (ITS). The notion of a "dynamic system state" serves as the cornerstone of ITS. When one considers the volume, accuracy, and availability of data, coupled with the diverse indicators of traffic conditions, the significance of this concept becomes evident. The standardization and alignment of data structures and data exchange services pose fundamental challenges for both the realm of information technology and ITS. In this context, DATEX II emerges as a specification designed to operate as well as represent the bridge between the dynamic traffic domain and information technology. The effective coordination and synchronization of traffic management strategies among road operators constitute a pivotal element in optimizing the capacities of road networks. This optimization aims to mitigate the adverse impacts of congestion while simultaneously enhancing safety.

[36] https://docs.datex2.eu/basics/generalintroduction.html

Common Data Elements	Operator actions, Impacts, Measured or elaborated data (e.g. travel times, measured traffic speed, elaborated traffic status, weather measurements, etc.), Messages displayed on Variable Message Signs (VMS), Service information (no rest area, delays on trains, etc.)

Table 17: DATEX II Data Standard

2.3.2 Other Data Standards

Another intermediate level of data which stands between the passenger, the infrastructure and other services are the indoor mapping solutions. Large airports-rail stations are a main component in a passenger trip, and are most likely the place where interchanges if apparent, happen. All airports inevitably experience a significant volume of multimodal movements, involving various modes of transportation for user access and egress. With the exception of air-to-air transfers, other transportation modes come into play. These movements can be categorized into two types: those involving local transportation for access or egress within the immediate vicinity of the airport and those connecting to interurban modes. The former has been the traditional focus, with significant efforts directed towards facilitating smooth interconnections for residents and visitors to the airport's local area. However, a more recent development is the direct linkage of air services through airports to other medium and long-distance transportation modes. This change has been partly driven by congestion on major air service routes and environmental considerations. Additionally, the influence of railway interest groups in decision-making processes may have played a role in this shift.[37]

2.3.2.1 Indoor Mapping

Technologies and systems for indoor positioning, mapping, and navigation (IPMN) have rapidly developed over the last decade due to advanced radio and light communications, the internet of things, intelligent and smart devices, big data, and so forth. Thus, a group of surveys for IPMN technologies, systems, standards, and solutions can be found in literature. However, currently there is no proposed solution that can satisfy all indoor application requirements; one of the biggest challenges is lack of standardization, even though several IPMN standards have been published by different standard developing organizations (SDOs). Therefore, this paper aims to re-survey indoor positioning and mapping technologies, in particular, the existing standards related to these technologies and to present guidance in the field.[38]

2.3.2.1.1 IndoorGML

Name	IndoorGML
Official Website	http://www.indoorgml.net/

[37] https://www.itf-oecd.org/sites/default/files/docs/05rt126.pdf - page 36

[38] https://www.mdpi.com/2305-6703/2/2/12

Managing Organisation	Open Geospatial Consortium
Standard Type	Technical Specification
Exchange Data File	Extensible Markup Language (XML)
Introduction	Indoor spaces dominate our daily activities, growing complex due to urbanization and high population density in limited areas. Spatial information becomes crucial for indoor location-based services, similar to outdoor contexts. However, disparities between indoor and outdoor spaces make it challenging to directly apply outdoor geospatial technologies indoors. The key difference lies in spatial reference systems; outdoor uses coordinates assuming Euclidean space, unfit for indoors. Instead, indoor locations are often denoted by identifiers like room numbers. Indoors, space differs from Euclidean norms, altering distance computation due to obstacles[39].
Overview	This guideline relies on a cellular concept of space, viewing an indoor area as a collection of distinct, non-overlapping cells. It comprises two primary module categories: the core module and extension module. The core module encompasses four fundamental components for both conceptualization and implementation (geometric model defining cells, cell-to-cell topology, semantic cell interpretation, and multi-layered spatial representation). Extension modules have the potential to be established upon the core module to serve specific application domains. In its initial iteration, the standard introduces an extension tailored for indoor navigation[40].
Benefits	• Indoor Navigation: IndoorGML enables more accurate and reliable indoor navigation solutions, helping people find their way within complex indoor environments like airports, shopping malls, hospitals, and large buildings. • Location-Based Services: It supports the development of location-based services within indoor spaces, such as indoor positioning, location-aware marketing, and personalized user experiences. • Emergency Management: IndoorGML aids emergency response teams in navigating and managing incidents within indoor environments, improving evacuation procedures and coordination. • Facility Management: It facilitates effective facility management by providing a detailed and standardized representation of indoor spaces, aiding in space utilization, maintenance, and resource allocation. • Retail and Marketing: Retailers can use IndoorGML to optimize store layouts, track customer movement, and offer targeted promotions based on customer location within stores.

[39] https://isprs-archives.copernicus.org/articles/XLI-B4/701/2016/isprs-archives-XLI-B4-701-2016.pdf

[40] https://isprs-archives.copernicus.org/articles/XLI-B4/701/2016/isprs-archives-XLI-B4-701-2016.pdf

	• Public Transportation: IndoorGML can assist in improving navigation within transportation hubs like airports, train stations, and bus terminals. • Accessibility: It contributes to making indoor spaces more accessible for individuals with disabilities by enabling accurate mapping of features like ramps, elevators, and accessible routes. • Augmented Reality (AR) and Virtual Reality (VR): IndoorGML can enhance AR and VR experiences by providing accurate spatial information for virtual content placement within indoor environments. • Building Information Modeling (BIM) Integration: It can be integrated with BIM models to create a comprehensive representation of both the exterior and interior of buildings. • Research and Analysis: Researchers and urban planners can use IndoorGML to study people's movement patterns, analyze traffic flow, and conduct spatial analysis within indoor spaces. • Security Planning: IndoorGML aids security personnel in planning and executing security measures within buildings and crowded indoor areas. • Efficient Infrastructure Planning: Organizations can use IndoorGML for efficient infrastructure planning, optimizing resources, and designing spaces that align with functional requirements.
Common Data Elements	Cells and Spaces, Geometry, Topology, Semantics, Levels and Floors, Navigation Information, Furniture and Objects, Attributes and Properties, Relationships, Extensions etc

Table 18: IndoorGML Data Standard

2.3.3 Data Harmonization

2.3.3.1 Definition

Harmonization is the process of minimizing redundant or conflicting standards which may have evolved independently. The name is also an analogy to the process to harmonizing discordant music.

Harmonization is different from standardization[41]. Harmonization involves a reduction in variation of standards, while standardization entails moving towards the eradication of any variation with the adoption of a single standard.

41 Pelkmans, J. (1987). "The New Approach to Technical Harmonization and Standardization". JCMS: Journal of Common Market Studies. 25 (3): 249–269. doi:10.1111/j.1468-5965.1987.tb00294.x.

2.3.3.2 Goal

The goal for standard harmonization is to find commonalities, identify critical requirements that need to be retained, and provide a common framework for standards setting organizations (SSO) to adopt. In some instances, businesses come together forming alliances or coalitions, also referred to multi-stakeholder initiatives (MSI) with a belief that harmonization could reduce compliance costs and simplify the process of meeting requirements. With potential to reduce complexity for those tasked with testing and auditing standards for compliance.[42]

2.3.3.3 Industry Benefits

In simple terms, data harmonization increases the value and utilization of data. Data harmonization also makes it possible for organizations to transform fragmented and inaccurate data into workable information—creating new analyses, insights, and visualizations. This means that data harmonization helps the user reduce the time taken to access business intelligence, discover key insights, and detect early disruptions. It also significantly lowers the overall cost of complex data analysis and the cost of handling data in the long run. If an organization is spending less time scrambling to find the right source of data, then it can spend that time more effectively elsewhere, such as in growing the business and making a significant revenue impact.

Whether an organization has been around for several decades or is a recent start-up, it will inevitably gather a plethora of data. Along with it, there is the distinct possibility that the enormous array of information gathered from a wide variety of sources will have errors and misinformation. Besides this, the sheer volume of information collected over a company's lifespan can be unwieldy and overwhelming.

With data harmonization tools, this data can be a valuable mine of insights and business intelligence. Organizations can learn things about their customers, changing market forces, and even insights about competitors. The good news is that every company across the globe is mining and storing data to make smart business decisions and manage their customers. But first, to make sense of all that data, organizations need to harmonize it.

Most companies spend huge amounts of time and resources on commissioning surveys, conducting focus group sessions, and gathering information from the internet, news channels, and social media networks. All this information does not come together in one manageable, cohesive body but rather as a mish-mash of raw data. To make sense of it as a whole, it needs to be harmonized. Raw, unharmonized data isn't suitable for business analysis. It often contains irrelevant pointers, misleading values, and duplicate statistics. However, when organizations use data harmonization techniques, they can standardize data and create a single source of verifiable information.[43]

2.3.3.4 Examples of Successful Harmonization

Implementing and operating data systems for public transport is a complex undertaking that demands a significant investment of resources and effort. While standardization plays a crucial role in simplifying these systems, reducing costs, and improving interoperability and capabilities, it's important to

[43] https://en.wikipedia.org/wiki/Harmonization_(standards)

recognize that the adoption process is gradual and requires a strategic vision and patience over a span of years, rather than months.

Transmodel, as a conceptual tool, holds considerable value in gradually aligning various standards to converge onto a unified format. The provided diagram illustrates how Transmodel has been employed over a 20-year period to align key National European standards, leading up to the EC ITS directive promoting the use of pan-European standards for public transport (PT) data. GTFS (General Transit Feed Specification) could potentially be included in this alignment process as well. For the effective progression of standards, there needs to be a two-way flow of information between the concrete formats used in the field, encompassing real-life workflows and new business requirements, and the abstraction of those new features as common concepts within the Transmodel reference model. This iterative evolution is essential for harmonizing and converting formats. It is imperative that this evolution continues to address future needs and advancements in the field.[44]

IATA aims to enhance the handling of Passenger Data by harmonizing systems, establishing forward-looking standards, and educating countries about international standards. Passenger data has become crucial for Facilitation, but non-standard and inefficient transmission methods are common due to government requirements for Advance Passenger Information (API) and Passenger Name Records (PNR). IATA, in collaboration with ICAO and WCO, has developed an API-PNR Toolkit to assist stakeholders in understanding the global passenger data transmission framework. IATA cooperates with UN counter-terrorism structures to align API exchange programs with existing standards, utilizing the Single Window concept for data requests. IATA contributes to the UN Counter-Terrorism Centre's API Project, promoting harmonized data exchange through workshops. Over 90 countries mandate API before flight arrival, with more planning to follow suit. IATA aims to standardize API requirements globally. Similarly, access to PNR is growing, and IATA seeks a global solution to ensure data protection while facilitating passenger flow[45].

The OSDM API and related documents are Open Source and accessible to all interested parties. Introduced in 2013 and released in 2018, it emerged from UIT's Tariff Model (nTM) and Full Service Model (FSM 2.0) initiatives. The OSDM comprises two standards: the Offline Model offering standardized static data on European rail distribution, and the Online Model facilitating consistent real-time booking and pricing across Europe. The team is presently encouraging adoption among European rail stakeholders and collaborating with European standards bodies to ensure compatibility[46].

2.4 Structure of the document

This section states how the document is organised providing the necessary background and building on it by the initial capture of standardization needs (section 2.3). Nevertheless, it is important to highlight again that the need of new or amended standard was not possible now as this deliverable is presented in M3 of the project and the consortium members need to elaborate on i) the solution's

44 https://www.transmodel-cen.eu/wp-content/uploads/2019/10/StandardsHarmonisation-2019-njsk-v1.0-1.pdf page 74

45 https://www.iata.org/en/programs/passenger/passenger-facilitation/passenger-data/

46 https://wiki.lafabriquedesmobilites.fr/wiki/OSDM_(_Open_Sales_and_Distribution_Model

architecture ii) its Key Performance Indicators and iii) the standards that will be implemented expect of the standards implemented for the transport data. Additionally, section 3.4 reasons the complexity to create a new data standard or amend an existing one.

2.5 Glossary of terms

This section identifies terms and their definition and shall include the reference to the source of the definition. However, there is not applicable in this version of STAND.

2.6 List of Acronyms

Acronym	Definition
AIDM	*Airline Industry Data Model*
AIDX	*Aviation Information Data Exchange*
AIRIMP	*Airline Industry Reservations Interline Message Procedures*
AMDB	*Aerodrome Mapping Database*
AMXM	*Aerodrome Mapping Exchange Model*
API	*Advance Passenger Information*
ATM	*Air Traffic Management*
AVL	*Automatic Vehicle Location*
BIX	*Baggage Information Exchange*
CEN	*European Committee for Standardization*
CONOPS	*Concept of Operations*
CR	*Change Request*
CRS	*Central Reservation System*
DATEX	*Data Exchange for Traffic Telematics*
E-ATMS	*European Air Traffic Management System*
EDI	*Electronic Data Interchange*
FAA	*Federal Aviation Administration*
FIXM	*Flight Information Exchange Model*
FTI&U	*Fast Track Innovation and Uptake*
GDS	*Global Distribution System*
GIS	*Geographic Information System*
GTFS	*General Transit Feed Specification*
IATA	*International Air Transport Association*
ICAO	*International Civil Aviation Organization*

KPA	*Key Performance Area*
NDC	*New Distribution Capacity*
NeTEx	*Network Timetable Exchange*
OGC	*Open Geospatial Consortium*
OI	*Operational Improvement*
OSDM	*Open Sales and Distribution Model*
PADIS	*Passenger and Airport Data Interchange Standards*
PIRM	*Programme Information Reference Model*
PNR	*Passenger Name Record*
REG	*Regulatory deliverable*
SIRI	*Service Interface for Real-time Information*
SJU	*SESAR Joint Undertaking (Agency of the European Commission)*
SPR-INTEROP/OSED	*Safety Performance Requirement-Interoperability Requirements/Operational Service Environment Description*
SSIM	*Standard Schedules Information Manual*
SSR	*Special Service Request*
TS/IRS	*Technical Specification/Interface Requirement Specification*
UIC	*International union of railways*
XML	*Extensible Markup Language*

Table 20: List of acronyms

3 Standardisation needs capture

3.1 Need a new or amended Standard(s)

Although it is difficult to capture at this initial version the standardization needs, the following paragraphs intent to link the goals of data sharing agreements and/or smart contracts with standardisation needs envisioning and outlining the challenges of such activities.

Considering the objective of the SIGN-AIR which is to allow TSPs to generate and monitor data sharing agreement and smart contracts we list and explain the potential standards amendments based on the data sharing goals that can be facilitated by SIGN-AIR platform. All the SIGN-AIR's contracts goals, such as single ticketing, coordinated timetables, optimised use of resources, increase passenger on demand services, increase access to passengers with reduced mobility (PRMs), disruption management and passenger and finally digitalization, harmonisation and standardization of data relate directly or indirectly to data standards of one or more transportation sectors. To identify whether a new standard should be created or an existing should be amended, closer examination is required which is presented below.

3.2 Objectives to be achieved

G1. Single Ticketing refers to a system implemented at different geographical levels, such as city or metropolitan areas (for instance, T-Mobilitat in Barcelona, ATHENA in Athens, MOBIB in Brussels, and VIVA VIAGEM in Lisbon). It can also be established at the country level, like the OV-Chipkaart in the Netherlands or the upcoming Ovpay ticketing system. Moreover, certain implementations extend this idea to an international level, for example, SNCF-Air France, Austrian Airlines-OBB, and Lufthansa-DB. The objective of SIGN-AIR is to expand this concept to include various transportation modes, encouraging a greater shift towards using public transport options. In order to answer to the requirement of single ticketing, clear understanding of how existing operators handle the ticketing part in terms of technologies, standards is required. Steps towards the direction of connecting a passenger ticket to other services is being achieved with the use of NDC regarding air travel. With a correct implementation mechanism, other modes of travel could possibly be merged inside the NDC exchange standard therefore allowing the single ticketing goal.

G2. Coordinated timetables have been partially achieved through pairing different transportation modes, but full and comprehensive coordination is still lacking. The SIGN-AIR initiative seeks to address this by extending coordinated timetables to include multiple transportation modes, thereby reducing passengers' waiting times during mode transitions. This improvement will also have an indirect impact on the capacity and throughput of the overall transportation system. To achieve the Coordination and synchronisation of different modes of travel, three vital sources of information must be identified: (1) the provision of all the required and validated timetabled data, (2) the real time updates of each operating vehicle – in order to correct if needed an unplanned delay and finally (3) the collection and storage of historic data, which will then provide insight regarding the final "fine tuning" of the original timetables, focusing in the best passenger information possible.

G3. To enhance the operation of hubs like airports and train stations, managers currently make decisions about the number of check-in and luggage drop-off counters based on predetermined timetables. However, if real-time information about the exact arrival of passengers from public transportation (PT) is exchanged, these decisions could be more precise. Conversely, PT operators rely on frequency schedules and lack knowledge about when passengers are ready to leave the airport after claiming their luggage. SIGN-AIR aims to bridge this gap by facilitating the exchange of data, allowing both parties to access timely and relevant information for better resource optimization. As seen previously in the brief analysis of data standards in aviation, the capability to exchange data required to tackle the issue of optimization of resources at an airport. The main problem that needs to be addressed is the specification of a flow of data that will make this information available to the target airport so that it can then correct allocate the needed resources.

G4. To enhance passenger on-demand services at airports, the current taxi system relies on on-site and situational factors. For example, if there is a queue, the airport staff may call for more taxis to meet the demand. The SIGN-AIR initiative aims to improve these services by providing transport-on-demand providers with more accurate information about the number of arriving passengers. It will also enable the combination of rides for passengers heading to the same or similar destinations. Moreover, a similar approach could be applied to transport passengers to the airport. This could potentially lead to a reduction in the number of cars congesting the access roads to the airport. In the conducted research so far, no data standard was identified regarding the automatic exchange of information required in order to coordinate the taxi system of the arriving airport in a passenger's journey. This implies the possibility that there is room for improvement in the task at hand. The SIGN-AIR platform, can be designed in a manner so that the correct handle of such information would be possible. A platform where passengers via the single ticket they have purchased, notify, and allocate the correct cab driver in order to collect them.

G5. Another objective of SIGN-AIR's contracts is to enhance accessibility for passengers with reduced mobility (PRMs). While airlines currently have established protocols to assist PRMs, transitioning between different modes of transport remains challenging, and sometimes even impossible for them. SIGN-AIR seeks to address this issue by promoting the exchange of information, enabling PRMs to have a more seamless and accommodating transportation experience. Passengers with mobility limitation must be taken into account very seriously. A vital role in order to achieve an enhancement in the accessibility for such passengers lies in the recent advancements in indoor mapping technology. A fully mapped airport layout containing all the source data needed in order to capture the passenger walking travel times, routes to follow, audio – visual information that is also updated dynamically via changes in the initial location of arriving and departing gates will provide a good starting point, which can then be extended further by other data standards such as NeTEx which are able to handle the different passenger limitations.

G6. Disruption management and passenger rights are well-addressed by full-service airlines and, in some cases, intercity railways with their respective recommendations in the event of disruptions. However, the challenge arises in multimodal trips, where the lack of agreements between various parties and cross-data integration makes it more difficult to provide seamless solutions. To tackle this issue, SIGN-AIR aims to thoroughly analyse and improve passengers' rights within multimodal chains, specifically focusing on the case of disruptions. By doing so, the initiative aims to ensure that passengers' rights are upheld and enhanced throughout their entire journey. Via the Smart contracts framework proposed in the SIGN AIR project, disruption management will be possible since each party has to agree to that in order to finalize the contract.

G7. The process of digitalization, harmonization, and standardization of data presents challenges as numerous Transportation Service Providers (TSPs) lack data in suitable formats or standards that can be easily shared. In response to this issue, SIGN-AIR seeks to offer guidelines and establish connections with crucial tools. These measures enable TSPs to facilitate data exchange beyond the SIGN-AIR platform while taking into account existing standards and European policies. The SESAR solution should be able to handle via TransiTool the generation of data of operators who do not have the technical knowledge to implement the data standards internally, so that they can finally be standardized and harmonized.

3.3 Expected benefits?

Below are the benefits of implementing each of the initiatives (G1-G7) as part of the SIGN-AIR project:

G1. Single Ticketing:

- Simplified Travel: Implementing a single ticketing system allows passengers to use various transportation modes seamlessly, eliminating the need for separate tickets and payments for each leg of the journey.
- Increased Public Transport Use: By encouraging a shift towards public transport options, single ticketing can lead to reduced reliance on private vehicles and, consequently, reduced traffic congestion and emissions.
- Interoperability: The integration of different transportation modes under a single ticketing system requires standardization and interoperability, which can lead to improved coordination and efficiency across the entire transportation network.

G2. Coordinated Timetables:

- Reduced Waiting Times: Coordinating timetables across different transportation modes can minimize waiting times during mode transitions, providing a more convenient and efficient travel experience for passengers.
- Increased Capacity and Throughput: Better coordination can optimize the use of infrastructure and resources, leading to increased capacity and throughput of the overall transportation system.
- Improved Passenger Information: Timely and accurate timetabled data, real-time updates, and historical data help provide passengers with reliable and up-to-date information, leading to better travel planning.

G3. Optimization of Hubs (Airports and Train Stations):

- Precise Resource Allocation: Real-time data exchange between public transportation operators and airport/train station managers enables better decision-making for resource allocation, leading to more efficient operations and enhanced passenger services.
- Streamlined Passenger Flow: By coordinating public transportation schedules with the arrival and departure times at hubs, passenger flow can be better managed, reducing congestion and delays.

G4. Enhanced Passenger On-Demand Services:

- Improved Taxi Services: Providing transport-on-demand providers with accurate information about the number of arriving passengers allows for better taxi dispatching, reducing wait times and improving the overall passenger experience.

- Reduced Congestion: Combining rides for passengers heading to similar destinations can lead to fewer individual taxi trips, reducing congestion on access roads to the airport.

- Environmental Benefits: Reduced congestion and more efficient taxi services can contribute to lower emissions and a greener transportation system.

G5. Accessibility for Passengers with Reduced Mobility (PRMs):

- Seamless Travel Experience: The exchange of information between different transportation modes and the use of indoor mapping technology can make travel more accessible and accommodating for passengers with reduced mobility.

- Inclusive Transportation: By addressing the challenges faced by PRMs during mode transitions, SIGN-AIR promotes inclusive transportation, ensuring that all passengers can use the transportation network with ease.

G6. Disruption Management and Passenger Rights:

- Consistent Passenger Rights: Thoroughly analyzing and improving passengers' rights within multimodal chains ensures that passengers are informed about their rights and receive appropriate assistance in the event of disruptions.

- Seamless Solutions: By addressing the lack of agreements and cross-data integration between various transportation parties, SIGN-AIR aims to provide seamless solutions for passengers facing disruptions during their journeys.

G7. Digitalization, Harmonization, and Standardization of Data:

- Improved Data Sharing: By offering guidelines and establishing connections with crucial tools, SIGN-AIR facilitates data exchange between Transportation Service Providers (TSPs) beyond the platform, leading to improved collaboration and efficiency.
- Adherence to Standards: Encouraging TSPs to adhere to existing standards and European policies ensures data compatibility and consistency, promoting a more unified and interconnected transportation network.

Overall, the implementation of these initiatives as part of the SIGN-AIR project can lead to a more efficient, seamless, and user-friendly multimodal transportation system, benefiting both passengers and transportation service providers.

3.4 Identification of amended or new Standard(s)

Deciding whether to create a new data standard or amend an existing one is a complex task that requires careful consideration of various factors. The difficulty in making this decision arises from several key challenges and considerations, presented below.

Compatibility and Interoperability: An essential aspect of any data standard is its ability to work cohesively with other existing standards and systems. Creating a new data standard could lead to compatibility issues with already established standards, potentially creating data silos and hindering data exchange between different stakeholders. On the other hand, amending an existing standard requires careful analysis of its impact on the current ecosystem, ensuring backward compatibility and smooth transition.

Stakeholder Alignment: Data standards involve multiple stakeholders, including government agencies, private companies, industry associations, and end-users. Each stakeholder may have different requirements, preferences, and vested interests. Deciding on a new standard or amendments requires aligning the diverse needs and finding common ground, which can be challenging and time-consuming.

Industry Acceptance and Adoption: The success of any data standard depends on its widespread acceptance and adoption by relevant industry players. Creating a new standard from scratch may face resistance from those already invested in existing systems. Conversely, amending an existing standard may require convincing stakeholders of the need for changes and overcoming inertia towards adopting new versions.

Time and Resources: Both creating a new standard and amending an existing one require significant time, effort, and resources. Developing a new standard involves research, testing, and validation, while amending an existing standard requires rigorous analysis and impact assessment. Deciding which path to take requires evaluating the available resources and understanding the potential risks and benefits of each approach.

Long-term Viability: Data standards should have longevity and adaptability to changing technological and industry trends. Creating a new standard could potentially lead to challenges in its long-term viability and relevance, especially if technological advancements outpace the standard's capabilities. Amending an existing standard requires careful consideration of its flexibility and potential for evolution to meet future needs.

Governance and Maintenance: Both creating and amending data standards require effective governance and ongoing maintenance. A new standard needs to establish a governing body and processes to ensure continuous development and updates. Similarly, amending an existing standard requires a governance framework that can handle versioning and ongoing maintenance.

Impact on Current Implementations: Decisions about data standards must consider the impact on existing implementations and systems. Creating a new standard could require substantial modifications to current infrastructures, whereas amending an existing standard may necessitate updates and adaptations to align with the changes.

In summary, the decision to create a new data standard or amend an existing one involves weighing technical, organizational, and industry factors. It requires a comprehensive understanding of the current landscape, stakeholder needs, and long-term goals to ensure that the chosen path leads to a cohesive, efficient, and widely adopted solution.

3.5 Technical development support

At this stage the identification of proposed standards development is not clearly defined, hence we are not able to cross reference a respective technical deliverable.

Beneficiaries' logos