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REPORT CONTRIBUTORS

Name	Company	Details of Contribution
Yves Amsler	UITP	Writer
Marco Ferreira	Thales Group - Portugal	Reviewer
Cristina Hernandez	UITP	Writer
Tom Jones	Amadeus	Writer
Daria Kuzmina	UITP	Reviewer
Rui Lourenco	Thales Group - Portugal	Reviewer
Lindsey Mancini	UITP	Reviewer
Riccardo Santoro	TRENITALIA	Reviewer
Javier Saralegui	Indra	Reviewer – Section 4
Javier Warleta	EPS expert	Reviewer
Maria Laura Trifiletti	RINA C-BE	Quality check

Table 1: List of contributors

EXECUTIVE SUMMARY

Produced as an outcome of the IT2Rail “lighthouse project” of Shift2Rail IP4[1], this “White Paper on adaptation and openness of business ecosystem” introduces the business perspective of IT2Rail. The work developed in IT2Rail should guarantee a business environment open to any system and service that might emerge within a Shift2Rail IP4[2] ecosystem without prejudice to the regulatory environment regarding the provision of transport services and the personal rights of the travellers. That’s why this White Paper analyses and proposes some paths to illustrate the paradigmatic business case for the entrance of new transport service providers, while assuring a respectful openness of the business ecosystem as well as competitive services for Europe as a whole.

This White Paper aims to show how the semantic technologies in the transport sector as they are described in IT2Rail not only allow but facilitate the entrance of new stakeholders in the Digitalized seamless European travel (eco)system. In so doing, it describes key elements of a generic business case for becoming a member of an ecosystem based upon semantic technologies.

Finally the White Paper advances and explains research recommendations towards a Digitalized Seamless European Travel Market an Interoperability Framework.

[1] IT2Rail (H2020 – 2015-2017) is a so-called “Shift2Rail Lighthouse Project”, one of the projects which started the research programme of the Shift2Rail JU –Joint Undertaking- paving the way for the works of the ambitious Multi Annual Action Plan (MAAP, November 2015) of Shift2Rail. IT2Rail is dedicated to the “Innovation Programme 4” (IP4) of Shift2Rail, targeted at generating innovative ICT Passenger solutions for an attractive Railway. See referenced documents [1]).
[2] Innovation Programme 4.

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LIST OF ABBREVIATIONS

EC	European Commission
EIF	European Interoperability Framework
EU	European Union
GDPR	General Data Protection Regulation
GVA	Gross Value Added
ICT	Information and Communication Technology
IP	Innovation Programme (as part of the Shift2Rail work programme)
MAAP	Multi-Annual Action Plan of Shift2Rail
SERA	Single European Railway Area
SETA	Single European Transport Area
WP	Work Package

INTRODUCTION

Transport is one basis of the EU daily activities and, hence, economy and wellbeing. According to the pocket book “EU transport in figures – Statistical pocketbook 2017”[3]:

- With around € 651 billion in Gross Value Added (GVA) at current prices, the transport and storage services sector (including postal and courier activities) accounted for about 5% of total GVA in the EU-28 in 2015[4];
- In 2014, the transport and storage services sector (including postal and courier activities) in the EU-28 employed around 11,2 million persons[5], some 5,2 % of the total workforce.

The current passenger transport markets in Europe are serving within EU 28 a total annual number of around 64,5 billion passengers, the very large majority of them being local public transport passengers (see section 2.1.1).

In this respect, it is essential to ensure that research and innovation results supported by the EU programmes, and in particular Shift2Rail, achieve results available to all the transport sector relevant actors, so as to properly reap the benefits of these innovative services, which are key to the establishment of a fully functioning Single European Railway Area (SERA) and beyond that to the creation of a Single European Transport Area (SETA).

[3] https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017_en

[4] This figure only includes the GVA of companies whose main activity is the provision of transport (and transport-related) services and that own account transport operations are not included.

[5] Figures on number of persons employed in transport, total workforce and shares per mode based on Eurostat Labour Force Survey (age 15-64 years).

REFERENCED DOCUMENTS

This section lists the document reference number, title, revision, and date of all documents referenced in the specifications document.

Reference Number	Title	Date
[1] Page i	Shift2Rail Joint Undertaking Multi-Annual Action Plan	26/11/2015
[2] Page 3	COM(2017) 134 final Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – European Interoperability Framework – Implementation Strategy. This new EIF is the result of taking into account new EU policies, such as the revised Directive on the reuse of Public Sector Information (Directive 2003/98/EC and as revised by Directive 2013/37/EU), the INSPIRE Directive (Directive 2007/2/EC, and the eIDAS Regulation). New EU initiatives, such as the European Cloud Initiative, the EU eGovernment Action Plan 2016-2020, and envisaged ones, such as the Single Digital Gateway, are also considered. https://ec.europa.eu/isa2/eif_en	23/03/2017
[3] Page 7	Semantic Heterogeneity as a Result of Domain Evolution. *SIGMOD RECORD,* 20, 4: pp. 16.20, 1991.	23/03/2017
[4] Page 11	9780471488545 - Adaptive Information: Improving Business Through Semantic Interoperability, Grid Computing, and Enterprise Integration by Jeffrey T Pollock; Ralph Hodgson	11/11/2004

Table 2: Referenced Documents

1. SEMANTIC INTEROPERABILITY – WHAT IT IS?

1.1 INTEROPERABILITY - WHAT DOES IT MEAN?

Transport is one of the key enablers for the well-being of any society and to the well-functioning of its economic activities. Indeed transport matters. Transport ensures everyday mobility of people and is crucial to the production and daily distribution of goods. That's why different transport modes and systems have appeared throughout Europe offering similar solutions to a common need. As a consequence numerous transport solutions emerged worldwide, each of them with its own system.

However the society that created these systems has largely changed and continues changing. Nowadays travel patterns are changing even faster: we are facing a new era where it is common to travel among cities in Europe, redefining the needs of the travellers and therefore of the transport systems. These systems need to work together to ensure a door-2-door travel experience. In this regard, one of the greatest challenges for the transport sector is "interoperability".

Michael Pellot, Transports Metropolitans de Barcelona

Public transport operators are highly fragmented and have so many different systems! It is difficult to make the travellers going through one to another without troubles!

So what does "interoperability" mean? "Systems' interoperability" is required when the best solution needs to be composed of several parts and elements of different systems. The main aim of this exercise is to increase the work efficiency of the different elements by their complementarity. Yet, the concept of interoperability is ill-defined in the literature. As it may be a very complex issue, particularly in the transport sector, one simplification is to talk about specific types of interoperability, e.g. physical interoperability (e.g. allowing a train to run on different countries' infrastructure).

> Interoperability is a characteristic of a product or system, whose interfaces are completely understood, to work with other products or systems, present or future, in either implementation or access, without any restrictions.

When we talk about "interoperability" in the Information Technologies sector, it is commonly agreed that for software developers "interoperability" means the ability to perform coordinated computational tasks distributed over networked heterogeneous devices and systems, regardless of the means by which that is done. And one of the most powerful technologies for achieving it is "Semantic Technology".

1.2 SEMANTIC TECHNOLOGY: A "MACHINE-TO-MACHINE" UNDERSTANDING

Any type of social or business relation needs to establish an information exchange between the involved actors, so transferring useful messages based on commonly understood concepts. This process occurs «automatically» when people talk to each other, provided that they share a common set of concepts (culture), a common way to organise them (semantics), a common language (dictionary and syntax) and a compatible way to pronounce words. If there is no common ground for any of these concepts between the sender and the receiver/listener, e.g. due to differences in culture, semantics, language or pronunciation, the communication becomes difficult and often impossible.

Business activities today are more and more searching to implement communication between computers, which supports and often replaces communication between humans. The overall process is exactly the same, so we can generalize the «communication process». Then, effective communication can occur only when both the sender and the receiver assign the same meanings to the same message.

Indeed when analyzing the different parts of a message, a good number of the approaches have found different ways to create this common ground, e.g. there are plenty of means to establish a solid communication channel between the sender and the receiver, in order to transparently transfer messages without altering them; widespread and flexible solutions has been identified in XML[6], which allows to build any kind of syntax and possibly translate between them by means of suitable transformations, etc. However it is harder to tackle the deepest level of messages: the semantic level. This approach is manifested in IT2Rail by the creation of the "Interoperability Framework". The Interoperability Framework proposes to create a common ground at semantic level applying Semantic Technologies to the transport sector: a structure including a set of concepts and the relationships between them. It is a way to allow computers to understand each other, exactly the same as human beings do.

In a sense this could be considered as the problem of providing machines with an "understanding" of the problem domain that endows them with the ability to execute a form of "machine run-time standardization" of data formats based on this understanding.

This collection of technical capabilities to automate a machine-to-machine understanding is what is called "Semantic Technology".

Semantic Interoperability refers to the ability of interacting computers to automate the interpretation of the data they process regardless of how this data is structured or exchanged.

The Interoperability Framework, understood as Semantic Interoperability applied in the transport sector as proposed in IT2Rail, encapsulates the «mechanics» of interoperability across the networked heterogeneous transport stakeholders. Therefore it uses «semantic interoperability» principles and technology.

[6] XML stands for eXtensible Markup It is a software language designed to store and transport data which is both human- and machine-readable.

1.3 MORE THAN A DATA EXCHANGE: A KNOWLEDGE EXCHANGE

It is important to note the key differences between the Semantic Technology (or simply Interoperability Framework) as defined in IT2Rail, and the European Interoperability Framework (onwards EIF).

The concept of EIF has been formalized and supported by several EC and European Union actions among which the adoption of a “European Interoperability Framework” in 2010 lastly updated in 2017 (see referenced documents [2]). According to the EIF:

> *“Interoperability means the ability of information and communication technology (ICT) systems and of the business processes they support to exchange data and to enable the sharing of information and knowledge. Two systems are interoperable if they are able to communicate to each other through a complete information exchange.”*

Therefore EIF could be defined as a large guiding initiative at EU level offering specific guidance on how to set up interoperable digital (online) public services so to create a Digital Single Market. It defines basic interoperability guidelines in the form of common principles, models and recommendations so as to make the links between public services in Europe more efficient. This proposal is mainly based on open voluntary and common standards.

On the other hand Semantic Technology goes beyond this approach. It ensures that the meaning of exchanged data and information is understood in the exchanges between machines in an automatic way, preserving the original information as it is and ensuring that “what is sent is what is understood”.

Cristina Hernández, UITP

Thanks to Semantic Technology, machines are able to solve automatically the interoperability challenge, allowing any company to concentrate its human resources in other more fruitful tasks.

In this context, the exchange of data within Semantic Technology is just a means to facilitate communication, meanwhile within the EIF it is a purpose itself. The real scope of interoperability is not the «data exchange», which today is rather easy to achieve, but the capability to make data meaningful for all the involved actors. Semantic Technology offers a way of working with no local computation, and is therefore faster and with globally lower cost.

In the main, Semantic Technology as developed in IT2Rail goes beyond the EIF purposes. The Interoperability Framework can be seen as a kind of “meta-standard” which is able to make information systems understand each other even when they follow different standards.

“Semantic interoperability” provides machine too machine technology allowing them to share and communicate those assumptions, and to use them to automate the process of mapping data across heterogeneous formats and protocols, so as to reduce the cost of interoperability. In a sense this could be considered as the problem of providing machines with an “understanding” of the problem domain that endows them with the ability to execute a form of "machine run-time interpretation of data" of data formats based on this understanding.

The challenge of allowing time-effective communication between all actors, whatever solution (standard or not) they were already using, could be met by using Semantic Technology solutions.

2. NON-TECHNICAL OBSTACLES FOR AN INTEROPERABLE SYSTEM

The key challenges in order to provide European travellers with new services offering real benefits are:

- first to acknowledge the current background of the provision of transport services characterized until very recently by modal approaches (silo perspectives) except for local public transport,
- then to take properly into account the evolution from transport silos towards an integrated SERA , and
- finally to build up a transport ecosystem which encourages all actors to use the Semantic Technologies at a low-cost.

2.1 THE CURRENT TRANSPORT MARKET IN EUROPE

Understanding the background of passenger transport in Europe requires taking into account some very basic features regarding market segmentation, which explain previous approaches to multimodal travel information[7] and drive business case opportunities for Travel Service Providers.

When Multimodal Travel Information Services are at stake, the traveller wants to get at any moment at least two types of information:

- Information on board regarding the vehicle as part of the travel chain;
- Information regarding the whole travel chain along the trip.

Additionally, travellers are increasingly connected to the internet and can benefit from additional information related or not to their travel.

[7] Market analysts are usually using three types of indicators regarding public transport customers:
- Passenger x km (pkm). Adding pkm from the different modes does not lead to any kind of overlap, and therefore pkm is the best indicator for measuring the consumption of transport. Unfortunately, this indicator does not differentiate the travellers: one air passenger travelling 1.000 km represents 1 000 pkm, but the same amount of pkm in urban bus, assuming an average of 2,5 km travelled per bus passenger, would be produced by 400 bus passengers;
- Passengers. The number of passengers is usually associated with a vehicle. In some cases, depending on the fare system and multimodal integration level, what is measured - through the validators – is a number of "users" entering a network (e.g. the metro in Paris), and one "user" may use several vehicles and represent several "passengers";
- Trips. A trip is made by a traveller between two points A and B with one or several modes. Not including the last parts of the trip made on foot, the traveller shall represent as many passengers as the number of vehicles he/she uses between A and B.

Measuring the number of passenger x km is rather easy, and is based on the number of passengers on board vehicles running a certain number of kilometres. Measuring the number of "passengers" and of "trips" often requires specific surveys. Measuring the number of trips always requires specific surveys.

2.1.1 MOST CUSTOMERS ARE LOCAL TRAVELLERS

The current passenger transport markets in Europe are serving within EU 28 a total annual number of around 64,5 billion passengers, the very large majority of them being local public transport passengers (around 56 billion passengers) distributed per mode as shown in figure 1.

All of these 64,5 billion yearly passengers are keen to get reliable travel information before and during their various journeys. One may consider either trips[8] or passengers, but whatever the indicator local public transport is extremely predominant among European transport markets.

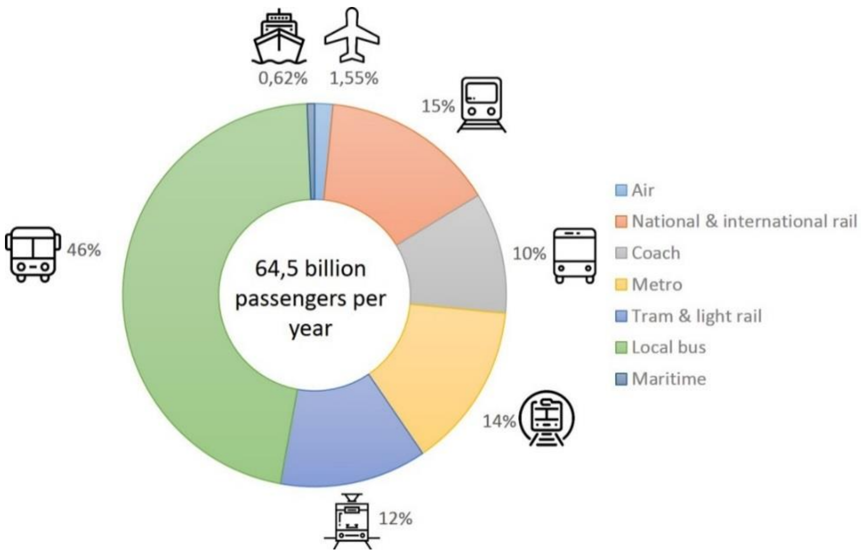

Figure 1 - Travellers' split between modes. Source: UITP, based on Eurostat figures

2.1.2 NON-COMMERCIAL SERVICES SHARE THE LION PART

The passenger transport markets in Europe are a very complex mix in terms of institutional background. Together they contain a mix of commercially opened (mostly long distance) and of regulated (mostly local) services. The largest portion of the services (in terms of numbers of passengers carried) is in the second category in which the services are depending upon decisions taken by local authorities - unlike long and medium distance travel mostly operated under fully open commercial contracts. However the local transport market is mostly non-commercially viable: it has to achieve numerous objectives which are not limited to transport but include among others social and environmental targets, the relationship between land use and accessibility to urban activities for all. Therefore local public transport is most often and largely funded and financed not only by the traveller but by the local taxpayer.

[8] However, if considering seamless travel from A to B, whatever trip encompasses usually more than one mode, so in terms of statistics *one "traveller" performing one trip represents as many "passengers" as the number of modes used along the travel from A to B*. Even if the ratio "local public transport over long and medium distance travel" would decrease if based on a number of trips/travellers and not of passengers, the relative importance of local public transport in the overall public transport market would still be extremely high (from about 30 to 1 in passengers it would not go below 20 to 1 in terms of trips/travellers).

Local public transport is most often operated under Public Service Requirements (or Obligations, so with acronyms PSR or PSO) defined by local Organising Authorities (OA). These authorities are responsible for the organisation of convenient local public transport and apply fare policies for every category of local citizens[9]. In most cases the fare policy is fully integrated - with tickets or passes valid over several or all of the public transport modes operated within the city conurbation.

The passenger public transport market structure explains why multimodal travel information on transport services has first been developed at the local level under the responsibility of the local authorities and in some cases by Public Transport Operator(s) depending on their public service contract with the authority. Each country, or even each region has its own vision of PSO and has the responsibility for public transport funding and financing. Therefore hundreds of multimodal transport planners have been produced at the city level by either authorities and/or operators.

2.1.3 THE TRADITIONAL SILO PERSPECTIVE

In broad terms until recently the current situation – which is evolving rapidly - was characterised by silo markets, where only local public transport was multi-modal. Typically the situation is still as follows:

Air market

The passenger air market is open and driven by competition between airlines and between airports. Each airline has its own commercial approach to customers in a market which has been opened at the end of the last century. Each company produces its own information. The competition is huge between long-term established companies and new “low-cost” air transport providers. The competition now also involves airports offering commercial services to air customers.

Rail market

The passenger rail market is encompassing two categories of rail services:

- the services operated on a fully commercial basis – like international and interurban high speed services also competing with air;
- the services provided under public services requirements – mostly local sub-urban and regional services; these services can be seen as a segment of local public transport (see below).

The rail services were and still are mostly provided by national rail operators which are extremely limited in number compared with local public transport carriers. These rail companies have developed information most often focusing on their own (commercial) services in a market only recently opened or opening to competitors. Very often passenger and freight rail services share the same infrastructure. Since this rail infrastructure is financed by rail users – contrary to the road infrastructure mostly financed by the taxpayer apart from some expressways in some countries – the competition with road modes for short and medium distance travel is unbalanced and there is for passenger rail a shift from commercial services to subsidised ones and for freight rail from rail to

[9] Other revenues for operators come in general indirectly from the local taxpayers.

road. For commercial passenger services the opening of competition to coach services is also impacting the business case of rail companies.

Coach market

Coach services are services which are usually not (properly) integrated in travel planners, despite their huge overall number compared with air and rail. Coach services are operated usually on a commercial and competing basis apart from some purposes (like education); they are very fragmented and information for travel is most often produced at company level (except when coach services are part of the local set of services regulated by regional PTAs).

Local public transport

Local public transport services are organised on a very different basis than the above services. They rely on a hierarchical structure of transport modes with rail networks as a backbone in major cities: metro; suburban rail (and regional rail in multi-centric regions); tram and light rail; buses; complementary services (e.g. specialised PRM services)... These services are most often not independent from each other and do not compete but serve specific functions at macro or micro city level. They are coordinated at city level by the PTAs and the fare policy is not reflecting the real cost of each modal service.

In Europe local public transport services operated under PSO are operated under public transport contracts which can be awarded either directly to “in-house” operators or following a tender process opening competition for given sets of services. In the latter case there is competition among operators, but this competition is not on a line except in UK) but for a line or for a bunch of lines.

For commercial services, there is one transport contract related to the transport service, binding the Transport Service Provider and the customer.

For services operated under public service contracts, there are two different transport contracts, since the operator has two clients, the public authority and the customer:

- the public service contract binding the operator and the public authority which defines the rules applied to the services to be provided to the customer;
- the entitlement binding the operator and the customer which is activated when the traveller validates its embodiment (and follows the smart ticketing scheme set up by the authority).

Therefore, business cases of operators are very different according to the competing rules applied.

Local transport services operated with smart ticketing schemes (moving towards MaaS) can be seen as a ‘mode’ at the higher level of intra-European transport, and represent – from a customer perspective - exemplary intermodal ecosystems including integrated ‘tickets’ or single contract-multiple entitlements, at the local level.

From a customer/traveller perspective, a “single” multi-modal travel market (which integrates the silos of air transport, rail etc.) is advantageous when they intend to travel outside their city of residence and to mix transport modes and other travel services. Travel agencies are an example of TPS (together with some distributors and retailers) participating in such a market.

All these actors are the “incumbent” travel service providers, with “established” business cases. TSO are not necessarily interested in developing their market and changing their business case to attract customers different from their client base. However all have understood that the attractiveness of their transport services depend more and more upon the attractiveness of the associated travel information services as well as on the cooperation with new travel service providers. Opening their data to other actors is under way and supported at EU level through adoption of regulatory EU decisions.

A “single” multi-modal travel market would, from a business perspective and for numerous players (suppliers, distributors, retailers etc.), offer a greater market size in terms of demand, and therefore offer greater business opportunities, without prejudice to the co-existence of the two categories of services. However other factors are largely influencing the European transport framework, which are presented in the next section.

2.2 FROM TRANSPORT SILOS TO AN INTEGRATED EUROPEAN TRAVEL MARKET

2.2.1 THE DIGITAL DISRUPTION AND NEW SOCIAL TRENDS

In the new century the internet has totally changed the relationship of customers with travel information. We have entered a “digital world”.[10] Customer’s “connectivity” has deeply impacted both *“[…] our understanding of society and travel needs and the solutions to serve a sustainable urban way of life and development.”*[11] Indeed, it has been widely demonstrated how *“[instant] access to big amounts of data provides a base for a more intelligent provision of services, catering for different types of users and mobility needs, both for passengers and goods*”. Transport service providers (including public authorities) need to better understand the new transport trends, not only from a technology perspective but also a social one, to develop the market in line with the needs and expectations of the customers.

In parallel with the extension on the use of internet, and due to increased competition when allowed (e.g. first in the air sector) the transport market has been proposing more and more “customized” services (and customised prices). The principle was originally to separate a basic level of transport offer from a huge variety of complementary services provided on-board (e.g. more attractive seats, food, beverage, additional luggage). It has been progressively enlarged by other services becoming part of the trip (access to lounge, access to internet, frequent traveller cards, services part of the “last mile”, renting a car, booking a hotel…). Now the “travel” is much more than only “transport”.

New and very innovative services also benefitting from increased internet usage have emerged in the last ten years at local and national levels. A typical example is that of UBER, created in 2009 in

[10] UITP published in 2017 a report on Digitalisation: http://www.uitp.org/sites/default/files/documents/News/UITP_Digitalisation_Report_2017.pdf
[11] ERRAC. Integrated Urban Mobility Roadmap. February 2017.

San Francisco and now used in 633 cities of the world[12], which is also drastically evolving: "*What started as an app to request premium black cars in a few metropolitan areas is now changing the logistical fabric of cities around the world. Whether it's a ride, a sandwich, or a package, we use technology to give people what they want, when they want it*."

Some of these innovative services (like UBER-pool) could also be used in a "shared-economy"[13]. Varied groups of experts, such as the Horizon 2020 Transport Advisory Group[14] have already pointed out the impact of shared economy: "*The success of various car-sharing initiatives and green commuting schemes suggests that people are becoming more willing to travel together. The growth of car-pooling also signals a shift in personal expectation from vehicle ownership to vehicle sharing. These are social trends* […]."[15].

The most promising trend is in the so-called "Mobility as a Service" (MaaS) experience[16]: car-sharing, car-pooling, bike sharing, cycling, on-demand services and others[17], with Public Transport as a backbone and the new mobility services integrated and tagged on it. It is the only mobility solution able to compete with the private car in terms of flexibility, convenience and cost-structure.

The concepts of "transportation" based on a modal approach and of "travel" based of multimodal services are evolving into a wider concept of "mobility" based on a service approach, with Public Transport at the heart of the integrated urban mobility solution[18]. In addition, according to other numerous analyses, vehicle ownership is perceived to be less attractive if compared to other goods (e.g. smart-phones) and/or services (e.g. travel experiences).

It has been agreed that Europe needs a better framework for the joint action of major stakeholders to fully exploit the opportunities which this radical transformation is bringing.

In this framework, new solutions proposed via research and innovation activities addressing transport, like the ones developed in IT2Rail, should help transform tomorrow's European transport systems by integrating these new concepts into their structures. This convergence between (1) new mobility trends, (2) societal needs and (3) the new possibilities offered by a "Web of Transportation" drives towards a paradigm shift within the transport industry. The shift from private vehicles to more environmentally friendly modes is being driven by new travel experience offers, sufficiently low-priced and attractive enough, across Europe. A new mobility system centred on the traveller (rather than the transport vehicle) emerges under the spotlight.

2.2.2 THE NEW SCALE OF TRAVEL AND INFORMATION SERVICES

In addition to digitalisation and new social trends, another disruptive factor has contributed to a full modification of the approach to travel and mobility: the opening of borders inside an enlarged Europe. This opening led to changing roles of major transport stakeholders. Introducing a European perspective to the travel and mobility markets, embracing the creation of a single European market,

[12] https://www.uber.com/en-BE/our-story/
[13] An economy in which individuals accept to share the use of assets with others, e.g. a car.
[14] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/smart-green-and-integrated-transport

[16] And also "New Demand Responsive Transport".
[17] Sometimes going beyond passenger travel and including freight.
[18] http://www.uitp.org/sites/default/files/documents/News/UITP_Digitalisation_Report_2017.pdf

has modified the previous segmentation between the transport sectors. It has also modified the relationship to the customers from a “local” to a “European” traveller’s perspective.

It is also important to highlight the positive effect that the new EU General Data Protection Regulation (onwards GDPR[19]) will have in the effective opening of borders for the EU travellers as personal data subjects. In an increasingly digitized world, this “European” traveller perspective would be impossible without previously removing all the already existing digital borders between EU countries, and this is exactly the aim of the GDPR, by harmonizing all data protection regulations throughout the EU.

Yves Amsler, UITP

The most important challenge for the public transport market is to change the paradigm of a ‘city-centric’ or ‘modal’ traveller’s perspective into a ‘European-over-local’ multimodal traveller’s perspective.

Aforementioned disruptive factors have changed the traditional approach of travel, but in addition:

- more and more travellers - the “(hyper) connected customer” (also called a “millennial”) - are connected and want to remain connected before and during their travel. Their expectations have also changed: they expect more than just being transported, they want to be informed in real time and to communicate within their personal networks even on board. In addition, some of them may be open to the “shared economy” and may share some transport modes.
- new travel services and mobility actors emerge taking advantage of the digital environment (in line with the “MaaS” trends);
- the territory for travel is no longer local. It is not limited to cities or regions but enlarged to the relationship between cities and regions within a country (interurban travel) or within the whole continent of Europe (international travel). This ‘European-over-local’ multimodal traveller’s perspective’ is challenging new institutional actors and especially the European Union and the EC as well as a variety of national and regional/local actors.

As customer needs and expectations are evolving dramatically, adaptation by traditional key stakeholders becomes more pressing, whilst newer stakeholders are emerging and entering the market as travel service providers and/or web service providers.

2.3 CREATING A EUROPEAN “WEB OF TRANSPORTATION”

The third high-level challenge consists in designing a technical framework which could support an eco-system of supply-chain players in which the channeling of comprehensive transport products and services from multiple transport modes could be concentrated into ubiquitous one-stop-shops.

[19] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation): http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1509707436721&uri=CELEX:32016R0679

Whilst there are obstacles of a non-technological nature to the emergence at European level of one-stop-shops today, clearly the significant obstacle, within the technology domain, is the high cost of interoperability between links in the supply chains i.e. the heterogeneous formats and protocols for the dissemination of timetables, availability and pricing data, from different modes/operators, results in very few (if any) one-stop shops covering travel all-over Europe, because of the very high cost of implementing and managing this heterogeneity. And this is the case, even if there were facilitating public transport policy or Transport Service Providers strategies favoring the distribution of transport products to third-party retailing operations (which there are not).

The application of a semantics technology approach to achieving interoperability in the transport sector, as introduced by IT2Rail, is a major innovation, and promises to significantly remove the technology cost barriers for consolidating and aggregating content.

Other challenges have centered on addressing operator concerns about the treatment and distribution of their data (one obstacle to the supply to 3rd party retail operations) due to concerns about the security and quality of that data for reaching the end-User, when the supply is out of the hands of Transport Service Providers proprietary distribution and retailing operations, as well as the higher cost of doing so.

With regards to the cost of 3rd party distribution, if the cost of interoperability is reduced, one might hope that this cost reduction could be passed on to the Transport Service Providers. For the quality and security issues, the approach in this instance has been to comprehensively reject a forced or prerequisite centralization of data and processes within a single prescriptive centralised platform. The philosophy of the approach has been to facilitate the access to data wherever it happens to reside (no moving data around or collecting it for central storage – except where this is already in place and is a Transport Service Provider agreed feature of legacy supply chains e.g. in the air sector or in the local public transport sector within a given local mobility area) and to facilitate access to expert processes e.g. journey planning, availability and pricing processes, wherever that resides in connection to the formal presentation of that raw-data in Transport Service Providers' itinerary offers. This has been achieved by interlacing the Shopping Process with access to Resolvers such as the Travel Expert Resolver (the Interoperability Framework comprises a number of such 'resolvers') which provides the Shopping Process with the knowledge of how to access, directly, the relevant Transport Service Providers and/or their contracted and approved aggregators and journey planning processors. The opportunity for maintaining the quality of data provision which direct distribution channels allow for, should therefore be equally available via indirect distribution channels. Additionally, whilst not formally introduced in IT2Rail, subsequent projects in the Sihft2Rail Innovation Programme 4 (onwards IP4) plan to use the semantics technology to establish an access capability which takes into account any Transport Service Provider-agreed access as reflected in today's Sales Licensing and/or Distribution Agreements which the Transport Service Provider maintains with its supply chain partners.

Together these approaches bring the benefits of a distributed architecture, data and processing such as authenticity, quality and no single point of failure.

3. BENEFITS OF THE INTEROPERABILITY FRAMEWORK: AN INCLUSIVE OPEN LOW-COST INTEROPERABLE SYSTEM

A multi-modal transport system across Europe is exactly the type of scenario we face when considering door-2-door transportation services, which need to combine several modes of transport in order to provide a complete journey solution to the traveller. In this scenario, the requested door-2-door services will need to work with a large number of different actors, each having legacy information systems based on heterogeneous protocols and languages.

To force all of such actors to feed their data into a centralised repository or change their systems to conform to a common protocol and language would be an unmanageable and practically impossible task, with no guarantee of success. Conventional approaches have concentrated in the past on altering artificially the essential features of the distributed computing landscape:

- The adoption or regulation of common formats and protocols for inter-process communication aimed at removing heterogeneity;
- The local importation of remote data sets (data exchange) aimed at removing the distributed nature of data resources;
- The centralized governance of participant actors in the scope of multimodal solutions aimed at controlling the openness of the network.

While designed to reduce the complexity of the technical challenge, these approaches reduce interoperability to controlling the movement of data sets across the network. However, they generate high costs in the adaptation of existing systems to common formats and protocols, in the administration and maintenance of these formats and protocols to keep them common in the face of changing requirements, and in forcing participants into a centrally synchronized roadmap for the deployment of solutions.

Indeed, experience accumulated over years of attempts at making systems not originally designed for distributed computing interoperate through various forms of standardization on common 'data exchange' formats and protocols has in fact provided ample evidence that by far the highest contributor to the costs of interoperability is the effort required to share and understand differing sets of assumptions about the interpretation of data, whatever the standard or the format or the protocol is used: this is the problem of "semantic heterogeneity"[20].

In contrast, the IT2Rail project has recognized one-stop-shopping for multimodal travel solutions across Europe as a natively distributed computing problem. Therefore the interoperability challenge could be redefined as "Semantic interoperability".

[20] V. Ventrone, S. Heiler - Semantic Heterogeneity as a Result of Domain Evolution. *SIGMOD RECORD,* 20, 4: pp. 16.20, 1991. See reference [3]

As a project dealing with multimodal door-2-door transportation services, it is no surprise that IT2Rail decided to go into the direction of semantic interoperability, in order to include all needed actors into a single ecosystem of cooperating services, thanks to the capability of non-ambiguously understanding each other offered by the Ontology. Within IT2Rail the interoperability challenge is redefined as "Semantic interoperability".

Any transport service provider may have particular business requirements to connect with complementary transport services as a means to increase market share. For instance, this connection has to be cost-effective, meaning that the cost to create the connection should be lower than the potential benefits and revenues; and it has to respect the estimated window of opportunity in terms of time, meaning that the connection should be made in a time-lapse shorter than the timing expected for any significant market change, so to ensure that the key conditions of the market will not change before ensuring the connection.

In addition, if multiple connections with different partner services are required, e.g. to reach a wide range of different transport modes, or with multiple distributor/retailer networks, there are some consequences: incertitude, time, skills and resources and mainly high cost for reaching an offer due to the number of different formats/protocols one or the other party will have to implement.

The Interoperability Framework may offer the means to effect this connection. It offers to all the transport service providers (e.g. travel services providers, its supply chain or any current and future transport partners) a significant reduction in the costs of interoperability enabling fast growing interconnectivity networks for those strategies which demand it.

However, even despite this advantage, the key question to answer is: why this technology may be implemented in the transport sector? Why is it attractive from a business point of view? Main advantages of the use of the Semantic Technology in the transport sector could be listed as follows:

- Reduce cost to join the ecosystem:
  - Absence of technical requisites to join the ecosystem (no need of specific formats or architectures)
  - Absence of pre-defined business models (easy access to the European business arena for anyone)
- Reduce cost of operations within the system:
  - High speed and light cost for data integration
  - Minimum efforts required to update data in real time
  - Increased possibilities to create new tailored business and services, in other words, a great opportunity for European travellers

3.1 REDUCE COST TO JOIN THE ECOSYSTEM

One of the main advantages of IT2Rail Interoperability Framework is the creation of a low-cost interoperable system. New technical possibilities may be interesting only if they are cost - effective. In this context, it is key to understand that the Interoperability Framework system is an open low-cost ecosystem: Anybody can join it in an easy quick way with no pre-requisites. That's an inclusive system that eliminates the need to adapt anything. This easiness, in conjunction with the size of the market targeted, makes this technology very attractive.

Riccardo Santoro, TrenItalia

How hard/costly is it to publish your own website? You annotate your data, attaching meaning to your publications, so allowing the system to identify your data. Current alternative processes are more complicated.

- **Absence of technical pre-requisites**

The provision of a set of semantic interoperability services that can be deployed in multiple architectures and configurations. For this, they do not mandate a specific set of communication protocols or frameworks, leaving the choice to partners: they may opt to re-use a shared enterprise service bus, perhaps on a virtual private network protected by specific security and authentication protocols, or decide to engage in pure peer-to-peer exchanges over the wide web, even a mixture of these or other options.

As an example, in the IT2Rail project the Interoperability Framework actually worked on the following type of data:

1. UIC Rail Stations in the UIC TSDUPD format
2. VBB Rail Stations, Subway Stations, Urban Rail Stations, Regional Rail Stations, Bus Stops, Ferry Stops and Tram Stops in the VBB proprietary format
3. GTFS data formats
4. Airports, Subway Stations and Bus Stations in the Wikidata format
5. Additional transport infrastructure facilities (i.e. Stop Places) in CSV format
6. Proprietary VBB Rest/XML web services for sales
7. Proprietary SNCF Rest/JSON web services for sales
8. Proprietary Trenitalia SOAP/XML web services for sales
9. Amadeus SOAP/XML web services for sales

This collection of formats were not the result of a previous agreement: they are the ones in which the transport companies involved in IT2Rail operate in production. The criterion of using integrated formats currently in operation, not expecting anyone to adapt to a different "common format", regardless of which common format that may be. That's the fundamental test of "adoptability" used throughout IT2Rail.

Moreover the additional cost to make a new system compatible with the other ones already integrated in the ecosystem is very limited, so making interoperability economically feasible. Moreover, such cost does not depend on the size of the overall system, making the system itself easily scalable.

While preparing the final demonstration for IT2Rail the Vienna public transport networks' web services were annotated and published, allowing the services to be integrated in the ecosystem within half a day.

- **Absence of pre-defined business models**

There are no pre-defined business models that need to be adopted in order to join the ecosystem. There is no pre-set business model, operation, or strategy. This ecosystem will emerge organically from the interoperable 'play-ground' provided by the Interoperability Framework (the so-called "web of Transportation"). It offers then a highly cost-effective way of combining and integrating complementary business solutions, as no other technology does. In other words, multiple and varied business-models can be supported technically so long as their semantics are captured within the eco-system's ontology and there are no previous requisites to join the ecosystem.

Tom Jones, Amadeus

That's an inclusive system that eliminates the need to adapt anything in order to join, it's like a business playground. The connectivity will be low cost: Business advantages for the future to explore.

Indeed, the functionalities and scope of the registered services in the eco-system correspond to a rich eco-system of business operations and business relationships, whose business applications are rendered interoperable through the Interoperability Framework.

Semantic technology enables faster, more agile analysis of more varied types of data. It provides means for multiple unlimited purposes and it sets the path for a successful and low-cost interoperability transport sector.

3.3 REDUCED COST OF OPERATIONS

It would be a mistake to underestimate the economic advantages of semantic technology. Certainly, the Interoperability Framework helps to decrease cost and to ensure the economic benefits of low-cost interoperability, particularly in a scenario with multiple different actors - as may happen in the current European arena.

- **High speed and light cost for data integration**

Indeed the Interoperability Framework may offer much more. Once operating, it contributes to speed up the process of interoperability within the ecosystem, allowing for-real time data update and eliminating common misunderstandings that could be created by using other interoperable technologies.

> An ontology, then, is an active model that contains a variety of data structures and some way of propaging changes through itself.
>
> Esther Dyson, cited by Jeffrey T. Pollock and Ralph Hodgson in "Adaptive Information: Improving Business through Semantic Interoperability, Grid Computing and Enterprise Integration" – see reference [4]-.

Besides, semantic technology can also reduce the difficult, slow and expensive process of integrating at European level data from multiple databases, making it possible to perform queries against a wider range of data. The existence of common entities among databases, with links between them, allows users to create queries without having to know exactly where the data resides or how it is organized. E.g. connecting a semantic access interface to each relational database can often be accomplished in just a few hours. Data that does not comply with one function can be hidden while remaining available for other functions that are less restrictive, rather than being totally removed from the database. And as data quality rules change, updates can be applied rapidly without extensive reprocessing. In addition, the ontology can also manage the definition of synonyms to match the terminology that is familiar to end users.

This is particularly useful in scenarios that include merging data, facilitating corporate restructuring, consolidating data from multiple internal business units for analysis and deriving insights from multiple, independent systems that use different database models and data formats. Indeed a qualitative model of the cost of Semantic Technology shows how the implementation costs, even if initially higher to the traditional data integration process, are quickly overpassed by them. This phenomena has a direct relation with the size of the ecosystem. In other words: the more the data sources to interoperate, the more economically advantageous the Semantic Technology is.

Companies that provides services can make their own decisions based on their economic objectives. The Interoperability Framework needs to be business attractive. If not, it will not be used.

They will want to verify that the expected satisfaction of new demand will compensate the efforts invested.

- **Minimum efforts required to update data in real time**

In the relational database world, it can be difficult, expensive and cumbersome to add new attributes or descriptions to a data entity. It can potentially require a new data structure, revising the movement of data from one database to another, and the rewriting of any associated queries.

Semantic technology reduces the cost and schedule for loading newly on-boarded data into a database. In addition, it enables business agility by making it easier to add or change the attributes and definitions of the data that an organization stores and analyses, as well as the relationships among the data entities.

In a semantic database, it is possible to automatically add new descriptions to existing entities as data is loaded into the graph database and to add rules applying to the new attributes and existing attributes. It is important to note that the expertise captured in the data definitions and annotation[21], minimizes the management efforts and knowledge requirements during the daily operations.

Riccardo Santoro, TrenItalia

We need to provide new composed updated solutions to offer the travellers, to avoid the “I do not know” answer. We expect significant reduction of the costs of mobility resources to put together a solution, to engage other mobility services

[21] “Annotation” consists of mapping and tagging data instances -of IP4 ontology terms- in the service messages – as well as describing their scope using ontology tags to validate authorized as opposed to unauthorized use. In other words, identifying the type of information published following the words proposed in the Interoperability framework dictionary: the “ontology”.

Benefits	Limitations

• Quick visibility at EU level
• Easy to-join ecosystem:
  ○ Absence of technical pre-requisites
  ○ Absence of pre-defined business models
• High speed light new data integration
• Lower cost of data integration in the medium-long term
• Respectful with every single organization data structure
  • Expertise captured in the data definitions, minimizing management efforts
  • New mean for multiple purposes, e.g. leveraging new insights to work with data
	• Initial cost higher
	• Requiring specialized skills to have a good knowledge of company data and of the ecosystem ontology
	• Direct exponential interest based on the population of the ecosystem (currently low mass)

Table 3: Benefits and limitations of the Interoperability Framework

- **A great opportunity for tailored services**

In the new century the internet has totally changed the relationship of travellers with travel information. We have entered a “digital world”. Travel patterns, needs and expectations are changing and we are facing a new era where it is common to travel among cities in Europe, redefining the needs of the transport systems. Indeed, the business ecosystem has deeply changed: many new travel services through digital apps are directly proposed to the connected travellers: e.g. journey planners, destination service marketing, weather along the itinerary and other information on parameters which may impact the travel conditions.

Certainly transport is simply a means to an end where the citizens want to arrive in a fast comfortable and economic way. The territory for travel is no longer local or limited to cities or regions but enlarged to the relationship between cities and regions within a country (interurban travel) or within the whole continent of Europe (international travel). In this regard transport means need to be conceived as a part of a whole integrated system.

The European traveller has specific new and emerging needs that must be met, e.g. language habits, special support, favorite experiences, etc. Meeting these needs is challenging when talking about European itineraries.

Furthermore the end-to-end travel process for a door-to-door itinerary is becoming more complex, starting before the start of the trip (planning the trip at home) and ending after the whole completion of the trip (through customer satisfaction surveys and business analytics tools).

This collection of changes– towards increased multimodality - and at a larger scale – now European wide - within the seamless travel market are challenging the transport sector: New solutions should combine new travel services with the traditional ones. In this context the Interoperability Framework offers an easy quick affordable means to make all these services interoperable to build tailored services and to meet each traveller's expectations.

The Interoperability Framework provides means to build traveller-centric business applications operating on a distributed "Web of Transportation" in a fast and low-cost way. It allows the service providers to be easily exposed to the travellers request and to invoke new ancillary transport services that are not yet on the table. It is a great business playground accessible –and affordable- to everyone.

And even more, it is possible to find room in this new technology for even further needs. Indeed one of the main expected added values is the possibility of extending the Interoperability Framework to other areas. Indeed, the Interoperability Framework architecture may be adapted over time and may be made sufficiently responsive for the services likely to be developed in the future.

Stefanos Gogos, UNIFE

Providing an integrated solution to the passenger is key to seamless mobility. It is not relevant anymore for modes to be agnostic from each other. A delayed flight for instance can be a major disruption in a door-2-door travel and for this reason solutions in the lines of "you need to spend the night in a hotel located one hour from where you are in order to catch a flight the next day" should simply be made redundant. Identifying disruptions to your overall trip early and providing efficient alternative solutions quickly across different modes and services has to be the way forward.

3.4 INITIAL LIMITATIONS

It would be unfair not to comment some of the current Interoperability Framework limitations, even if they do not surpass or overshadow the already listed benefits. While semantic technology can deliver rapid and dramatic benefits, it also requires new ways of thinking about data, as well as new skills and tools:

- There is a basic need, at the early steps, of annotating and defining all the data descriptions and detailed models early in the analysis process. This may mean extra cost and efforts in a phase where the ecosystem has not yet been established;
- To join the ecosystem, organizations must rely on an expertise that might not be present or integrated in their current resources. Skills are required to generate the correct axiomatic systems, e.g. an ontologist (semantic data modeler) to ensure the right implementation of the Ontology. In addition, as the ontology is a dynamic living one, the ontologist can create new meaningful attribute synonyms so that users in different groups can continue to use familiar terms without cumbersome negotiations;
- There is a minimum threshold in terms of ecosystem size where, under the certain market conditions, it is not economically advantageous to join the ecosystem. However the size of the ecosystem is not in direct control of the members.

The last aspect is the most difficult to achieve. Indeed, the number of actors potentially involved is extremely high, and the scale of “the minimum threshold” to make the initiative successful is not known. Convincing the key players to join the ecosystem is key to create the “critical mass” allowing for a wider and speedy growth of the ecosystem.

Some of these aspects are proposed to be addressed in further IP4 projects.

4. IN PRACTISE: HOW TO JOIN THE ECOSYSTEM

In a Semantic Technology ecosystem, in case any potential members wishes to increase exposure of its products and services in this ecosystem (e.g. like the one described above: a new Mobility-as-a-Service[22] local operator), they just need to annotate their services to provide the necessary mappings with the IT2Rail ontology and publish them in the Service Registry and they will join the ecosystem.

> As a practical example of annotation, a Travel Service Provider may be requested to find itineraries for a travel from A-to-B, in other words, a Travel Service Provider may have a Web Service to get “Itineraries” from an origin to a destination.
>
> By using semantic conversion, the itineraries are processed to generate “Travel Episodes” as this is the concept defined in the IT2Rail ontology. In other words, the type of solutions required are mapped against the ontology, and they are identified as “Travel Episodes”.
>
> Therefore this annotation or mapping among the concepts defined in IT2Rail and the concepts used by the Travel Service Provider allows the different components and services of the ecosystem to “speak” with the Travel Service Provider without forcing the Travel Service Provider to adapt to a particular standard.

It is worth mentioning than in IT2Rail the Travel Service Providers integrated were not requested to annotate their services and interfaces themselves. For the demonstration developed in IT2Rail, this mapping exercise was done manually by each of the project partners. This has been possible in a reduced scope scenario. A wider scenario would also require each Travel Service Provider annotating its own services. For this reason, one of the objectives for Shift2Rail IP4 is to facilitate as much as possible this annotation process, so it could be easily done by any Travel Service Provider without external help.

[22] Mobility-as-a-Service: As part of the sharing economy, any shift away from personally-owned modes of transportation and towards mobility solutions that are consumed as a service, e.g. car sharing, bike-sharing, ride-sharing, car-pooling and others. Varied groups of experts, such as the Horizon 2020 Transport Advisory Group have already pointed out the impact of shared economy: “The success of various car-sharing initiatives and green commuting schemes suggests that people are becoming more willing to travel together. The growth of car-pooling also signals a shift in personal expectation from vehicle ownership to vehicle sharing. These are social trends […].”

- **The Ontology as the key asset**

An “ontology” is a description of the set of data within a domain. Ontologies are there since 30 years and more. However, today we have the adequate assets (computer with high processing capacity and large memory) and infrastructure (ubiquitous Internet offering wide-band connectivity) to deploy it in real-life large-scale applications.

Within IT2Rail the design of the Interoperability Framework is conducted thanks to the creation of a common dictionary of transport concepts including definition and internal relationships, based on the knowledge shared by the 27 IT2Rail partners. In other words, an “ontology”.

The Interoperability Framework relies on a shared domain ontology - an explicit, formal, shareable, machine-readable and computable description of the associated data and exchanges.

This ontology is an “open specification”. It does not incorporate as a requirement any proprietary implementation technology or vendor specific constraint. The main value of the ontology is to allow the entrance of any company in the ecosystem while respecting each companies’ particular implementation approach, for example different programming languages, a different run time environment, a different deployment strategy, or even a different architecture. In other words, no pre-requisites are needed.

The ontology is an “open specification” in the sense that it is made available to anyone under the term of an open source license. The Ontology can be easily distributed and shared, so it can become the common reference for all applications needing to exchange and understand information, in a specific domain. Moreover, the Ontology can be easily extended and modified, without impact on the software of applications using it. It is an ideal solution to ensure that heterogeneous, distributed information systems can exchange meaningful information and use it in order to cooperate in achieving a common objective, as part of the same ecosystem.

Having the ontology at its center, the Semantic Interoperability solution needs to be completed with some additional artefacts or assets, which allow to properly interface existing data sets with the semantic environment:

1) Web Service Descriptors: Metadata descriptions of the functionalities offered. It includes binding information. This information is needed to publish the services provided by each Travel Expert (i.e. Journey Planning, Booking, Issuing). Different languages (e.g. RDF) could be used for describing Web Services.

Example: A Travel Service Provider offers a Web Service to get the availability of the trains between an origin and a destination. This Web Service requires input parameters such as origin, destination and date, and returns a data structure describing the availability of the trains.

2) Business Rules and Processes: All the business rules logic is held in the models shared. This information is not mandatory and depends on the business processes and services provided by each Travel Expert.

Example: The “booking” of a railway ticket is articulated into three main steps named offering, pre-booking and booking. However the urban metro ticket does not include the three steps as there is not necessity to pre-book and book. In other words, an itinerary offer item involving SNCF will request a “booking” function but not the urban modes.

3) Schemas and Mappings: Schemas or mappings between schemas/ontologies aiming at supporting the technical interoperability between services/systems. This is what it is called “the annotation process”. This joint mapping between concepts is defined in the ontology.

Example: A Travel Service Provider returns a field in a Booking response called “seat”. This concept is mapped to the field “SEATCODE” in the IT2Rail ontology.

4) Data Sets, also called collection of data. It provides certain specific information about a transport domain that needs to be shared. This information is needed by the IT2Rail ecosystem so to provide the right interpretations and outcomes.

Example: The coding conventions used for common objects such as the Stop Places. This asset presents two levels:

- the semantics of the dataset, in other words, a common agreement about a concept – E.g.: Stop Place is an element of the Transport Infrastructure where Vehicle(s) may stop and where Traveller(s) may board or leave Vehicle(s).
- the data included in the dataset – E.g. “Zaventem Airport” is a Stop Place included in a GTFS file provided by the Travel Service Provider.

For more information about the assets, you may visit the IT2Rail website: www.it2rail.eu

- **New transportation service providers**

The Interoperability Framework will enable new business applications to 'interoperate' in an easy and fast way so as to provide the customer with comprehensive information on available travel options, corresponding processes for their booking, payment, ticketing (including consumption and/or modification), etc. More exclusively the Interoperability Framework could also provide a more favourable environment for particular added-value services to flourish.

Indeed, a variety of new travel services created by a digital society are influencing more and more the travel options proposed to the customers:

- Either at the interurban level and even at international level – like carpooling (e.g. BlaBlaCar);
- Or at local level - car sharing (and now electric vehicles car sharing), bike sharing, new forms of car renting etc.

These services are known by the general public through word-of-mouth and third-hand endorsement. It is a challenge for transport authorities and incumbent actors to identify them and analyse how they have to be considered as complementing or competing with regulated public transport services. Another challenge is to add them into the multimodal travel information services.

Delphine Grandsart, European Passengers Federation

First and last miles should be considered as regular actors in the transport sector, so included in our business arena

- **New services distributors**

The ecosystem could easily offer new services if offered by other ecosystem members. In the case of any members wishing to invoke the services of new ecosystem partners, the ecosystem members need to implement a single message-set based upon the 'native-ontology' in order to reach the new partner services - regardless of format/protocol. Therefore the eco-system easily completes and updates the travel offer.

Beyond this, there is a need to trust that the ecosystem can evolve at the same pace as the market: so here reference to Governance and the way in which the ontology evolves (the processes for how and when it gets changed/updated) is important. On top of that, trust in the capability of the ontology to capture business model features; to capture processing methods (e.g. 2-step booking process versus 1-step booking process) etc. is also important so that the members can trust that there are no constraints on the flexibility of the technology to evolve not just forwards but in depth or complexity. These are key things to build up.

5. FURTHER STEPS

The results of IT2Rail have demonstrated that the implementation of Semantic technologies in the transport sector is sound and feasible, meeting the fundamental expectation of automating the generation of conversion between standards through logical processing of the ontology. However this is only a single step of a longer way: additional tooling (i.e. utilities) may be needed.

Current challenges such as a ‘status-quo mentality’ or ignorance of the technology could threaten its wider implementation. To solve it, the Shift2Rail Joint undertaking is proposing different research calls addressing a wider understanding of this technology in the transport sector, e.g. by the development of pilots in all Europe (calls integrated in the Innovation Programme 4 – IP4). The implementation of the Interoperability Framework requires these tools to be understood and shared.

> As a lighthouse project of the Shift2Rail Innovation Programme 4 (IP4), IT2Rail has implemented a technical demonstrator of the Semantic technology, providing research-based evidence about the convenience of applying Semantic Technologies in the transport sector as a whole. However this travel does not finish there.

Sharing an Interoperability Framework for travel and adopting the Semantic Technology in the Transport sectors would certainly contribute to the identification and emergence of new travel services of interest for the European traveller, thus leading to opportunities for new unknown business cases not only for incumbent travel service providers but also for new actors in the emerging European multimodality market. Semantic Technology will allow a higher degree of automation of distributed processes across multiple data formats and protocols, spanning unspecified actors. It would in particular facilitate the creation of new interoperable applications and reduce the time to market for software developers. The benefits offered by the Semantic Technology include a great opportunity to improve European citizens lives, so a better Europe to live and to work in. It is clear that the Interoperability Framework offers new possibilities that could be capitalized thanks to research activities, setting out the future capabilities.

5.1 ADDITIONAL ATTRACTIVE & VALUE IF SERVICES

The Interoperability Framework offers low-cost interoperability to ecosystem members. Indeed, the technology could also be leveraged towards a number of other IF services which encourage market-take-up. Here below is a list of ideas which have been discussed within IT2Rail and by members of Shift2Rail-IP4 and which could find themselves as objectives in subsequent calls for members or open calls:

- **Personal Data Protection & Security services**

One of the flagship examples of additional Interoperability Services that may help to improve the lives of the European citizens is enabling the exercise of their rights under the new General Data Protection Regulation (onwards GDPR) solving a common problem where all ecosystem partners are involved. There is no data storage in the Interoperability Framework, but the IF may know how to identify where an individual's data is within the ecosystem. A service could use this capability to dialogue automatically with the relevant target entities and even deliver an individual's request (display, copy, delete) to the personal data hosting entity. Equally, from the personal data hosting entity's perspective (e.g. any Transport Service Provider) this service would encourage the development of automated service/channels for such requests and allow for the automated satisfaction of end-user requests which have been channeled in accordingly, so reducing labor costs attached to operating a purely manual system to deal with end-user requests.

The Interoperability Framework could give us a service to enquire the ecosystem about "how/where is my data" or even to delete it in a distributed manner.

Javier Warleta, ADDocean Technologies (ethical, privacy and security expert)

It could be a way to build a one-shot trust service: the future Shift2Rail IP4.

- **Security of Authorized Access**

One principle objection to the concept of 'sharing' or 'opening' up access or availability of raw transport data (e.g. timetables) has been Transport Service Provider reticence that to do so will mean losing control over that data, the way it is interpreted, the way it is used, to whom it is passed or made available, and ultimately the way it is refreshed, updated and managed, with potential risk of inaccurate data or poor quality data being passed to end-users, knowing that the consequences may then back-fire on the original Transport Service Provider.

To reassure the transport stakeholders, especially those Transport Services Providers concerned about joining an eco-system which might expose them to indiscriminate access of their services and data, it is important to highlight the potential of the IF ontology and semantics for describing the Services on offer at registration time.

Ontology tags for describing the services can be designed to reflect business rules around authorized access. So that the geographical attributes or type of accessing entity, identity of accessing entity or even ultimate retail entities can be described sufficiently accurately so as to reflect the Transport Service Provider's current commercial agreements in terms of distribution and sales licenses.

In other words, a Transport Service Provider would have full assurance that, by joining the ecosystem, no unauthorized entity can access their products and services, and that the Transport Service Provider remains in full control.

Other services (see below) could encourage Transport Service Providers to 'open up' once they have the confidence that the technology is granting them complete control over their distribution strategy. Even a Transport Service Provider that today will not distribute to any entity outside of its direct distribution and retail outlet network needs to be satisfied that this will not 'break' by virtue of joining the eco-system. They need to be assured of that, and the semantics technology enables this control very easily.

The technology also favors accessing distributed expertise and processing, so that data is accessed where it is stored today, without moving it around, or centralizing it; whilst the Transport Service Providers own expert processors e.g. journey planning expertise is also easily accessible.

Due to this factor, it could even be claimed that this innovative use of semantics technology in the travel industry reinforces the quality of data and the quality of data-processing which exists today within Transport Service Provider direct channels.

- **Flexibility to experiment**

The Interoperability Framework can also offer discovery of business analytics reports, produced by Business Analytics service providers with access to all past activity within the ecosystem. For example, one difficult aspect for Transport Service Providers to master is identifying popular multimodal passenger flows i.e. where origins and destinations for trips/journeys are tracked across transport modes. Normally, each transport mode captures data about the passengers, and their journeys, which that mode is supporting, but there is little captured data on how each passenger continues their journey towards which destination and via which other mode.

Such business reports could prove invaluable to Transport Service Providers seeking to identify important multimodal passenger flows which pass through or close to their own transport network, but which also identifies the other transport networks the real journeys also 'touch' – so suggesting potential Transport Service Provider partners for commercial agreements and the development of joint-products services which combined are capable of capturing more passengers than either service would do when offered as a stand-alone service.

In conjunction with this, the IF could run two modes: production and simulation. Simulation could allow any Transport Service Providers to edit their service descriptions, changing the ontology tags, in order to reconfigure their distribution strategy e.g. opening up to third party distribution channels and retail outlets.

In simulation mode, the Transport Service Providers (or any supply chain member) could request to run relevant pre-prepared mobility request scripts, allowing them to compare, for example, the number of times their products and services are offered in the list of itinerary offers presented to the customer with the number of times, using their current distribution configuration. This could help the Transport Service Providers to identify potential partners for expanding their distribution.

These two factors alone would offer some mitigation on the risk of changing distribution strategy, by more keenly focusing on the best candidate partners, and allowing for results based experimentation of different distribution strategies, prior to 'going live'. These types of facility are not available anywhere today in the real market-place.

- **Business Playground environment**

In addition to the above features, the IF could make available a simple Service Registry Scan or search, which was capable of summarizing, automatically, using the ontology tags on the service descriptions, the lists of available services, with a description of what they do and what their scope coverage is. In this way, every time a new member joins, all existing eco-system members could find out about the new services which are available.

This provides a wealth of opportunity, since knowing what is available can feed the imaginations of companies seeking to add value to their service offerings. For example an online feed service of weather or traffic conditions, may prompt a journey planning service, invoking them, to recommend other itineraries (to be on the safe side) than those which available information on timetables and service disruptions would otherwise suggest.

In other words, such scan search would provide ecosystem members with a view on what new services are on offer within the ecosystem which could be invoked for combined for added value purposes with their own services. This could then allow for current ecosystem members to deliver innovative new products/services or innovative new features for existing products/services. Once again, the IF technology and environment can make this type of opportunity available to ecosystem members, which as an automated service would be practically impossible in any other business / production environment.

5.2 MAY THIS ECOSYSTEM BE BASED ON TRUST?

This technical solution has proven to be useful to the improvement of the digitalized seamless European travel market. However this technology is not sufficient: a challenge for all actors is to build multimodal trust and to share attractiveness for commonly agreed specifications between the numerous travels stakeholders. The integration of the multiple actors in this single ecosystem is a matter of trust. But what enables this trust? In an ecosystem like the one proposed, with no central control, trust is a very delicate asset that should be further investigated.

Important elements which prospective ecosystem candidates might want to be able to trust:

- That no un-authorized access of current products and services is possible;
- That the wider granting of access to current products and services will not degrade the quality of information about those products and services, to the detriment of the Transport Service Provider;
- That the final costs, and time-to-market, of interoperable connectivity are far lower and faster than their equivalents based upon traditional methods of achieving interoperability;
- That the evolution of the ontology, is able to keep pace with the evolution of business within the market-place, to reflect new business models, new business processes, and new business relationships;
- That the evolution of the ontology is neutral and transparent and not dominated or prejudiced by any dominant player, or sector, within either the industry or the supply chain;
- That financial security is guaranteed – products and services distributed and sold via the ecosystem will generate their legitimate settlement.

A number of these items are ensured by the technology itself, and the flexibility and speed with which real world phenomena can be represented and rendered machine-readable. Some others are supported by the distributed nature of the ecosystem architecture, its services and its data, as we have seen in previous sections.

Finally, for trust in the evolution of the ecosystem, and the ontology supporting it, we must look to one of IP4's open calls GOF4R which addresses the operational aspects of governance and ontology evolution into the future.

In a separate IP4 project called GOF4R the governance of the Interoperability Framework is studied so to better understand how to manage the rights and obligations of the stakeholders joining the ecosystem, including the key aspect of trust. Likewise, the issue of neutrality and transparency is also addressed in terms of the bodies required to manage such governance. Indeed, even if this topic has not been yet addressed in the current investigations, the technological tools proposed by IT2Rail may become the means by which trust can be built, in addition to addressing other data privacy and cyber security issues. It is important to note that, as any tool, the Interoperability Framework will not itself provide the content of the rights and obligations, but technically support the flexibility with which the ecosystem can build and implement the Governance procedures as needed and agreed.

Mr. Guido Di Pasquale, UITP

A sustainable governance, through GoF4R project, will effectively define the processes and environment to best promote the use of the Interoperability Framework components and secure the confidence for service providers to deploy them, creating the right conditions to foster its European wide implementation.

Scott Heath, Network Rail

We could be part of the solution, influence it and be part of it