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SEMANTICS FOR PERFORMANT AND SCALABLE INTEROPERABILITY OF MULTIMODAL TRANSPORT

D2.1 Initial analysis of requirements of S2R IP4 projects and other EU initiatives

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EXECUTIVE SUMMARY

In order to define a reference architecture for the Shift2Rail IF and facilitate the market uptake, one of the SPRINT's tasks is to define the requirements for the IF of Shift2Rail ecosystem (members of IP4) and external organizations tackling a similar problem of IT interoperability.

This report is the first output of WP2 Task 2.1 on the analysis of S2R IP4 projects and related EU initiatives to support the elicitation of requirements for the C-REL IF architecture design.

The methodology applied to this deliverable included conducting surveys both for the IP4 projects and external initiatives, face-to-face meeting with the CONNECTIVE project and with MASAI & ITxPT, and desk research.

SPRINT defined key topics for the data collection:

- Understanding the interoperability and its environment;
- Data management;
- NAPs;
- Indicators of the processing;
- Network aspects;
- Interoperability services,
- Asset manager;
- Security.

The information was collected and analyzed from:

- ATTRACkTIVE and CONNECTIVE CFM projects;
- Initiatives:
    - The EIF, ERTICO, STA, IDSA, STRIA, EU ITS Platform, MaaS Alliance: desk research;
    - NAP: desk research, questionnaire;
    - ITxPT, MASAI: desk research, face-to-face meeting;
    - TRANSMODEL: questionnaire
- Projects: OASIS; MyCorridor, Data Market Austria.

The work done in this deliverable will be more elaborated in D2.2: Requirements for an IF architectural design (C-REL) – the first output of Task 2.2 on the elicitation of requirements for the C-REL IF architecture design.

ABBREVIATIONS AND ACRONYMS

Abbreviation	Description
APC	Automatic Passenger Counting
API	Application Programming Interface
AVMS	Automatic Vehicle Monitoring
C-REL	Core Release
CCTV	Closed-circuit television
CEN	European Committee for Standardization
CFM	Call for members of Shift2Rail
CRM	Customer Relationship Management
DB	Deutsche Bahn
DCAT	Data Catalog Vocabulary
DNS	Domain Name System
DNS-SD	DNS Service Discovery
DPI	Dynamic passenger information
DRM	Driver Relationship Management
EBSF	European Bus System of the Future (EU-funded project)
EIF	European Interoperability Framework
EU	European Union
FMS	Vehicle Fleet Management System
FMStoIP	Fleet Management System to Internet Protocol
FOAF	Friend of a friend is a machine-readable ontology
GNSS	Global Navigation Satellite System
GSMA	Global System for Mobile Communications Association
GTFS	General Transit Feed Specification
H2020	Horizon 2020 framework programme
HTTP	HyperText Transfer Protocol
IDSA	International Data Spaces Association

IF	Interoperability framework
IP	Internet Protocol
IP4	Innovation Program 4
ISO	International Organization for Standardization
ITxPT	Information Technology for Public Transport
ITS	Information
JSON	JavaScript Object Notation
MaaS	Mobility as a Service
MADT	Multi-application driver terminal
MQTT	Message Queuing Telemetry Transport
NAP	National Access Point
NeTex	Network Timetable Exchange
NFC	Near-field communication
OJP	OJP (Open Journey Planning)
OTA	Over The Air
PCI DSS	Payment Card Industry Data Security Standard
PT	Public Transport
RDF	Resource Description Framework
REST	Representational State Transfer
Protobuf	Protocol buffer
RTIG	Real Time Information Group. Digital Air Interface
S2R	Shift2Rail Joint Undertaking
SIRI	Service Interface for Real-time Information
SOAP	Simple Object Access Protocol
SPARQL	Protocol and RDF Query Language
STA	Smart Ticketing Alliance
STRIA	Strategic Transport Research & Innovation Agenda
TiGR	Telediagnostic for Intelligent Garage in Real time
TSP	Transport Service provider

VEHICLEtoIP	Vehicle to Internet Protocol
WP	Work Package
WSDL	Web Service Definition Language
XML	eXtensible Markup Language
XSD	XML Schema Definition

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1. INTRODUCTION

SPRINT project is a continuation of work that was done for enabling the IF - technical interoperability of heterogeneous, multimodal transport-related services by relieving applications from the task of locating, harmonizing and understanding multiple and independent data and event sources, services, etc. in the frame of Shift2Rail IP4[1] (IT2Rail[2], ST4RT[3], GOF4R[4], CONNECTIVE[5]). Within these projects, a set of core concepts and technologies that are part of the IF was developed. SPRINT aims to improve key aspects of the Shift2Rail IF to bring the market uptake of the multimodal transport ecosystem envisioned by IP4 closer to reality and addresses the following challenges:

- Improve IF performance and scalability to sustain a large deployment.
- Simplify/automate all the necessary steps needed to integrate new services and sub-systems in the IP4 ecosystem.

In order to define a reference architecture for the Shift2Rail IF and facilitate the market uptake, one of the SPRINT's tasks is to define the requirements of Shift2Rail ecosystem (members of IP4) and external organizations tackling a similar problem of IT interoperability.

This report is the first output of WP2 Task 2.1 on the analysis of S2R IP4 projects and related EU initiatives to support the elicitation of requirements for the C-REL IF architecture design.

An analysis of the relevant S2R IP4 projects and their ongoing activities was conducted with a focus on the CONNECTIVE project. All relevant European initiatives that can influence the design of the IF for the realisation of the SERA[6] were analysed as well.

The methodology applied to this deliverable included conducting surveys both for the IP4 projects and external initiatives, face-to-face meeting with the CONNECTIVE project and with MASAI[7] & ITxPT[8], and desk research.

For the preparation of this deliverable SPRINT project used GOF4R D5.1 Deployment Roadmap as a reference that contains an explicit analysis of all initiatives. The outcomes of D2.1 will feed D2.2: Requirements for an IF architectural design (C-REL) – the first output of Task 2.2 on the elicitation of requirements for the C-REL IF architecture design.

2. METHODOLOGY FOR REQUIREMENTS' COLLECTION

The information for this deliverable was collected by three methods:

[1] https://shift2rail.org/research-development/ip4/
[2] http://www.it2rail.eu/
[3] http://www.st4rt.eu/
[4] http://www.gof4r.eu/
[5] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=CONNECTIVE
[6] https://ec.europa.eu/transport/modes/rail/events/single-european-rail-area-sera-events-technical-pillar-4th-railway-package_en
[7] http://masai.solutions/
[8] https://itxpt.org/

- Analysis of initiatives by desk research method: website, issued documents and published requirements and recommendations.
- Analysis of the direct answers through the questionnaire and interviews.
- Face-to-face meeting.

2.1 OVERVIEW OF THE QUESTIONNAIRES AND THEIR GOALS

The questionnaires were composed separately for IP4 projects and initiatives that may be interested in the IF deployment.

The questions for initiatives were produced in such way so SPRINT project could get high-level answers regarding the requirements to the interoperability. The survey was focused on the wide target audience that is why it included all main aspects of the IF and SPRINT's objectives. The key topics touched:

- **Interoperability basics and its environment:** understanding the concept of the interoperability, interoperability issues, domain's standards, policy for data/services access.
- **Data management performance and scalability requirements:** volume of data to be exchanged, frequency of data exchange, type of data.
- **National Access Point:** awareness, the status of realization, datasets to be managed.
- **Availability and reliability requirements:** specific requirements and dependencies.
- **Response-time and speed of processing:** constraints for execution, time-sensitive operations.
- **Network aspects.**
- **Level of automation:** query formation, conversion.

The questionnaire is shown in Annex 1.

The questions for IP4 projects were more focused on the technical aspects of the IF and projects' developments:

- **Interoperability Services:** translation of data, dealing with legacy systems, etc.
- **Asset manager:** type of provided services, consumption of external services, a lifecycle of assets, etc.
- **Security and data sovereignty:** privacy issues, authentication, access control and user restrictions, etc.
- **SPRINT objectives vs CFM projects objectives.**

The questionnaire is shown in Annex 2.

3. REQUIREMENTS FROM S2R IP4 PROJECTS

3.1 BRIEF OVERVIEW OF PROJECTS

In order to get feedback regarding existing requirements to the IF, SPRINT conducted a survey with two IP4 CFM projects: CONNECTIVE and ATTRACkTIVE.

ATTRACkTIVE - Advanced Travel Companion and Tracking Services – project aimed to[9]:

- Provide specification, design and implement a system in charge of collecting travel information from multiple sources, to detect and handle transport events and disruptions for all modes and to provide travel tracking services.
- Specify, design and implement the required techniques and tools to design novel forms of travel experiences, including an advanced travel companion, shielding the traveller from the heterogeneity and complicity of intermodal services and with navigation assistance.

The project launched in 2016 is supposed to be finished by June of 2019.

CONNECTIVE - Connecting and Analysing the Digital Transport Ecosystem – project launched in 2017 deals with the interoperability framework and business analytics.

Its outcomes of the project will provide new levels of interoperability and seamless access to all transport data and services in a multimodal and distributed environment while offering a common business intelligence to extract insights of the ecosystem, valuable for both users and service providers[10].

3.2 SUMMARY

The questionnaire presented in Section 2 was sent to representatives of the CONNECTIVE and ATTRACkTIVE projects, who provided the first round of responses offline. Then, a pair of meetings (one in person, and one via conference call) was held with representatives of the two projects to further discuss their answers and ask for clarifications.

Annex 3 shows the raw answers provided by the project representatives (including the comments gathered during the two meetings), which are summarized and discussed in the rest of this section.

Concerning the **types of data** (in terms of “liveness” of data, rather than contents) handled by the systems developed in the CONNECTIVE and ATTRACkTIVE projects, they handle both **real-time** data (i.e., data that must be handled quickly, though not necessarily within a strict deadline) and also **historical** data (i.e., data that is needed for later elaborations). Real-time data, in this case, corresponds mostly to shopping requests, but also data about disruptions, for trip tracking purposes. Historical data, instead, concerns information such as tariffs and topologies. Data concerning the shopping process (which includes the shopping requests by the users, but also tariffs and topologies) requires conversion from legacy formats. As of now the trip tracking data, instead, does not seem to

[9] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=ATTRACKTIVE

[10] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=CONNECTIVE

require the services of the IF, though this might change in the future. Some of the data exchanged are also **meta-data**, which is data concerning the features of the service interfaces themselves. This meta-data is exchanged infrequently.

The **size of the data** exchanged currently with the services developed by the CONNECTIVE and ATTRACkTIVE projects is rather small, in the order of 10KB. In addition, the frequency of the data exchanged is currently rather low, because the systems are still in a prototype phase. However, once the systems are deployed in a production environment, it is expected that the frequency of requests will increase considerably.

Concerning the **format** of the data exchanged, the format most commonly used in the CONNECTIVE and ATTRACkTIVE projects is TRIAS[11]. However, other data formats are handled, such as GTFS[12]. In any case, a clear need to handle data represented in legacy data formats clearly emerges.

As mentioned above, currently the data handled by the CONNECTIVE and ATTRACkTIVE projects concerns the shopping process and trip tracking services. However, in the Co-Active[13] and MaaSive[14] projects token validation scenarios (and corresponding data) are also being considered.

The CONNECTIVE and ATTRACkTIVE projects are integrating into the IF various services. The more mature ones concern the planning phase of trips; other types of services under development or under consideration include booking, ticket issuing, after sales. The technologies used in the development of these services are rather standard ones. SOAP/XML, REST/XML, REST/JSON are the technologies for the invocation of the services, whereas for their description WSDL and JSON schema are machine-readable formats under consideration. Nevertheless, currently, services developed in the CONNECTIVE and ATTRACkTIVE projects are not annotated with meta-data that facilitates their discovery. Indeed, since the ecosystem is at the moment rather small, there is not a specific need for automated service discovery. However, as the ecosystem grows in size, service discovery is expected to become an issue.

The **creation of services** is done manually. However, the CONNECTIVE and ATTRACkTIVE teams expressed support for techniques that would allow service providers – for example, TSPs – to specify the configuration of their services, which would then be traduced into services (or skeletons thereof).

Access to services implemented by S2R projects is, for the most part, unrestricted. When restrictions needed to be imposed (for example, to limit the types of users that could access certain data, for example, the so-called meta-network of a TSP), they have been implemented on an ad-hoc basis. Some components of the global ecosystem, an, in particular, the server side of the Travel Companion, use JSON Web Tokens (JWT)[15] to control the access to the primitives offered. If any restrictions are necessary, in the future they will be regulated through legal contracts (though currently, no such contracts are in place).

Artefacts handled by S2R projects (e.g., provided services and data) at the moment are not managed through a codified lifecycle for their creation/update/destruction.

[11] https://www.mentz.net/fileadmin/user_upload/PDF_Dokumente/Vortraege/NEW_IT-TRANS_WorkshopVDV_Kohl.pdf
[12] https://developers.google.com/transit/gtfs/
[13] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=CO-ACTIVE
[14] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=MaaSive
[15] https://jwt.io/

Currently, the **discovery of external services** is done manually, as it mostly relies on documentation made available by service providers. Hence, service selection is also done by inspecting the documentation and interacting with service providers. The documentation of external services is sometimes provided through standard technologies such as WSDL, XSD, Swagger[16], JSON schema.

The ecosystem developed within the CONNECTIVE project includes the following components: asset manager, resolvers, converters, triple stores, and implementations of provided services, plus a broker that facilitates the access to these services. Internally, the components that are being developed make use of a variety of semantic Web technologies such as SPARQL and RDF. The ecosystem includes several ontologies, including one derived from the IT2Rail ontology, plus others related to TSPs and the TRIAS standard. These ontologies are used for data conversion purposes, both through a general-purpose, annotations-based mechanism, but also through one-to-one, ad-hoc conversion mechanisms.

4. REQUIREMENTS FROM INITIATIVES

4.1 THE NEW EIF

In this chapter, the new European Interoperability Framework (EIF) will be analysed according to [1]. It is important to clarify that the EIF is the result of an initiative of the European Commission aimed at promoting seamless services and data flows for European public administrations. Therefore, the EIF is a general framework which can be applied to all domains. On the other hand, the Interoperability Framework started by the project IT2Rail and carried out within Shift2Rail IP4 (including the SPRINT project) is a domain specific framework targeted to the transport domain and specifically to seamless multimodal travel services. The EIF is meant to be a generic framework applicable to all public administrations in the EU and it lays out the basic conditions for achieving interoperability The EIF is acting as the common denominator for relevant initiatives at all levels including European, national, regional or local. It is also necessary to mention that the interoperability should be guaranteed in a sustainable way and not as a one-off target or project.

The new EIF gives specific guidance on how to set up interoperable digital public services and it offers recommendations, among other things, on how to improve governance of their interoperability activities or ensure that both existing and new legislation do not compromise interoperability efforts.

The purpose of the EIF is to:

- inspire European public administrations to design and deliver seamless European public services to other public administrations, citizens and businesses,
- provide guidance to public administrations on the design and update of national interoperability frameworks (NIFs), or national policies, strategies and guidelines promoting interoperability,

[16] https://swagger.io/

- contribute to the establishment of the digital single market by fostering cross-border and cross-sectoral interoperability for the delivery of European public services.

The EIF´s structure is as follows:

- 1 x conceptual model,
- 4 x levels of interoperability,
- 12 x underlying principles,
- 47 x recommendations.

4.1.1 Conceptual model

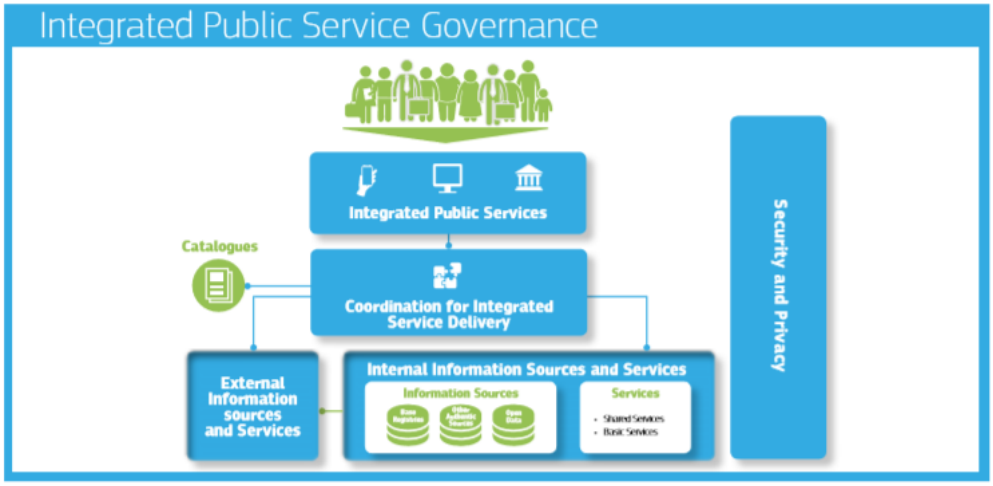

Figure 1: The conceptual model for integrated public services [1]

The model is modular and comprises loosely coupled service components interconnected through shared infrastructure. The conceptual model promotes the idea of interoperability by design. It means that for European public services to be interoperable, they should be designed in accordance with the proposed model and with certain interoperability and reusability requirements in mind because reusability is a driver for interoperability. The following picture shows the basic components of the conceptual model.

The model´s structure comprises:

- ‘integrated service delivery’ based on a ‘coordination function’ to remove complexity for the end-user;
- a ‘no wrong door’ service delivery policy, to provide alternative options and channels for service delivery, while securing the availability of digital channels (digital-by-default);

- reuse of data and services to decrease costs and increase service quality and interoperability;
- catalogues describing reusable services and other assets to increase their findability and usage;
- integrated public service governance;
- security and privacy.

4.1.2 Layers of interoperability

An interoperability model consists of four layers of interoperability:

- **Legal**

Legal interoperability is about ensuring that organisations operating under different legal frameworks, policies and strategies are able to work together. The first step towards addressing legal interoperability is to perform 'interoperability checks' by screening existing legislation to identify interoperability barriers: sectoral or geographical restrictions in the use and storage of data, different and vague data license models, over-restrictive obligations to use specific digital technologies or outdated security and data protection needs, etc.

- **Organisational**

In practice, organisational interoperability means documenting and integrating or aligning business processes and relevant information exchanged. Organisational interoperability also aims to meet the requirements of the user community by making services available, easily identifiable, accessible and user-focused.

- **Semantic**

A starting point for improving semantic interoperability is to perceive data and information as a valuable public asset.

    - In the EIF, semantic interoperability covers both semantic and syntactic aspects:
    - The semantic aspect refers to the meaning of data elements and the relationship between them.

The syntactic aspect refers to describing the exact format of the information to be exchanged in terms of grammar and format.

For example, agreements on reference data, in the form of taxonomies, controlled vocabularies, code lists and reusable data structures/models are key prerequisites for achieving semantic interoperability. Approaches like data-driven-design, coupled with linked data technologies, are innovative ways of substantially improving semantic interoperability.

- **Technical**

The technical interoperability covers the applications and infrastructures linking systems and services. Aspects of technical interoperability include interface specifications, interconnection services, data integration services, data presentation and exchange, and secure communication protocols.

At semantic and technical levels, but also in some cases at an organisational level, interoperability agreements usually include standards and specifications. At a legal level, interoperability agreements are made specific and binding via legislation at EU and/or national level or via bilateral and multilateral agreements.

4.1.3 Underlying principles

The underlying principles are as follows:

- **Principle setting the context for EU actions on interoperability**
    - Subsidiarity and proportionality
- **Core interoperability principles**
    - Openness
    - Transparency
    - Reusability
    - Technological neutrality and data portability
- **Principles related to generic user needs and expectations**
    - User-centricity
    - Inclusion and accessibility
    - Security and privacy
    - Multilingualism
- **Foundation principles for cooperation among public administrations**
    - Administrative simplification
    - Preservation of information
    - Assessment of Effectiveness and Efficiency

4.1.4 Recommendations

The complete list of recommendations is described below:

Recommendation 1: “Ensure that the national interoperability frameworks and interoperability strategies are aligned with the EIF and, if needed, tailor and extend them to address the national context and needs.”

Recommendation 2: “Publish the data you own as open data unless certain restrictions apply”.

Recommendation 3: “Ensure a level playing field for open source software and demonstrate active and fair consideration of using open source software, taking into account the total cost of ownership of the solution.”

Recommendation 4: “Give preferences to open specifications, taking due account of the coverage of functional needs, maturity and market support and innovation.”

Recommendation 5: “Ensure internal visibility and provide external interfaces for European public services.”

Recommendation 6: “Reuse and share solutions and cooperate in the development of joint solutions when implementing European public services.”

Recommendation 7: “Reuse and share information and data when implementing European public services, unless certain privacy or confidentiality restrictions apply”.

Recommendation 8: “Do not impose any technological solutions on citizens, businesses and other administrations that are technology-specific or disproportionate to their real needs.”

Recommendation 9: “Ensure data portability, namely that data is easily transferable between systems and applications supporting the implementation and evolution of European public services without unjustified restrictions, if legally possible.”

Recommendation 10: “Use multiple channels to provide the European public service, to ensure that users can select the channel that best suits their needs.”

Recommendation 11: “Provide a single point of contact in order to hide internal administrative complexity and facilitate users´ access to European public services.”

Recommendation 12: “Put in place mechanisms to involve users in analysis, design assessment, and further development of European public services.”

Recommendation 13: “As far as possible under the legislation in force, ask users of European public services once-only and relevant-only information.”

Recommendation 14: “Ensure that all European public services are accessible to all citizens, including persons with disabilities, the elderly and other disadvantaged groups. For digital public services, public administrations should comply with e-accessibility specifications that are widely recognized at European or international level.”

Recommendation 15: “Define common security and privacy framework and establish processes for public services to ensure secure and trustworthy data exchange between public administrations and in interactions with citizens and businesses.”

Recommendation 16: “User information systems and technical architectures that cater for multilingualism when establishing the European public service. Decide on the level of multilingualism support based on the needs of the expected users.”

Recommendation 17: “Simplify processes and use digital channels whenever appropriate for the delivery of the European public services, to respond promptly and with high quality to users´ requests and reduce the administrative burden on public administrations, businesses and citizens.”

Recommendation 18: “Formulate a long-term preservation policy for information related to the European public services and especially for information that is exchanged across borders”.

Recommendation 19: “Evaluate the effectiveness and efficiency of different interoperability solutions and technological options considering user needs, proportionality and balance between costs and benefits.”

Recommendation 20: “Ensure holistic governance of interoperability activities across administrative levels and sectors.”

Recommendation 21: “Put in place processes to select relevant standards and specifications, evaluate them, monitor their implementation, check compliance and test their interoperability.”

Recommendation 22: “Use a structured, transparent, objective and common approach to assessing and selecting standards and specifications. Consider, relevant EU recommendations and seek to make the approach consistent across borders.”

Recommendation 23: “Consult relevant catalogues of standards, specifications and guidelines at national and EU level, in accordance with your NIF and relevant DIFs, when procuring and developing information and communication technologies (ICTs) solutions.”

Recommendation 24: “Actively participate in standardization work relevant to your needs to ensure your requirements are met.”

Recommendation 25: “Ensure interoperability and coordination over time when operating and delivering integrated public services by putting in place the necessary governance structure.”

Recommendation 26: “Establish interoperability agreements in all layers, complemented by operational agreements and change management procedures.”

Recommendation 27: “Ensure that legislation is screened by means of ‘interoperability checks’, to identify any barriers to interoperability. When drafting legislation to establish the European public service, seek to make it consistent with relevant legislation, perform a “digital check” and consider data protection requirements.”

Recommendation 28: “Document your business processes using commonly accepted modelling techniques and agree on how these processes should be aligned to deliver the European public service.”

Recommendation 29: “Clarify and formalize your organisational relationships for establishing and operating European public services.”

Recommendation 30: “Perceive data and information as a public asset that should be appropriately generated, collected, managed, shared, protected and preserved.”

Recommendation 31: “Put in place an information management strategy at the highest possible level to avoid fragmentation and duplication. Management of metadata, master data and reference data should be prioritized.”

Recommendation 32: “Support the establishment of sector-specific and cross-sectoral communities that aim to create open information specifications and encourage relevant communities to share their results on national and European platforms.”

Recommendation 33: “Use open specifications, where available, to ensure technical interoperability when establishing the European public services.”

Recommendation 34: “Use the conceptual model for the European public services to design new services or reengineer existing ones and reuse, whenever possible, existing service and data components.”

Recommendation 35: “Decide on a common scheme for interconnecting loosely coupled service components and put in place and maintain the necessary infrastructure for establishing and maintaining the European public services.”

Recommendation 36: “Develop a shared infrastructure of reusable services and information sources that can be used by all public administrations.”

Recommendation 37: “Make authoritative sources of information available to others while implementing access and control mechanisms to ensure security and privacy in accordance with the relevant legislation.”

Recommendation 38: “Develop interfaces with base registries and authoritative sources of information, publish the semantic and technical means and documentation needed for others to connect and reuse available information.”

Recommendation 39: “Match each base registry with appropriate metadata including the description of its content, service assurance and responsibilities, the type of master data it keeps, conditions of access and the relevant licences, terminology, a glossary, and information about any master data it uses from other base registries.”

Recommendation 40: “Create and follow data quality assurance plans for base registries and related master data.”

Recommendation 41: “Establish procedures and processes to integrate the opening of data in your common business processes, working routines, and in the development of new information systems.”

Recommendation 42: “Publish open data in machine-readable, non-proprietary formats. Ensure that open data is accompanied by high quality, machine-readable metadata in non-proprietary

formats, including a description of their content, the way data is collected and its level of quality and the licence terms under which it is made available. The use of common vocabularies for expressing metadata is recommended."

Recommendation 43: "Communicate clearly the right to access and reuse open data. The legal regimes for facilitating access and reuse, such as licenses, should be standardized as much as possible."

Recommendation 44: "Put in place catalogues of public services, public data, and interoperability solutions and use common models for describing them."

Recommendation 45: "Where useful and feasible to do so, use external information sources and services while developing European public services."

Recommendation 46: "Consider the specific security and privacy requirements and identify measures for the provision of each public service according to risk management plans."

Recommendation 47: "Use trust services according to the Regulation on eID and Trust Service as mechanisms that ensure secure and protected data exchange in public services."

As it is described above, the new EIF contains, among other things, a wide range of recommendations regarding interoperability framework including the principles which can be also considered as requirements for the design of the IF.

4.2 ERTICO

ERTICO[17] – ITS Europe was founded by the initiative of the European Commission and the industry leaders to fill the gap between research and deployment of mobility services on roads. ERTICO is a public-private partnership of 120 companies and organisations which develop, promote and deploy Intelligent Transport Systems and Services. Likewise, ERTICO promotes and facilitates the rollout of Intelligent Transport Systems and Services in Europe through a variety of European co-funded projects, Innovation Platforms or international cooperation.

4.2.1 Focus of ERTICO

Focus areas of ERTICO are as follows:

- **Connected & Automated Driving**

There are highly automated vehicles and many of them are collecting a large amount of real data that can be used to train deeper their machine learning algorithms. In this area, there are a number of platforms, such as ADASIS[18] or SENSORIS[19] and also European policy activities as STRIA etc. Among the current objectives, it is possible to include support for interoperable, reliable and compliant connectivity for automation. This is done by supporting C-ITS (Cooperative Intelligent Transport Systems) and interoperability testing to ensure that devices are interoperable because of that the emphasis on interoperability of services at application level increases.

[17] https://ertico.com/
[18] https://adasis.org/
[19] https://sensor-is.org/

- **Clean Mobility**

Deployment of intelligent transport solutions can help reduce the carbon footprint and emissions. For this reason, it is necessary that systems and services need to be made more efficient and attractive through interoperability and better information. One of the particular examples of the solution is interoperable electric vehicle charging. Through eMI3 [2] (ERTICO's innovation platform – e-Mobility ICT Interoperability Innovation Group), clear pan-European interoperability rules are defined.

In particular, for the eMobility market, interoperability leads to non-discriminatory eMobility services (charging, navigation etc.) without limitation and with a coherent service quality level at an optimized price.

In this case, there are three kinds of interoperability concerns:

  - Establishing a fair business case for all actors respecting investments and operating costs (interoperability needs to be low-cost in order to retain innovation and sustainability).
  - Define clear interoperability rules and pieces of evidence
  - Ensure pan-European coherent and equivalent service level

- **Transport & Logistics**

Current topics within this domain are, for example, supply chain integration, multimodal transport, consolidation of deliveries, reverse logistics and also digitalisation process of transport networks and infrastructure. The aim is to develop solutions for connecting logistics information systems with different characteristics and which are based on the real-time exchange of information.

In particular, ERTICO is developing the European Digital Innovation Hub for supply chain and logistics. The Hub is overcoming the fragmentation of data exchange in the supply chain and is ensuring scalability and also interoperability.

- **Urban Mobility**

In this area, ERTICO strives to create a wide-spread deployment of a new generation of cooperative applications, digital infrastructure and personalised mobility services and it is Mobility as a Service (MaaS) which creates new ways to use and pay for mobility. So, the aim is to create a single market for MaaS. To achieve this goal, ERTICO is working on guidelines and the framework for MaaS deployment interoperability.

- **Cross-Sector**

The idea of the Cross-Sector area is that progress made in one area seeps into the others. This progress is for example standardisation, interoperability or smart mobility knowledge centres. The interoperability is necessary because devices and data platforms are likely to provide data in different formats or to use incompatible communication interfaces. Interoperability is addressing this aspect while providing the ability for devices and systems to exchange consistent data using compatible and thus interoperable formats and interfaces. Last but not least, standardisation is the key enabler for interoperability.

4.3 EU ITS PLATFORM

EU ITS Platform (EU EIP)[20] is a point of cooperation to promote, accelerate and optimize the future traffic data by deploying them in a harmonized way. This encourages the development of an integrated network by employing intelligent transport systems as well as uniform technical standards. Below we describe the most relevant projects in terms of data management[21]:

- **Arc Atlantique:** It is a project of improvements in the road network with vital strategies with the objective of implementing an efficient and multimodal transportation network.
- **Crocodile:** It establishes that each transport authority, public or private, implements an infrastructure for data exchange based on DATEX II[22].
- **EU EIP:** Encourages the development of an integrated network improving the use of the infrastructure through the use of intelligent transport systems.

The revised projects focus more on the management of traffic data and basically, all the proposed systems are supported by DATEX II model, which is a standard model at European level for the exchange of data related to traffic.

This standard does not support semantic interoperability but a possibility could be to study if the transformation of DATEX II to an ontology would improve the management and interoperability among the used datasets, as it has identified in the public transport where efforts in the transformation of NeTEx[23] to a corresponding ontology have started.

4.4 NAP

The “DIRECTIVE 2010/40/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport”[24] establishes a framework in support of the coordinated and coherent deployment and use of Intelligent Transport Systems (ITS) within the Union, in particular across the borders between the Member States, and sets out the general conditions necessary for that purpose.
It identifies “Priority Areas” as follows:

- Optimal use of road, traffic and travel data,
- Continuity of traffic and freight management Intelligent Transport System (ITS) services, ITS road safety and security applications, —
- Linking the vehicle with the transport infrastructure

[20] https://www.its-platform.eu/
[21] https://www.its-platform.eu/projects
[22] https://datex2.eu/
[23] http://netex-cen.eu/
[24] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:207:0001:0013:EN:PDF

and for each Priority Area lists the following “Priority Actions”:

a) the provision of EU-wide multimodal travel information services (MMTIS)

b) the provision of EU-wide real-time traffic information services (RTTI)

c) data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users (SRTI)

d) the harmonised provision for an interoperable EU-wide eCall;

e) the provision of information services for safe and secure parking places for trucks and commercial vehicles (SSTPA)

f) the provision of reservation services for safe and secure parking places for trucks and commercial vehicles.

Specific Commission Delegated Regulations 2017/1926[25], 2015/962[26], 886/2013[27] and 885/2013[28] supplementing Directive 2010/40/EU apply to the provision of data and/or services for priority actions a), b), c) and e) respectively. All four Delegated Regulations require Member States to manage National Access Points as “single points of access for users” of data, although with some variations across the priority areas. For example, 885/2013 (SSTPA) includes the notion of *international* access points to which Member States may contribute data, and National Access Points are made the subject of a specific article in the 2015/962 and 2017/1926 Delegated regulations only. Additionally, there is no explicit requirement that MMTIS, RTTI, SRTI and SSTPA National Access Points be the same for the same Member State, and the recommended data standards are also different for the different MMTIS, RTTI, SRTI and SSTPA National Access Points.

The current status of implementation of National Access Point is described in the EU EIP Annual NAP Report - 2018[29] published by the European ITS Platform (EU-EIP) grouping National Ministries, Road Authorities, Road Operators and partners from the private and public sectors of almost all EU Member States and neighbouring countries, cooperate in order to foster, accelerate, and optimise current and future ITS deployments in Europe in a harmonised way. The report, published March 1st 2019, is also available as an interactive map at https://www.cestrin.ro/web2014/nap_eueip/.

Two of the main findings of the report are stated as:
(General) *An overview of the NAPs across Europe shows that the NAPs vary in system architecture, organisation, monitoring of data users, accessibility, etc. Thus, there is a need for a more coordinated approach and exchange of ideas and best practices.*

(Specific to MMTIS) *Several countries across Europe are taking their first steps in introducing Multimodal Travel Information in their respective National Access Points. With the adoption of the new Delegated*

[25] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32017R1926&from=EN
[26] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32015R0962&from=EN
[27] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32013R0886&from=NL
[28] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32013R0885&from=NL

[29] https://www.its-platform.eu/filedepot_download/1971/6491

Regulation on the provision of EU-wide multimodal travel information services, "suggesting" the user of NeTEx and SIRI protocols, an important challenge emerged, that is to make all the existing applications compatible with the new orientations.

Included in these findings is the expression of two important requirements, namely

- a need for a more coordinated approach and exchange of ideas and best practices
- to make all the existing applications compatible with the new orientations (e.g. NeTEx and SIRI).

Following the developments of the IT2Rail and ST4RT projects, the SPRINT refinement of the Interoperability Framework semantic integration technologies can provide the tooling necessary to meet those requirements as follows:

- Accommodating legitimate variations in the organization and application management functionalities of NAPs that may be better adapted to prevailing conditions in different Member States while preserving, at the same time, the necessary commonality of interoperability services. This approach can reduce the cost and the effort of top-down coordination across Member States
- Automating the conversion across data specifications and therefore guaranteeing 'compatibility with the new orientation' without the need for synchronized development effort.

An initial assessment and conceptual approach towards both objectives is available in A. Carenini, M. Comerio, I. Celino, "Semantic-enhanced National Access Points to Multimodal Transportation Data", International Semantic Web Conference 2018, Monterey, CA[30].

4.4.1 Austrian National Access Point

AustriaTech, the host of the Austrian NAP[31], provided the answers to the questionnaire that may be found in Annexe 4.

AustriaTech sees interoperability as an enabler for continuity and added value against the background of a targeted purpose and should be pursued between entities if various components along a value chain can add to the process itself and the overall quality of the outcome in a way that would not have been possible without interconnecting them. If interoperability by design is not possible, any facilitators of interoperability should come with a minimum of effort to implement and a maximum of effect. NAP conceptualizes an interoperable ecosystem as a framework which facilitates communication and interaction with other systems to create added value for users and end-users where it would not have been possible otherwise. Interoperability must not be an end to itself, but be a crucial step on the way to a goal. Moreover, AustriaTech feels a need for the interoperability in their organization as they are hosting the National Access Point.

AustriaTech is aware that EU transport authority, operator and infrastructure manager have to allow access to transportation data due to EU Regulation (EU 2017/1926). Also, there is the project

[30] http://ceur-ws.org/Vol-2180/paper-09.pdf
[31] www.mobilitydata.gv.at

PrioAustria which AustriaTech coordinates is about implementing necessary interfaces and creating stakeholders' awareness.

NAP as "administrator" provides metadata about available road safety-related universal traffic information. The priorities and most significant challenges regarding the regulation are raising awareness among those who are considered and make them comply with the delegated regulations (i.e., making data/services available through the NAP and providing self-declarations). AustriaTech's current efforts focus on a typical NeTEx profile and a harmonised metadata catalogue for interconnecting NAPs across Europe.

AustriaTech is willing to share all data sets listed in the delegated regulations via the NAP with registered users and the public. Public users are only able to read and download metadata and information, which are provided by a respective registered user. The full functionalities of the NAP are only available for registered users. Registered users can provide metadata about traffic information and other information. The use of the NAP is free of charge for non-profit and commercial purposes. The type of data AustriaTech mainly operates upon is meta-data as it is interested in "data about data" in a structured and standard manner so it could discover, retrieve, process, analyse and utilise the desired information and knowledge using them.

The introduction of a new service in AustriaTech depends on the specific provisions of the delegated regulations, the NAP can be regularly amended and can consequently be a subject to revision from time to time. The administrator reserves the right, at its discretion, to amend and modify the NAP at any time without any prior notice. The service of the NAP in itself does not change.

4.5 STA

Smart Ticketing Alliance[32] originated from the desire to have interoperability between upcoming regional and national public transport electronic ticketing systems, integrate and publish functional and technical needs of such systems and collaborate with other European and International bodies to promote interoperability in smart ticketing. To achieve this, a focus has been on the customer media while allowing for the concept of dynamic and multiple applications.

The Alliance drives a coordinated effort towards global ticketing interoperability for the public transport sector. The STA was founded in 2015 as the follow up to the IFM project[33]. The term "Smart ticketing" refers to new technologies and integration of services not directly linked to the basic functions of tickets. The main issues smart ticketing is facing are providing complementary services related to users' mobility, improving the relationship between users and their tickets and the public transport operator and their tickets, and increasing public transport efficiency as well as the depth of data created through usage, with the arrival of ITS, the ticketing system has incorporated an important statistical function that permits its operator to better know the transport network usage by tracking its user (whilst respecting the privacy rights) [3].

Smart ticketing can work as one wallet for several tickets of the user's journeys to use a combination of trips and services which will participate in the total enhancement of the level of services, image,

[32] https://www.smart-ticketing.org/
[33] https://cordis.europa.eu/project/rcn/85567/factsheet/en

and accessibility of public transport network aiming to increase public transport users. Within the guidelines, potential implementation of smart ticketing requires:

- Using a dedicated application;
- Smart Ticketing based on the virtualization of tickets;
- Smart Ticketing based on secure identity and back-office processing.

The implementation of smart ticketing represents a response for users' needs (more accessibility and fairness), public policy needs (decreasing the number of car users, reduction of pollution and reducing public expenses) and transport operators' needs (reducing operational costs of ticketing, improving fare collection efficiency, improving knowledge of customers' behavior/choices/preferences). In addition, smart ticketing gives the chance to provide to the customers with additional/alternative fare possibilities without cancelling traditional paper or magnetic ticketing [3].

To deploy smart ticketing, a recommendation should be considered: the ticketing system can be described as smart if it allows implementation of public transport fare policy at the level of the whole public transport network which requires full authority and clear code.

In order to ensure interoperability from standard perspective, STA makes use of standards and specifications published by Organizations for Standards, bodies such as CEN and ISO; and other membership bodies such as GSMA, the NFC Forum, etc. The public transport industry has an advantage over other industries as its e-Ticketing infrastructure is compatible with NFC technology which gives the chance to provide a mobile service based on the available infrastructure.

NFC may be used for replacing a customer card or token, as personal mobile sales terminals, to provide a customer with access to traffic, a time table and fare information which will improve classical fare management systems. However, NFC Mobile Devices (NMD) is required to be technically interoperable with the contactless readers and a PT object that are used for ticketing and payment in Public Transport (STA, n.d.).

The NFC business processes definition should cover the entire life-cycle of PT cycle from creating a personal account to payment, therefore, a customer can cover all steps of the service life-cycle seamlessly by using the mobile device which is one of the requirements for successful implementation of mobile e-Ticketing services.

In addition, STA considers it is essential that public authorities and users can be confident in the quality of contactless communication between contactless readers and fare media. Certification is the appropriate means to give trust. The STA certification program established by STA consists of a Group of Certification Bodies (GCB) bringing together Certification Bodies (CBs) authorized to certify compliance of transportation and acceptance media with the CEN technical specification TS 16794 about contactless communication. Extension of the certification scope to other technical fields, such as the application layer, may be decided later [4].

The objective of the STA Group of Certification Bodies is to establish a common approach to conformity certification and the technical equivalence of certification carried out by the STA Group of Certification Bodies' members. The members work collectively to achieve these aims but remain

independent certification bodies being responsible for their own decisions and for the control of their different certification marks. The STA Group of Certification Bodies (STA GCB) works as a platform to ease mutual recognition between the member certification bodies (and the testing laboratories for product testing) and to limit the costs of those agreements. A primary goal of the STA GCB is to ensure that the certification bodies and the associated testing laboratories operate on a common basis. The main principles of the STA certification program are the following:

- a Group of Certification Bodies (GCB) gathers Certification Bodies (CB) authorized to certify compliance with CEN TS 16794;
- Membership of GCB is open to two categories of CB:
  1. CB accredited according to ISO/IEC 17065 against CEN TS 16794;
  2. Provisional membership during a temporary period: CB having successfully completed the eligibility application with its National Accreditation Body or already accredited for a scope closely related to CEN TS 16794.

4.6 MaaS Alliance

The Mobility as a Service (MaaS) Alliance[34] was established in 2015, following the launch of the MaaS concept at the ITS European Congress in Helsinki in 2014. The MaaS Alliance is a public-private partnership creating the foundations for a common approach to MaaS, unlocking the economies of scale needed for successful implementation and take-up of MaaS in Europe and beyond [5]. The main goal is to facilitate a single, open market and full deployment of MaaS services:

- Integrate various forms of transport services into a single mobility service accessible on demand.
- Facilitate a diverse menu of transport options: public transport, ride-, car- or bike-sharing, taxi or car rental/lease, or a combination thereof.
- Provide access to mobility through a single application with a single payment channel instead of multiple ticketing and payment operations.
- Create new business models and ways to organize and operate the various transport options, with advantages for transport operators including access to improved user and demand information and new opportunities to serve unmet demand. The aim of MaaS is to provide an alternative to the use of a private car that may be as convenient, more sustainable, help to reduce congestion and constraints in transport capacity, and can be even cheaper.
- Make MaaS is a user-centric, customer-centric, market-centric proposition within a societally grounded context.
- Propose shared work program engaging transport operators, service providers and users.

[34] https://maas-alliance.eu/the-alliance/

- Make MaaS the best value proposition for both private and business users, by helping them meet their mobility needs and solve the inconvenient parts of individual journeys, as well to improve the efficiency of the entire transport system.

The alliance plays a significant role in promoting the value of MaaS, monitoring the MaaS market and influence the European policymaking. The evolving of MaaS market is based on access and openness data, open APIs and more flexible transport and mobility regulations [5]. It is required to encourage all market players and avoid stifling innovation when defining regulatory principles for a digitalized transport system as open IT architecture and standardised sub-element features, such as payment, ticketing, authentication and security are required to maximise the development of the MaaS market by building safe payment channels (compliance with PCI DSS), giving the option of anonymous trips for traffic management, traffic planning and urban planning purposes [6]. One of the requirements that should be considered while building a MaaS system within the Interoperability framework is exchanging high-quality data with the principles of openness and inclusivity which means opening the ecosystem to all service providers for all different kind of users, including persons with reduced mobility or disabilities. Also, the design of the value chain should meet the high expectations related to ecological and financial sustainability to build attractiveness and public acceptance for MaaS services [5].

It is highly important to mention the significant role of users in the MaaS ecosystem as the fundamental principle of MaaS is based on user-/customer-centric view in a societally grounded framework, with a market-centric approach. In the MaaS ecosystem, every user is characterised by a unique identity, which is built on different attributes (their own set of personal preferences, financial profile, physical characteristics and past behaviours). To deliver personalized offerings, service providers have to recognize, serve and safeguard the individual preferences of every user for MaaS. Users should have the possibility to manage their own data and minimize the data collected, processed and stored by the providers. The user's trust in MaaS relies on the ability of the whole ecosystem to foresee and/or adapt to potential needs and requests of the user, [6]. Also, convenience is highly important to users as it is required to clearly inform them of the ranking policy by the MaaS providers, compensation in the case of inconvenience service, personalised transfer information, planned journey depending on the user's need and providing the users with ranking of services based on their preferences [6].

Finally, MaaS ecosystem should include the following components:

1. **Infrastructure:**

As for any transport mode, the infrastructure components are the base for vehicles operation:

- Pavements
- Road/rail networks
- Charging infrastructure
- Stops for public transport
- Parking capabilities

2. **Drivers and vehicles**

Currently, they are cars, small and large buses, trams, underground systems, bicycles which are the moving hardware above the infrastructure.

3. **Transport Service Providers**

Uni-modal transportation offered by transport service providers which include a CRM, a DRM, ticketing, billing and clearing capabilities, as well as a routing/dispatching engine.

4. **Mobility Service Providers**

A multi-modal done by integrating different transport providers.

5. **Passengers**

MaaS users via mobile phone apps or browser apps.

4.7 ITxPT

The ITxPT (Information Technology for Public Transport) is the association that enables interoperability between IT systems in Public Transport by offering public specification of IT architecture based on standards with open interfaces for onboard, over-the-air and back-office IT systems[35].

It provides public transport authorities and operators with recommendations and requirements to support the purchase and integration of interoperable IT architecture. What is more, industry suppliers use the specifications to design ITxPT-compliant equipment and services. It also provides a framework for how to design hardware and software so that modules can be integrated into a coherent architecture. This simplifies IT suppliers' access to the market and gives purchasers the flexibility to select services and components from many different providers. ITxPT should be understood as an agreement between many public transport stakeholders to enable digitalization and integration of mobility services.

ITxPT defines interoperability on 3 levels[36]:

1. **Hardware level:** Installation rules, space requirements, connectors, etc.
2. **Communication protocol level:** Interfaces, declaration of service, etc.
3. **Service level:** List of services, format of the service, format of data etc.

ITxPT supports the incentives for the transition from proprietary systems to an open integrated architecture based on established standards. ITxPT is interested in enabling data exchange in traffic systems in the following areas: autonomous vehicles, electrification and charging infrastructures,

[35] https://itxpt.org/
[36] https://itxpt.org/technology/itxpt-specifications/

multi-modal transportation, Mobility-as-a-Service concepts. The main target audience of the ITxPT is IT suppliers, authorities & operators, and vehicle manufactures.

In February 2019, the joint meeting with the representatives of SPRINT, MASAI, ITxPT and Shift2Rail was held in Paris. SPRINT used this opportunity to reveal high-level requirements of ITxPT and MASAI.

At this moment, the specifications of ITxPT covers onboard systems and company2company communication. It does not adapt to existing environment (to each transport operator), but it's a complete/full solution. ITxPT has started from the hardware solutions and didn't think yet how to "package" the high-level solutions, so the possibility to be integrated with the S2R IF.

Despite ITxPT created their own specifications, they have started to deal also with legacy data models. TRANSMODEL family of standards are taken into account as a single reference datamodel.

If the organisation (device providers and vehicle providers) wants to join ITxPT, it has to be certified. ITxPT architecture describes a set of services and the way these services interact or exchange information using an IP network in order to satisfy these needs. ITxPT specifications for the interoperability contain four parts: installation, onboard, back-office and over-the-air. Content of the specifications is the following:

S 01 Installation requirements specifications: first level of the interoperability. It describes the installation requirements to pre-equip vehicles with compliant ITxPT On-board Architecture and PT networks with Back-office Architecture.

- Power supply interface;
- FMS interface;
- Other interfaces (audio, antenna, wireless, etc.);
- IP network
- Space: inside the vehicle (volume, area) if it is enough space to install;
- On-board IP;
- Harness.

S 02 On-board architecture specifications:

- Protocols DNS and MQTT
- Module inventory;

- Time service;
- GNSS location;
- FMStoIP;
- VEHICLEtoIP;
- AVMS;
- APC;
- MADT;
- MQTT Broker.

S 03 Back-office architecture specifications:

- Architecture;
- TRANSMODEL;
- NeTEx;
- SIRI;
- OJP;
- TiGR.

S 04 Over-the-air architecture specification:
Which type of data can be standardised between vehicle and back-office

- MQTT bridge OTA;
- Protobuf;
- EBSF;
- RTIG.

Moreover, ITxPT has the following working groups:

- **FMS needs collection:** analyse feedback from FMS group regarding ITxPT collection needs and evaluate impact for coming FMS release;

- **MQTT:** identify relevant use case to implement MQTT, define related MQTT services specification (content and data structure);
- **Additional IP services:** define a specification for new services such as DPI for formatted data in relation to Passenger, Information, CCTV, bandwidth announcement and low battery;
- **Security:** perform the risk analysis with the consultant and issue recommendations;
- **Over the air protocol:** analysis return from experiences and update of S04;
- **SIRI/NeTEx:** Preparation of EU call in the frame of EU priority action A: training action and Project Support Action (PSA);
- **PT Trends to specification strategy:** understand an impact of current and future trends (electrification, autonomous vehicles, mobility as a service, cooperative ITS, zero emission, etc.) to roadmap for developing the ITxPT specification;
- **Virtualization:** define technical solutions to decouple services from hardware, host multiple application on common hardware and define impact and requirements on ITxPT specification;
- **Responsibility Model for interoperability:** legal, commercial, governance aspects when building an integrated ITxPT architecture.

Finally, ITxPT created three deployment guidelines:

- **G01 – Vehicle Installation Guidelines:** this guideline may help to integrate in plant and in retrofit ITxPT modules and services;
- **G02 – Vehicle and Interface with Back-office Systems Guidelines:** this guideline may help the deployment of ITxPT architecture (equipment and applications);
- **G03 – Back-office Systems Interoperability Guidelines:** This guideline may help to implement at back office level an ITxPT IT architecture.

Thus, ITxPT can be interested in ontologies and putting stakeholders together, the right place for the processing of the TSP's needs.

4.8 MASAI

MASAI (MOBILITY BASED ON AGGREGATION OF SERVICES AND APPLICATIONS INTEGRATION), an EU-funded project addressed the interconnection of digital services to facilitate mobility in heterogeneous and varying environment, continued to develop after the project was finished in 2018[37]. MASAI designed the system in the field a MObility Open Network of Services (MOONS) as an interconnected distributed environment, on which any service module can be easily

[37] https://cordis.europa.eu/project/rcn/193390/factsheet/en

plugged to interact with others (using principles such as DNS-SD). Now, MASAI is an ecosystem of service providers and concierges in the travel, mobility and tourism sector[38].

MASAI standardizes service provider APIs and provides concierges with service discovery tools to aggregate these services. MASAI has a centralized publication system (directory service) managed by MASAI association. The directory contains "Concierge apps and modules" and "Services". All organizations involved in MASA has to comply with MASAI's APIs and implement their specifications. To build an app, the developed has to use a special SDK. Stakeholders of MASAI can be a concierge or a service provider, or both. The service provider is interested in promoting the service, so joining MASAI they can ensure their service is available for inclusion in MASAI-derived apps and other tools. The concierge wants to improve travel experience of his customers, so it contributes a model to connect travellers with MASAI services.

MASAI in the Travel & Tourism ecosystem:

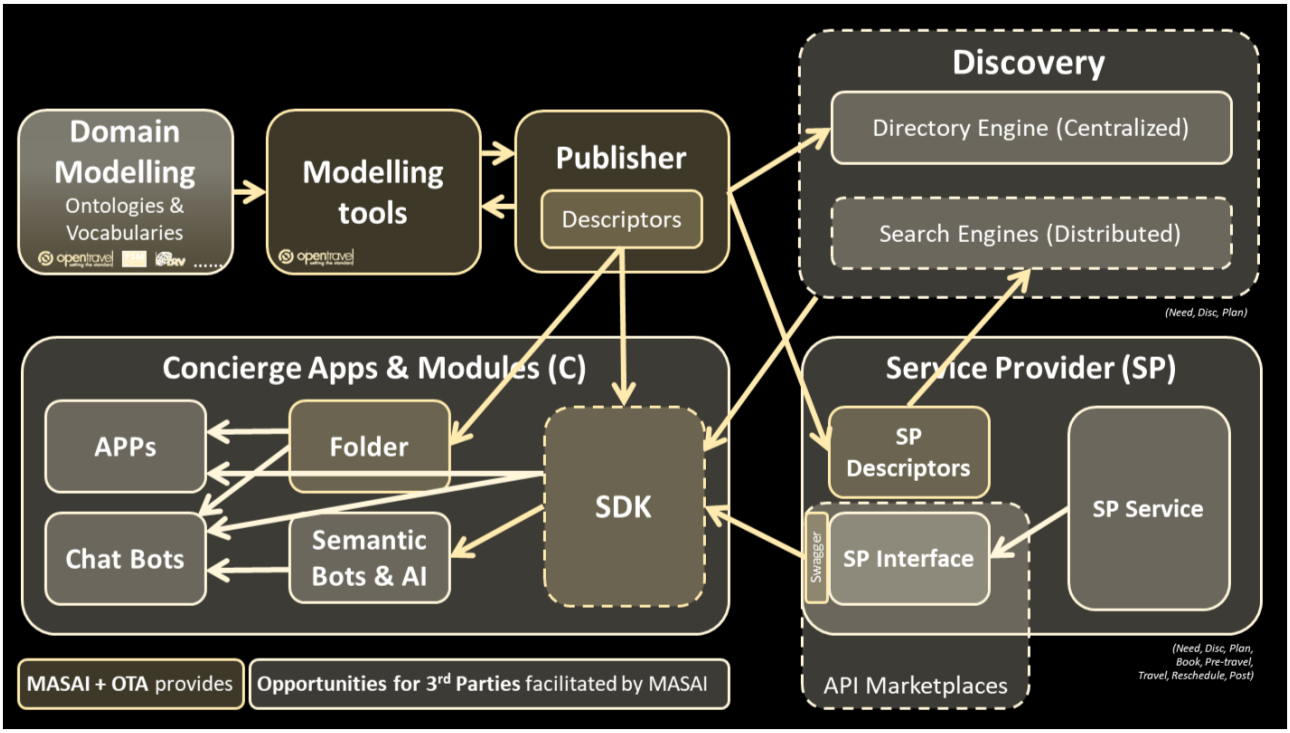

Figure 2: MASAI's ecosystem

Source: MASAI presentation

MASAI started their work with Open Travel[39] and now expands to other standardisation areas with a dynamic complementing and aggregation.

Use cases of MASAI:

[38] http://masai.solutions/

[39] https://opentravel.org/

- **Nice pilot use case.** Provide an e-concierge application for delegates to organize a touristic trip when they have free time.
- **Portugal pilot use case.** Enabling long-distance bus service provider to aggregate their services and expand their business.
- **Trans Europe use case.** Integrate a broad range of service providers by powering the concierge DB Reisebuddy with MASAI.

According to the analysis done by SPRINT, MASAI can be interested in:

- Ontologies;
- Orchestration (assembling offers) concierge;
- Folder (wallet) - Travel companion;
- Security mechanisms;
- Putting stakeholders together.

4.9 IDSA

A data-driven business ecosystem is an ecosystem in which data is the strategic resource used by the members to jointly create innovative value offerings. Key to success is to share and jointly maintain data within such an ecosystem, as end-to-end customer process support can only be achieved if the partners' team up and jointly utilize their data resource. Since data is turning into a strategic resource, and companies increasingly collaborate in business ecosystems, a fundamental conflict of goals arises as a main characteristic of the digital economy. On the one hand, companies increasingly need to exchange data in business ecosystems. On the other hand, they feel they need to protect their data more than ever before since the importance of data has grown so much. This conflict of goals is all the more intensified, the more a company is engaged in one or more business ecosystems, and the higher the value contributed by data to the overall success of the collaborative effort. Data sovereignty is about finding a balance between the need for protecting one’s data and the need for sharing one’s data with others. It can be considered a key capability for companies to develop in order to be successful in the data economy.

By proposing architecture for secure data exchange and trusted data sharing, the International Data Spaces contributes to the design of enterprise architectures in commercial and industrial digitization scenarios. The International Data Spaces positions itself as an architecture that links different cloud platforms through policies and mechanisms for secure data exchange and trusted data sharing (or, in other words, through the principle of data sovereignty). Over the IDS Connector, the International Data Space’s central component, industrial data clouds, as well as individual enterprise clouds, on-premises applications and individual, connected devices can be connected to the International Data Spaces.

IDSA defines the following major roles related to its data ecosystem:

- Data owner: it is the legal entity or natural person creating data and/or executing control over it. This enables the Data Owner to define Data Usage Policies and provide access to its data.
- Data provider: it makes data available for being exchanged between a Data Owner and a Data Consumer.
- Data consumer: it receives data from a Data Provider. From a business process modelling perspective, the Data Consumer is the mirror entity of the Data Provider; the activities performed by the Data Consumer are therefore similar to the activities performed by the Data Provider.
- Data user: it is the legal entity that has the legal right to use the data of a Data Owner as specified by the usage policy.
- Data app: applications that can be deployed inside the Connector, the core technical component required for a participant to join the International Data Spaces. Data Apps facilitate data processing workflows.
- App provider: it develops Data Apps to be used in the International Data Spaces, and publishes them in the App Store for being accessed and used by Data Consumers and Data Providers.
- Broker service provider: it is an intermediary that stores and manages information about the data sources available in the International Data Spaces. As the role of the Broker Service Provider is central but non-exclusive, multiple Broker Service Providers may exist at the same time.
- Clearinghouse: it is an intermediary that provides clearing and settlement services for all financial and data exchange transactions.
- Identity provider: it offers a service to create, maintain, manage, monitor, and validate identity information of and for participants in the International Data Spaces. It consists of a Certification Authority (managing digital certificates for the participants of the International Data Spaces), a Dynamic Attribute Provisioning Service (DAPS, managing the dynamic attributes of the participants), and a service named Dynamic Trust Monitoring (DTM, for continuous monitoring of the security and behaviour of the network.
- Vocabulary provider: it manages and offers vocabularies (i.e., ontologies, reference data models, or metadata elements) that can be used to annotate and describe datasets. In particular, the Vocabulary Provider provides the Information Model of the International Data Spaces.
- App store provider: it is responsible for managing information about Data Apps offered by App Providers.

The main distinctive factor in the International Data Spaces initiative is the importance given to data sovereignty. This principle led to four different design choices:

- data providers do not upload any data onto a remote server. They provide metadata describing their data, and they either upload or describe the connector that let data consumers access their data. The catalogue then becomes a metadata catalogue.

- Data provided by connectors is not openly available. It must be requested explicitly according to a request process.

- connectors provide encrypted data, and data is unlocked per-data consumer. The trustworthiness of the communication is granted by using asymmetric encryption, and so when the requester is granted access to the data provided by the connector, he is provided with a decryption key.

- implementation assessment and certification. To join the IDSA ecosystem, the software components of the participants must be certified. The certification program assesses the interoperability of the connector wrt. the specifications and the other available connectors. When a participant is found not respecting the specifications, or in case of misbehaviours, his encryption key is revoked by the cryptographic certification authority and is therefore excluded from the actual operations.

According to the aforementioned design principles, the IDSA ecosystem is an open ecosystem with strong formal barriers. Entering the ecosystem is open to anyone, but newcomers must be certified by the IDSA and must obtain the keys from the cryptographic certification authority. From an architectural point of view, the ecosystem is tailored to publishing and access to data services. Connectors are actually services exposing data via common standards like HTTP and MQTT. The advertisement of such connectors is done via descriptions to be published in a catalogue, while the documentation about the vocabulary to be adopted for such descriptions is hosted in a vocabulary server. The vocabulary is expressed using Semantic Web standards, therefore it is an ontology whose terms are taken reusing terms found in commonly used vocabularies like DCAT, FOAF and Dublin Core Vocabulary.

The presence of a catalogue in IDSA is alike the Asset Manager in the Shift2Rail ecosystem. Both catalogues contain metadata, descriptions about resources, which use vocabularies and ontologies defined according to the Semantic Web standards. The descriptions of data access policies and the importance of per-user data encryption and decryption could be interesting for the Shift2Rail ecosystem since they are tailored to the case of non-publicly available data, where each data provider must assess exactly what kind of data is used by which consumer. The data access policies related to monetization could also be further investigated since the S2R ecosystem should not force the providers to offer data and services for free.

4.10 STRIA

STRIA[40] project aimed at the realization of a more integrated and effective transport system across Europe, and to make better use of innovation and new technology in transport. It is composed of different parallel projects including Connected and automated transport (CAT), Transport electrification, Transport vehicle design, development and manufacturing (VDM), Low-emission

[40] https://trimis.ec.europa.eu/roadmaps

alternative energy for transport, Network and Traffic Management (NTM), Smart mobility systems and services, Infrastructure. Among them, the "Smart mobility systems and services" seems relevant for the SPRINT project.

In specific, STRIA Roadmap for Smart Mobility and Services[41] aims to assess emerging new technologies such as multi-modal, electric and autonomous vehicles, drone technology and on-demand mobility services. Their current developments are focused on the following directions:

- **Road:** Investments in cooperative intelligent transport systems and connected driving technologies to improve the flow of road traffic on urban roads will result in better movement of goods and people.
- **Rail:** The growth of different international and local railway traffic flows requires better planning and management.
- **Autonomous transport systems:** Autonomous electric vehicles are expected to form a significant component of mobility as a service in urban transport. As with sharing models, autonomous vehicle technology will blend with mobility as a service model and can potentially enable widespread smart traffic management.
- **Drones and low-altitude aerial mobility:** Drone and low-altitude aerial mobility are now technically possible for passenger transport. However, the combined demand for such vertical urban mobility solutions requires governance, regulation and infrastructure innovation.
- **Big and open data:** Faster and cheaper processing, freely available data capacity and computing power are enabling greater energy efficiency, spatial distribution and utilization of transport, mobility and smart city assets and systems.
- **Data governance:** The flow of big and open data requires significant governance and regulatory design to ensure the interests of all stakeholders and that access to available data is equally protected.
- **Data availability and processing:** Transport systems are increasingly able to aggregate and analyze data from multiple sources and networks to dynamically face demand and operate more efficiently.

[41] https://trimis.ec.europa.eu/stria-roadmaps/smart-mobility-and-services

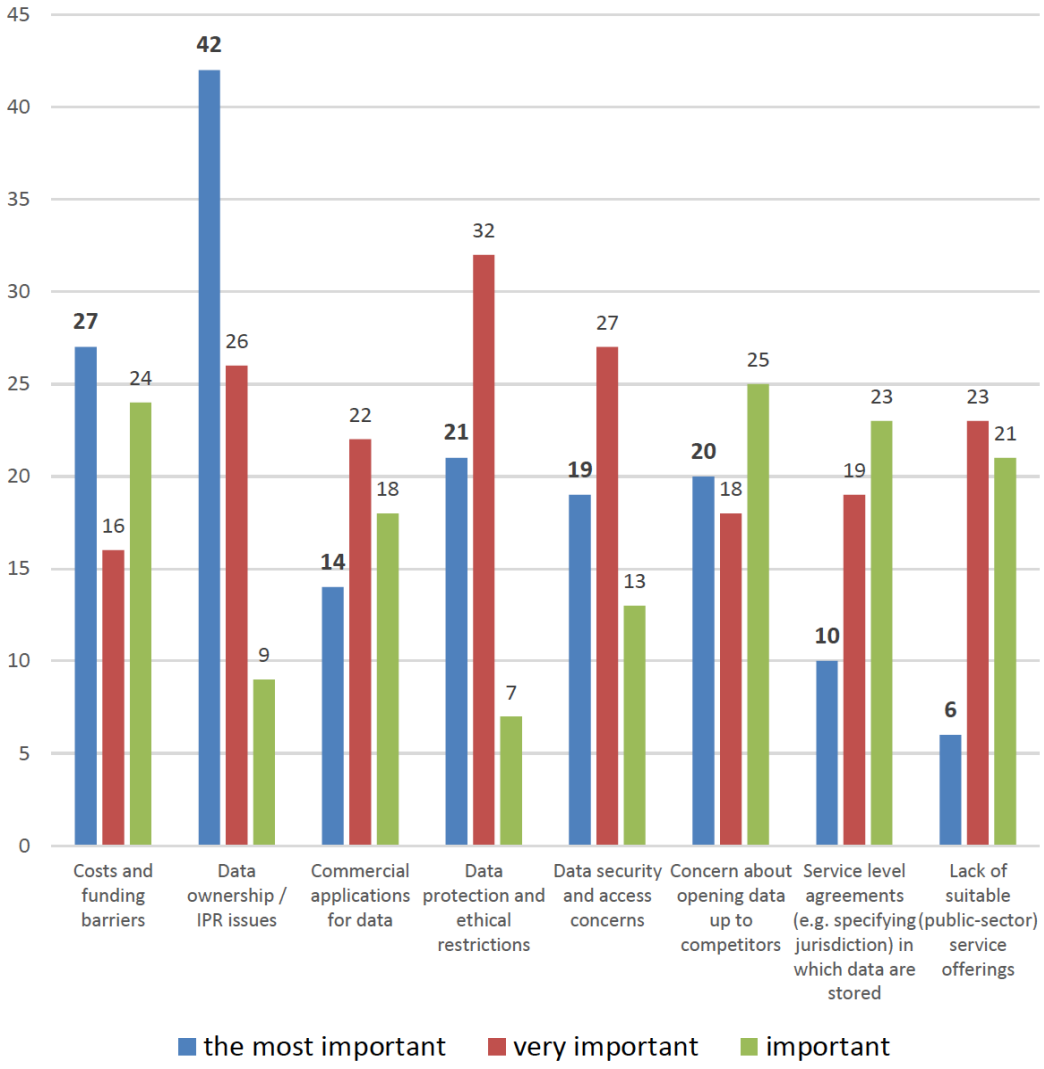

Figure 3 TRC barriers [7]

Above mentioned goals unveil the underlying requirements and the still lacking systems and infrastructures within the transportation domain that could be a valuable source of inspiration for the SPRINT project. For instance, data availability, governance, and analysis in an interoperable and dynamic manner are among the most important requirements that we could learn from this project.

Another interesting idea in this project that could be informative for our research the is the idea of Transport Research Cloud (TRC). According to [7]: "*Transport researchers collect and generate large amounts of data whether from monitoring actual freight/person movements, recording sensor data from vehicles and infrastructures, or capturing video of various transport related phenomena. They come from different background and apply a wide range of methods: transport research is inherently cross-disciplinary and so provides an ideal context in which to apply principles such as FAIR. Unfortunately, most of the data that these researchers collect are used once and then stored away in locations that are inaccessible to other researchers*".

TRC tackles this issue to provide a cloud-based solution for data sharing within the transport research community. In their comprehensive requirement analysis for the construction of TRC, they

have identified and analyzed the scope and characteristics of transport data that prove the high divergence and heterogeneity of data in of this domain. Evidently, it hampers the interoperability among various transportation actors and fosters the needs for unification and standardization to utilize such data in a cross-organization manner.

Furthermore, the report discusses the key role of machine-readable description and discovery approaches (e.g. semantic, ontologies and metadata) that reveals another core requirement.

Finally, the report has classified the main barriers toward the development of TRC such as divergent stakeholders and data owners, legal and cultural barriers, data sensitivity and privacy issues, quality of data, etc., as shown in Figure 3. Given that mission and goals of TRC and Interoperability Framework have many common aspects, such study is a valuable source of information for us to identify the potential obstacle in our way and direct our requirement analysis toward addressing those issues.

4.11 TRANSMODEL

Representatives of TRANSMODEL[42] also took part in the questionnaire and provided answers in Annex 5.

TRANSMODEL defines interoperability in two definitions:

- Interoperability of systems is the ability of a system to easily re-use the information provided in different ways (in particular by various providers, in different formats).
- Interoperability of information is the situation in which information A and Information B are semantically equivalent, i.e., have the same purpose (scope) and can easily be replaced one by another without loss of information.

TRANSMODEL conceptualizes an interoperable ecosystem as a framework for sharing/exposing data in an interoperable manner to facilitate communication and interaction with other systems. The organization needs interoperability when considering overlaps in standards and mappings between standards as the IF may ease mapping processes (mappings between ontologies) and when examination of semantic equivalence of semantic models is a difficult and time-consuming topic and needs high-level expertise. The (partial) automation would be helpful.

Data interoperability is one of the issues that the organization is facing and that can be overcome by partial harmonization (where possible) and mapping.

For TRANSMODEL, complete centralization is not realistic. Even if a single format is recommended, several profiles will co-exist. However, recommendations to use well-established references for new systems would enhance interoperability. Actors in this domain often use their APIs. Interoperability problems are getting more obvious therefore, so installing new platforms to be closer to standards are preferable. TRANSMODEL considers a single Reference data model for a particular

[42] http://www.TRANSMODEL-cen.eu/

purpose/scope and several local models. The usefulness of a Reference model is clearly to be either used as is (often parts of it) or to compare/map other locally defined models. Mappings make it possible to identify similarities and differences, and, e.g., express judgment on the degree of interoperability of systems. If a new actor wants to contribute to their data/services to TRANSMODEL, in the case of "reference data model for public transport" it can be considered as an "initiative". Then actors wishing to conform to it should follow "conformity statements" expressed in the standard documentation, as a minimum. A Mapping Matrix has further been established and used (within a range of projects) which provides a specific qualification of the mapping. If an actor wants to use the related implementation standard (NeTEx or SIRI) then more automatic validation routines may be used (e.g., an open source tool called Chouette, developed in France). However, TRANSMODEL initiative is not related to the implementation of organisational issues.

TRANSMODEL is aware that an EU transport authority, operator and infrastructure manager have to allow access to transportation data due to EU Regulation (EU 2017/1926) and help the EU Member states implement the Regulation – teaching/information/dissemination of standards which is their main priorities. Developer of TRANSMODEL is a basis for NeTEx, SIRI, OJP and currently investigating gaps/overlaps in standardisation. The developer of an extension to TRANSMODEL – a reference model for the alternative modes of transport (vehicle sharing/pooling/rental). The proposer of a project for the development of an API for publication of the information concerning the alternative modes (based on the model as mentioned above) as an extension of NeTEx.

4.12 PROJECTS

4.12.1 OASIS

Open applications for semantically interoperable services (OASIS)[43] is an initiative to improve the accessibility of public sector services by taking advantage of linked open data by improving the services of local governments. This initiative presents a set of vocabularies designed to reduce the costs of data adoption and increase interoperability through a common semantics in the context of public services and more in detail, in the public transport domain. OASIS also develops a set of proof of concepts over the transport domain to test the vocabularies and methods to expose Linked Data on the Web proposed in the initiative. The main contributions of OASIS are[44]:

- **TransportDCAT-AP:** It is a profile representation of metadata about open public transport data whose main objective is to generate common vocabularies for representing metadata model for public transport at the European level. It is based on the EU standard for metadata, DCAT-AP, and the datasets following TransportDCAT-AP specification can be uploaded to the EU Open Data portal.

- **Tripscore (at Open Summer of Code 2017)[45]:** This application shows a demo about the use of Linked Data datasets exposed on the Web following the Linked Connections Vocabulary[46] in a route-planner application. Following the Linked Data Fragments approach for exposing the data using linked web pages, the server is focused on providing the data in

[43] https://oasis.team/
[44] All the publications can be found at: https://oasis.team/publications
[45] http://tripscore.eu/
[46] https://linkedconnections.org/

an interoperable way while the client should implement the route planner algorithm, hence, improving the availability of the server.

- **Semantic Framework for public services and transport data interoperability:** This contribution represents a set of vocabularies (Services and Transport Ontologies) for improving the interoperability of different heterogeneous data sources that are necessary for providing efficient services to the citizens in a smart city context. It also provides a set of tools for transforming the raw data to the corresponding dataset following the defined vocabulary (e.g., gtfs2lc application47).

- **Access Flanders (at Open Summer of Code 2018 - Belgium):** This application is a data collector to look for accessibility information in public buildings. Based on a citizen science approach, it collects the data from the crowd and publish it following standard vocabularies and using RDF. As the collected data are interoperable with other datasets it can be reused, for example, adding new features of linked data based route planners, such as Trispscore.

- **The Public Transport Accessibility Ontology (at Open Summer of Code 2018 - Spain):** The Public Transport Accessibility Ontology is an extension of the General Transit Feed Specification Ontology which is a translation of the GTFS model. Its purpose is to represent accessibility elements in public transportation. It was used in the oSoc18[48] (Spain) pilot app on searching and annotating accessibility descriptions of public transportation in Madrid, specifically the metro system and buses. Besides the basic GTFS classes for stops, stations and routes, the ontology models platforms and accesses to metro stations, bus stops, and several types of announcements and billboards that are relevant to people with disabilities. There are also classes for disability features, disability types, annotations, and app users. Each station, access, platform or bus stop may have different accessibility features. The ontology has properties to represent that an accessibility feature addresses a certain disability type and that annotations have been made by a user on different dates.

4.12.2 MyCorridor

MyCorridor[49] project is funded by the EU's Horizon 2020 programme and its main objective is to achieve sustainable multi-modal travel within and across borders by focusing on the development of more convenient and user-centric IT infrastructure for shared vehicles and public transportation.

This project is working towards the realization of Mobility as a Service (MaaS) concept by envisioning of a hub for services provider to share their service and make it available for end-users in a unified manner. Furthermore, focusing on traffic management services, for example by real-time monitoring of the traffic and providing the transport authorities quick solutions. Finally, its main objective is to enable the one-stop-shop service for the traveller through unified ticketing and single payment mechanism.

[47] https://github.com/linkedconnections/gtfs2lc
[48] https://2018.summerofcode.be/
[49] http://www.mycorridor.eu/

In short, functions offered by MyCorridor target three domains:

- Firstly, the platform would be utilized by the travellers to send a request for mobility and arrange their trip
- Secondly, MyCorridor acts as a gateway for service providers who are willing to register their transport services and make them available on the platform
- Thirdly, traffic management

A sample use-case for the first category of the services is provided at [8], describing a working day for Catherine visiting different places in Rome. Using MyCorridor application, she could select her preferred ways of transports (car sharing and bus for example) along with other options such as the fastest way, cheapest trip and minimum interchange of the transport vehicle. Finally, by inserting the starting and endpoint, MyCorridor matchmaking process starts discovering possible mobility options according to her preferences.

Concerning the back-end operations, an example provided by MyCorridor [9] includes a story of a typical service provider, Christopher, the owner of an interurban bus service. He could register to MyCorridor platform and presents the information about his service, such as transportation type, travelling hours, etc. In addition, the service provider could add the service endpoints for instance for booking or availability checking operations. After the registration, the service is available in the pool of services discoverable by consumers.

Finally, the project also focuses on storage and dissemination of data shared by service providers as well as data used for the prediction of user preferences. The project relies on an open cloud system, assuring the security and privacy concerns for sharing the data among interested parties. MyCorridor data management includes data controller, producer and manager. Former acts as the point of contact for data protection issues and will coordinate the actions required to liaise between different beneficiaries. The data producer is any entity that produces data within MyCorridor scope. Each data producer is responsible for the integrity and compatibility of its data during the project lifetime. Finally, the data will coordinate the actions related to data management. As the MyCorridor open data will be hosted either by institutional databases or by an open free of charge platform (e.g. Zenodo), no additional costs will be required for hosting the data.

The project is still in its starting phase and no actual implementation is yet delivered. However, by analysing the above-mentioned use-cases and the overall objective of the project we can observe some of the necessary requirements as following.

It is evident that the MyCorridor is supposed to act as a registry enabling the users to discover desired mobility services. The registration is accomplished through an online form where service provider could essentially stipulate the structure of their service. For example, the service provider could denote that the response to their service URL is in the form of XML, or JSON. Although it is necessary information for any service consumer to interact with preferred service, certainly it is not enough. More precisely, a JSON payload without knowing the underlying data model and vocabulary is meaningless. In this direction, a need for a reference model or ontology is required to unify heterogeneous data models and vocabularies used by arbitrary service providers.

In addition, MyCorridor states the possibility of service composition that indicates a sticky interaction among different services. To realize such functionality, in the high divergent transportation ecosystem some sort of message/service call conversion from one service provider data model to another seems inevitable.

4.12.3 Data Market Austria

Data has become an important raw material that is of high importance in nearly every industry sector worldwide. Data have swept into every industry and business function and are now an important factor of production, alongside labour and capital.

The Data Market Austria (DMA) project[50] is working to address the following problems:

- requirements for successful data-driven businesses (concerning regulatory, technical, research, business or societal issues) are not elicited and existing success stories are not visible;
- existing data environments and processing infrastructure are not efficiently connected
- the quality of existing data is often low;
- data use is often associated with high costs because of the lack of interoperability provided.

The Data Market Austria (DMA) is an ecosystem of federated data and service infrastructures. It aims at making data from various data providers accessible and interoperable by allowing the submission, storage, management and dissemination of static datasets or streaming data services. By creating a metadata vocabulary, standardizing the ingest of data and ensuring the quality and completeness of metadata, it lays the ground to enable participants to share or consume datasets residing in different infrastructures.

The contributions provided by DMA to have a sustainable Data-Services Ecosystem in Austria are:

- **Advancing Technology Foundations** by
    - using blockchain techniques to allow resilience through a decentralized approach towards provenance, data computation, curation, preservation, and security;
    - developing the technology basis for data and service brokerage, leading to recommendations for bringing together data and services based on user requirements;
    - developing processing and analysing approaches that have acceptable processing speed while fusing multiple data sources, each subject to potentially different security and tracking requirements.
- **Creating a Data Innovation Environment** by building a community of stakeholders (SMEs, start-ups, large enterprises, academics, public administration) around the Data-Services

[50] https://datamarket.at/

Ecosystem that operate in a clearly regulated environment using innovative business models that ensure the long-term sustainability of the Data-Services Ecosystem.

- **Interconnecting Clouds** by developing the technology for transparent but controlled access to distributed services, and to public and proprietary data through the Data Market Austria Portal.

Different pilots have been realized to demonstrate the reuse of data and services and resulting value generated through innovative applications built on multiple open and proprietary data sources in the Austrian Data-Services Ecosystem. Here, we focus on the pilot related to the Mobility sector.

To achieve the enormous potential of connected mobility solutions for the general public, future services need prediction strategies. Typical preconditions for predictions are complex and therefore time-consuming algorithms and access to different datasets. The DMA proposes two demonstrators to show:

- how open data can be used together with closed data;
- how the same data can be used in different scenarios and business domains both for analysis and operations;
- how added value can be generated.

The proposed demonstrations are:

- **Taxi Fleet Management:** both public data offers (e.g. actual arrival and departure times of airplanes and trains, information on large cultural, sports events or congresses) and proprietary data (e.g. knowledge on the number of persons at places based on mobile phone usage) can be used to implement prediction models and thus allowing the fleet operator an optimized planning of his capacities.
- **Historical Traffic Flow Characteristics:** DMA developed methods and tools that enable the extraction and provisioning of historical traffic flow characteristics and mobility patterns. The usage of the Data-Services Ecosystem enables unprecedented possibilities. Firstly, knowledge from multiple (open and closed) datasets can be combined to provide higher quality results (e.g., cellular network data aided by floating car data) or to study interdependency factors (e.g., an impact of weather on mobility). Secondly, users can be offered the possibility to search, discover, and access (free or paid) mobility information in an understandable and ready-to-use form, rather than buying stand-alone complex raw dataset. Having access to knowledge instead of data allows filling the gap between a data provider and a data consumer.

From an architectural point of view, the Data Market Austria ecosystem is a federated network of data and service nodes, each one publishing descriptions about managed asset onto metadata catalogues. The consistency of the information contained in the catalogue is guaranteed via the extensive usage of blockchain technologies. Such technologies are used to store metadata describing the assets and their licenses and terms of use. Accessing an asset is not always for free, and the Ethereum blockchain technology is also therefore used to perform economic transactions.

The usage of private blockchain technologies as a building block for a federation of nodes is indeed interesting for the Interoperability Framework, as similar concepts could pave the way for a distributed and federated Shift2Rail ecosystem.

The process to publish a new asset (either a dataset or a service) is not clearly described, anyway the hints contained in the technical documentation suggests that each registered user is able to publish assets and freely describe their license terms. There is no hint about a quality check to be performed by a trusted third party.

The Data Market Austria architecture can be considered as a best-of-breed example of how to build a decentralized ecosystem, and it should be better analyzed with the aim of identifying possible components to be reused in the context of Shift2Rail IF. Another possibility could be to propose the addition of a compatibility layer to DMA to obtain an IF-compatible architecture.

5. CONCLUSION

The work done in this deliverable will be more elaborated in D2.2: Requirements for an IF architectural design (C-REL) – the first output of Task 2.2 on the elicitation of requirements for the C-REL IF architecture design. Using different tools for data collection (desk research, questionnaires, face-to-face meetings), SPRINT project was able to define:

- Key requirements and ongoing work in CFM projects (CONNECTIVE and ATTRACkTIVE projects);
- The list of initiatives relevant for the IF, their requirements, recommendations and the level of relevance to the IF.

The main outcomes are:

- Shift2Rail IP4 IF can consider the EIF as a good example of the interoperability implementation.
- ERTICO as a public-private partnership, NAP as the main contact point of the country for users of data, MaaS Alliance as a supporter of integrated transport approach, MASAI as an ecosystem of service providers and concierges can become the main users of the IF, so collaboration with them will facilitate the market uptake.
- Cooperation with EU ITS platform can help with the study on how the transformation of DATEX II to an ontology would improve the management and interoperability among the used datasets.
- ITxPT is the right organisation for identification and deep analysis of the interoperability needs.
- The experience of IDSA can be taken into consideration because its catalogues have much in common with the Asset manager in the Shift2Rail ecosystem.

- The Data Market Austria architecture can be considered as a best-of-breed example of how to build a decentralized ecosystem, and it should be better analyzed with the aim of identifying possible components to be reused in the context of Shift2Rail IF.
- TRANSMODEL is the right initiative in order to define the reference ontology.

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