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IT2Rail: information technologies for shift to rail

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Abstract

The IT2Rail-“Information Technologies for Shift2Rail” project is a first step towards the long term IP4 -“IT Solutions for Attractive Railway Services”, one of the Shift2Rail Joint Undertaking’s Innovation Programmes, which aims at providing a new seamless travel experience, giving access to a complete multimodal travel offer which connects the first and last mile to long distance journeys. This is achieved through the introduction of a ground breaking Technical Enabler based on two concepts:

- The traveler is placed at the heart of innovative solutions, accessing all multimodal travel services (shopping, ticketing, and tracking) through its travel-companion.
- An open published framework is providing full interoperability whilst limiting impacts on existing systems, without prerequisites for centralized standardization. This Technical Enabler will be completely settled in the context of the Shift2Rail IP4, and IT2Rail is proposing a reduced approach to the scale of a specified use case without weakening any of the key concepts of IP4, such as the usage of Semantic Web technologies, meta planning on distributed data, travel companion with a protected and secured personal wallet stored in the cloud and including the rights to travel.

The use cases will be defined as specific instantiations of our open concepts, and will benefit from a completely scalable architecture fully instantiated in IP4. This approach is addressing all the key challenges of the work program, supporting a complete door-to-door multimodal travel offer and proposing a seamless integration of the very diverse existing and future services for planning, one-stop-shop ticketing, and real-time re-accommodation.

Moreover, thanks to an Interoperability framework which insulates travel applications from the standards fragmentation in multimodal transport, IT2Rail liberates business-model innovations in the market-place, guaranteeing the economic self-sustainability of these e-services in the long-term.

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1. Introduction

Embracing the ambitions set out by the European Commission 2011 White Paper, the comprehensive programme of research and innovation Shift2Rail introduces an Innovation Programme [IP4] ‘IT Solutions for a Seamless Attractive Railway’, dedicated to solutions for transport multimodality, seamlessness and sustainability. It is within the spirit of preparation for the IP4 programme that the ‘Information Technologies for Shift2Rail’ [IT2Rail] project has been established.

The ambition of IT2Rail is to transform the European citizen’s global travel interactions into a fully integrated and customised experience, traveler focused, through the introduction of radical new technologies and solutions. This should render the entire European transportation system into a natural extension of citizens’ work and leisure environments, across all modes, local and long-distance, public and private.

IT2Rail’s vision should lead to a dramatic increase in ‘rail attractiveness’, generating sufficient growth in demand to support a major shift to rail through a large spectrum of travel services (figure 1):

A seamless travel experience: a complete multimodal travel offer, focused on connecting the first and last mile (mainly urban public transport services) to long distance journeys combining air, rail, coach and other services.

A seamless access to all travel services: the travel experience will be totally enhanced through the integration of a wealth of travel services supported by innovative digital technologies.

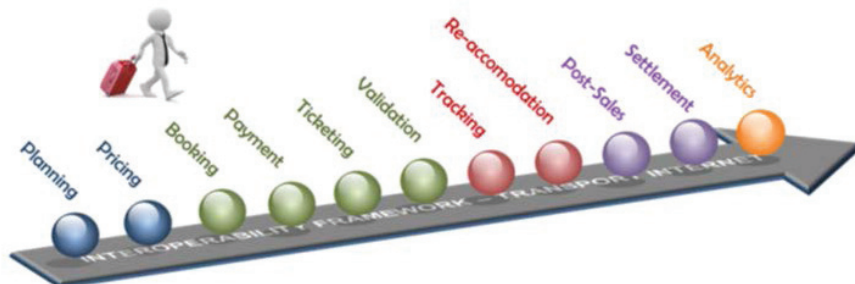


Fig. 1. A large spectrum of travel services.

This core objective of extended seamlessness will be answered though the introduction of a ground breaking ‘Technical Enabler’ driven by two concepts:

- The travel experience becomes the ‘product’ with the Traveler placed at the heart of innovative solutions. This user centric shift ensures that multimodal travel services mask the complexity of the transport system and offer a whole new door-to-door travelling experience with strong appeal, simplified access and trusted reliability.
- An open published framework will allow unprecedented services interoperability, whilst limiting impacts on existing systems, without prerequisites for further centralised standardisation. Transport industry incumbents and newcomers will discover wide opportunities to provide new services, products and new competitive business models.

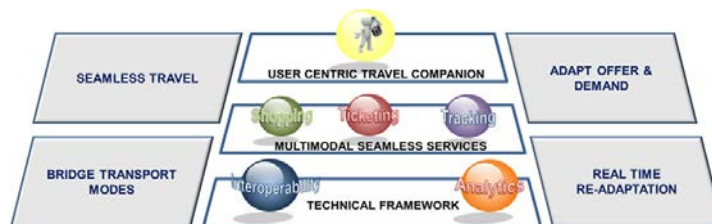


Fig.2. Building a technical Enabler.

The practical objectives of IT2Rail encompass a quick win approach through a concrete integration of preliminary technical demonstrators of the core technologies offered in Shift2Rail IP4. Considering the limits of the open call, the approach is organised around specific use cases which nevertheless will permit the illustration of the key concepts (figure 2):

- **Objective 1:** Directly and personally interfacing with the user, the user-centric Travel Companion application will be specified while a first ‘feature-reduced’ implementation will present its key concepts (unique travel identifier, user preferences and travel/payment wallets). The final objective is to allow the Traveler to access all multimodal services (shopping, booking, ticketing and tracking) with special attention to mobility constraints.
- **Objective 2:** A new-era Travel Shopper application will allow multimodal travel planning, integrating at least rail, urban and air transportation offers in ‘one-stop shop’ mode. A first ‘feature-reduced’ implementation will facilitate travel shopping of regional, urban, rail and air itinerary combinations in co-modal fashion including the first and last mile of the multi-modal travel.
- **Objective 3:** IT2Rail will develop a ticketing concept based on interoperability across transport modes. The final objective is to allow the citizen to book and pay, in ‘one-click’, a complete multimodal travel solution across heterogeneous transport systems and operators. The citizen will instantly receive ‘dematerialised entitlements’ (electronic entitlement tokens or links to them) in the travel companion associated to their unique traveler identifier. These travel entitlement tokens will be readable by the relevant validation devices throughout their multimodal travel using, for example, their smartphone.
- **Objective 4:** An ambitious set of trip tracking technologies will be designed to take the ‘stress’ out of travel service disruptions and incidents by providing traveler-tailored information and ‘on-the-fly’ re-accommodation services in a multimodal travel environment.
- **Objective 5:** To guarantee interoperability of all multimodal services described above, open standards for a ‘new generation’ Interoperability Framework, will be developed and published. This relies on the coding of coherent transportation ontologies and semantic web technologies to establish an embryonic ‘web of transportation things’ through which the complexities of fragmented standards are masked from the participating travel applications. Whilst this has the potential to forge links between multimodal transport information and a wealth of other travel-related and destination services. A simplified first implementation of the framework will prove the concept for the core capabilities associated to travel shopping, ticketing and tracking.
- **Objective 6:** Key concepts of the application of a business analytic solution, interfaced dynamically with other services (shopping, ticketing and tracking) will be explored for the IT2Rail use cases, taking into consideration the needs for data protection, according to legal constrictions, in a competitive business environment.
- **Objective 7:** Benefits and applicability of the concepts will be clearly demonstrated within the IT2Rail deliverables through a real door-to-door test of technical demonstrators applied to the specified use cases using a reduced scope of European virtual ‘travel corridors’, involving a limited number of major European transport operators and Urban Transport authorities covering a diversity of legacy systems and environments.

The sleek articulation of IT2Rail with the wider scope of Shift2Rail will offer a remarkable time to market for future IP4 innovations. The objective is to create the momentum that will optimise European Railway usage in its integration with other modes of transportation.

2. Overall approach and methodology

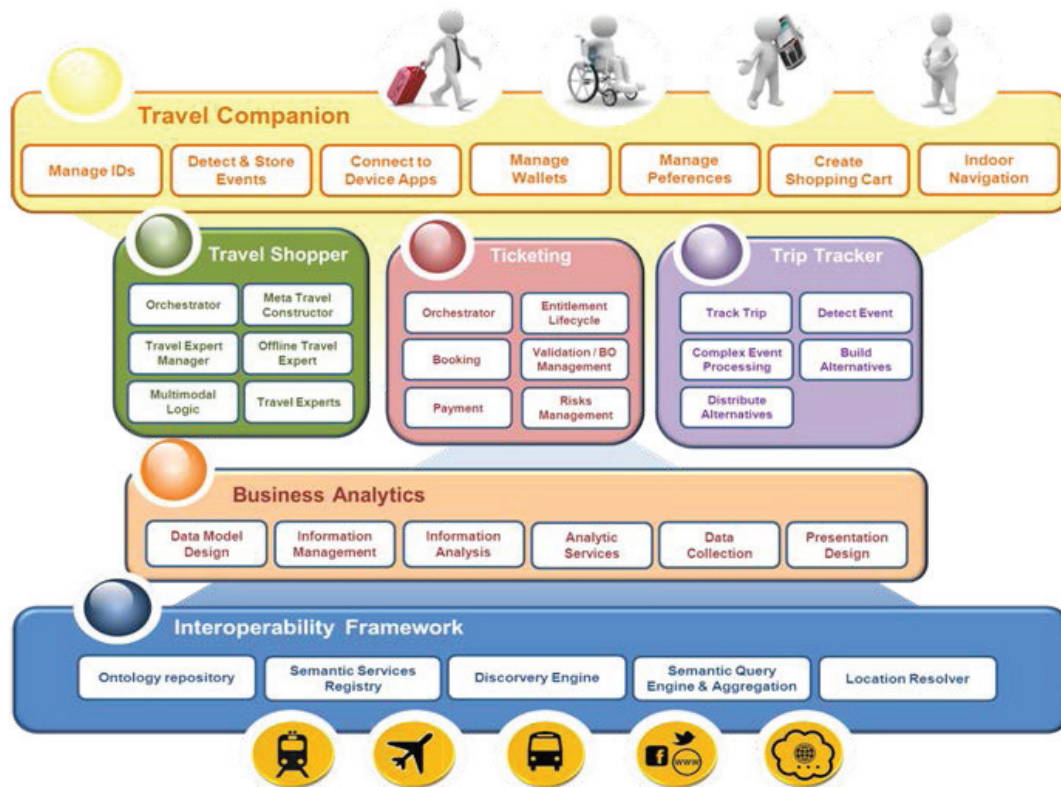


Fig. 3. Overall functional Approach.

The approach and methodology (figure 3) will be focused on the development and introduction of a new ‘Technical Enabler’, based on:

I - Interoperability Framework

The interoperability framework guarantees technical interoperability of all multimodal services by insulating consumer applications from the task of locating, harmonising and understanding an open-ended world of data, events, and service resources, which are consequently made available ‘as a service’. The innovation relies upon semantic web technologies, designed to exploit the establishment of a ‘web of transportation things’ based on coherent and mapped transportation ontologies.

This technology addresses the fragmented state of the market without need for additional centralised standardisation and leverages existing transportation ontologies. It is also open and expandable as data providers can join on voluntary basis by sharing data annotated with terms of the ontology’s vocabulary.

Compliant with the principle of openness, the interoperability framework is agnostic toward any application requiring its services, thus allowing multiple and concurrent implementations of the multimodal services and travel companions to access the full range of available data.

II - Travel Companion application

Directly and personally interacting with the user, the Travel Companion is a protected and secured data store in the cloud accessible by the citizen through a preferred smart-device through a dedicated application. It introduces the major concept of a unique identifier used by an individual citizen to access and operate on the entire European

Transportation System. As such, the Travel Companion is uniquely associated with a citizen and his/her secured ID, not with specific Travel Service Providers or retailers.

The cloud data store is organised in a set of secured compartments containing, among others, traveler preferences, preselected customer payment means and credentials, itineraries obtained from a Travel Shopper, and entitlements from ticketing processes. The Travel Companion application is accessible via smart devices and is portable with respect to different travel retailers. Personal data shall be managed in accordance with the legally required protection of privacy and individual rights.

By customising his/her Travel Companion the traveler can build a personal and dedicated virtual 'travel environment' where he/she can feel shielded from the complexity of the transportation system. Interaction with the Travel Companion can be customised according to personal choice, e.g. language and other 'local' properties, whilst indoor navigation and other capabilities as made available by local instrumentation may be discovered automatically by the interoperability framework.

III - Travel Shopper application

Using the services of the Interoperability Framework the Travel Shopper accesses distributed travel and transportation resources as a service of the interoperability framework as well as traveler preferences, stored in the Travel Companion. This provides the capability to build a tailored set of integrated door-to-door, multi-modal itineraries in answer to a traveler mobility query. The shopper has for ambition to become a seamless one-stop shop servicing all traveler itinerary requests including the first and last miles of the European journeys, as well as demonstrating how innovative and expert or 'niche' shopping related applications can be orchestrated at relatively low cost.

IV - Ticketing application

Using the services of the Interoperability Framework, the ticketing component locates and interacts with multiple booking engines and/or payment processors distributed across the network to generate bookings and entitlements for one or more of the multi-modal itineraries selected by the citizen on the Travel Shopper. Ticketing also coordinates payments as requested, and stores created objects (e.g. entitlement) in the citizen's Travel Companion.

Nowadays, multimodality and seamlessness are especially visible also through the traveler's ability to navigate throughout the heterogeneous urban transport environment (card centric systems, back office centric, electronic entitlement tokens or their physical embodiments, near field communication technologies etc.). The ability to access other older generation transport network systems whilst offering an open and adaptive capability towards the latest progress of the transport industry (near field communication technologies, EMV payment, etc.) is at the heart of this multimodal service.

V - Trip Tracker

Using the Interoperability Framework and Business Analytics Framework, Trip Tracker monitors relevant events available on the 'web of transportation things' that could affect the traveler's trip. Matching those events with the preferences and door-to-door itineraries, stored in the Travel Companion, Trip Tracker aims to provide the user with a shield against travel disruptions by enabling real-time seamless re-arrangement. To this end, Trip Tracker may automatically invoke Travel Shopper and Ticketing to create alternate itineraries, and, through the Travel Companion display alerts, offer alternative routings and trigger re-accommodation where applicable or desired.

VI - Business Analytics Framework

The Business Analytics Framework will allow the operators to adapt their transport environment and services with greater accuracy by listening to traveler's feedback, thus contributing to the ease and seamlessness of the traveler's experience. Integration with Social Networks will be a valuable source of traveler's feedback. The Business Analytics Framework uses 'big data' technologies to access the 'web of transportation things' through the Interoperability framework and leverage the data published by the multimodal services to generate analytical insights, (e.g. service disruptions risk) tailored on demand to multiple consumers. The created analytical data sets are -in turn- semantically annotated and published back to the 'web of transportation things' thus contributing to its enrichment. Selected analytics can also be accessed by the Traveler through their Travel Companion.

The introduction of this 'Technical Enabler' will be supported by a sound and robust methodology based on the following principles:
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Initiate an involved community around the new developed concepts:

The complexity of a very fragmented transport market can be addressed through innovative technology but the need for the federation of all stakeholders (public authorities, operators, services providers, users, etc.) around our key concepts/services is paramount. IT2Rail will lead to the organisation and the coordination of a large and inclusive community, which will play an active and integrative role.

Lead a robust system engineering to ensure consistency:

The IT2Rail activities put openness and interoperability at the core of the specifications and design activities, to support a common and consistent engineering approach.

The methodologies applied for the new development considered by IT2Rail will promote the concept of 'Resource oriented Architectures' and 'Agile developments' to benefit from the feedback of the Community.

Finally, IT2Rail will work breakdown and organisation breakdown with Shift2Rail IP4.

Implement a strategy for convergence of all technical demonstrators:

Whilst the various technical demonstrators can be seen as separate services, it is their combination which will guarantee the emergence of a complete multimodal transport seamless system. As such, a comprehensive effort of integration and convergence of the technologies needs to be achieved to offer a concrete door-to-door demonstration of the pan European seamless multimodal travel experience.

Integrating all technical demonstrators together and relying on a first iteration of the Interoperability Framework, IT2Rail will demonstrate the interoperability of each multimodal service (Shopping, Ticketing, and Tracking) with the User (through its Travel Companion). This demonstration will base itself on a European virtual travel corridor encompassing air, rail, urban travel modes and using transport operators' data and legacy systems.

3. Ambition

In contrast with the current situation in which travelers must adjust to different interfaces, devices, protocols, conventions, procedures and tools developed over the years by many retailers and operators, IT2Rail will place the traveler back at the centre of the transport infrastructure and introduce ground breaking technologies in the transport domain. Travelers will only need one smart device and one application to define, shop and enjoy their trip.

3.1. Advance provided beyond the state-of-the-art:

To meet our ambitions, the following fundamental technologies (sourced from an open market of suppliers extending beyond the conventional reach of 'pure' transportation vendors), will be implemented:

Semantic Web technologies:

At present transportation information systems rely on the exchange of data in an agreed syntactical format, or schema, describing a specific representation of facts, states and events about the business domain. Knowledge about the domain itself, which is needed by systems for the interpretation of the exchanged data, is exchanged via human readable documents. Interoperability comes therefore at a high cost of implementation and an even higher cost of evolution. This conventional approach, sometimes resulting in fragmentation, is perceived as the main obstacle to seamless multi-modal travel.

In contrast, IT2Rail approach accepts that the world of transportation service providers needs to be open-ended, evolves at its own pace, uses multiple data formats and interfaces. Our interoperability is positioned at the semantic level and defines formal and explicit models of the transportation domain in an open standard machine-readable language that will be exchanged automatically by computers. Automatic construction of an open-ended 'web of transportation things' will be enabled with associated access, query and operation services. This radical approach will transform the way data are perceived as it will become immediately usable when providers autonomously publish and make it available.

From Tickets to Travel Entitlements:

Current ticketing and validation systems across transport modes and operators have great variability in terms of concepts, architectures and equipment. Level of services, capability description, booking, known or unknown destination, pre-paid product versus post-payment, validation media and profile of users vary greatly from a system to another. The consequences today are that the citizen must often switch between several sites in order to book, pay and ticket the component parts of their intended trip – and must have multiple tickets to validate through the multimodal travel.

In contrast, IT2Rail approach aims to hide this complexity from the citizen and enable ‘one-click’ booking/payment and ticketing of complete multimodal itineraries as produced by the Travel Shopper component. This entails orchestrating multiple but parallel dialogues with several booking, payment and ticketing engines, including the all-important roll-back activities should any single transaction fail in order to eliminate risk. Sustained by the concept of a unique traveler identifier and the Travel Companion wallet - the citizen will have easy access to the complete and integral components of his/her trip, including easy production of the entitlement and tokens required for all ticket validation controls and inspection controls encountered on the way. This is facilitated by connectivity to the Interoperable Framework which will allow one-click ticketing applications to manage the different message formats pertaining to each mode/operator providing services. The creation of a unified entitlement lifecycle management will radically simplify the traveler’s life by abolishing uncertainties associated to ‘behind-the-scenes’ multiple booking, payment and ticket processes. Furthermore, it is intended to design a shared ecosystem that would support any type of commercial agreements between travel service providers. Although the IT2Rail use cases will demonstrate management of co-modally retailed transport segments only, the design will also serve ‘through-ticketing’ across modes.

Considering the validation process as a key element for the traveler experience improvement, IT2Rail will leverage on the introduction of high capability traveler connected devices through the Travel Companion application. Although downward compatibility to existing and legacy systems will be possible for operators joining the scheme without modification of existing equipment, our approach will promote new technologies.

Distributed Big Data and Analytics:

As with interoperability, current solutions for data discovery and analysis in transportation are designed around large schema-based data stores which are kept by each Provider separately, restricting the extent of the analysis, or that need to be copied and harmonised on such centralised stores to yield significant insights on an extended range of phenomena.

In contrast, IT2Rail approach accepts that open-ended, non-centrally coordinated world of networked sensors, devices, social media, services and transactions will generate an increasing volume of useful data in various forms. By using novel ‘big data’ technologies such as ‘intentional’ semantic information, retailers and operators will gain the capabilities to analyse distributed and heterogeneous linked data. Publication of analytical results back on to the distributed web of linked transportation data will demonstrate that sharing data make them more valuable.

Meta planning on distributed data:

The ambition for IT2Rail multimodal Travel Shopper services is to escape from centralisation, fragmentation and opacity of data which together straitjacket the emergence of multimodal door-to-door travel planning services across today’s individual transport-mode markets.

In contrast, to the centralisation of data, IT2Rail approach will promote the integration of distributed travel operator data and the orchestration of services such as expert travel- planning. The Interoperability Framework facilitates both aspects by enabling applications based upon different standards or coding lists to communicate meaningfully but with no costly application adaptations. In this way, travelers will not have to decipher their own needs into formats/codes that can be understood by travel retailing platforms, and travel shopping can cater for the full range of travelers mobility queries from narrow-scoped specific (syntactical) targeted shopping (location A to location B) to vague (semantic) pre-shopping inspiration (where can I go for a cheap beach holiday during August?).

Information Security:

The current environment sees the dissemination of traveler's and consumer's private personal and payment data across a range of retailers and operators which individually store and control all digital travel contents with disparate levels of security.

In contrast, IT2Rail will give citizens full security of their seamless travel experience by providing them with their own personal and secured Travel Companion, allowing them to control the storage and sharing of their personal preferences, wallets and shopping carts. Advanced security mechanisms and technologies will be adopted in order to protect the Travel Companion from malicious or erroneous access attempts from unwanted or denied sources, from cloning and/or falsification, and from the possible user's own tampering with content such as proofs of purchase, payment or booking. At the same time retailers and operators will be able to identify and authorise Travel Companion access to their own systems and networks.

*3.2. Innovation potential***Travel experience will become the product:**

The conventional approach of designing systems based on the operator's operational capabilities and 'customer needs' abstracted as mere system transactions will be replaced by modelling human behavioural patterns in relation with transportation on different modes, at interchanges, and in different gender sensitive and cultural settings. A full set of characters will be modelled around which the design of components, interactions and human-machine interfaces will be conducted.

Go beyond technical seamlessness:

IT2Rail will extend seamlessness to encompass the full range of interactions between citizens, their digitalised work and leisure environment, devices including vehicles, smart cities and intelligent transportation systems, and the transportation network, all considered as an open-ended, self-sustained world of networked resources and services. Building on open semantic web standards and big data technologies, IT2Rail aims to provide interoperability with existing available resources automatically discovered over the network, but also to allow providers to design and offer enriched and smart travel services.

Break the complexity for the traveler:

IT2Rail will provide the tools to construct a digital, customised, integrated and operable representation of the seamless transportation environment with which the traveler interacts. It will mask differences in local protocols, procedures, customs or physical facilities and devices which currently make the overall transportation system hard to understand, trust or use, particularly for citizens in an unfamiliar environment or with specific cultural, sensorial or mobility constraints.

Foster the emergence of a competitive industry on open standards:

Current seamless multimodal travel solutions rely on top-down integration efforts, and/or centrally controlled standardisation of data formats and protocols on common platforms, with long development cycles. Moving beyond the state of the art by designing our solution as a possible implementation of a set of open specifications, IT2Rail will encourage multiple concurrent implementations by a competitive industry, thus reducing cost and risk barriers to adoption. By leveraging positive network externalities, IT2Rail aims to accelerate the process and reach self-sustainability of the expansion of the network of Travel Service Providers and of their suppliers.

4. Expected Impacts**Impact 1 - Improvement of the economics of the Travel Services Providers and customers ecosystem:**

The ecosystem's economics of Travel Service Providers will benefit by the elimination of the need for any common and scheduled 'platform' development. By supporting full semantic interoperability of interchangeable and loosely

coupled tools, data and services, within a distributed ‘web of transportation things’, multiple concurrent implementations will be developed independently by specialist suppliers and co-exist competitively. This will apply downward market pressure to the cost of sourcing tools and technologies for travelers, retailers and operators, while allowing them to retain full control of the choice of business models through which to consume or provide value.

Impact 2 - Reduction of the time to market for innovations:

The IT2Rail Project is conceived and scoped to deliver a demonstration of its full set of capabilities on significant realistic use cases within a European multimodal virtual travel corridor. This approach allows for an early discovery of potential technological, organisational or business process issues while at the same time containing the Project’s scope within achievable limits. It will pave the way to a complete set of use cases under Shift2Rail IP4. This approach will significantly reduce the risks of expensive redesign or rework.

Impact 3 - Enrichment of passenger experience:

Below are some examples of how each of the stakeholders (travelers, services retailers and transport operators) will perceive beneficial impacts thanks to IT2Rail:

- i) The traveler is now the owner of all travel information which is stored alongside preferences and payment means in secured cloud wallets. Such information is portable seamlessly between different Travel Companions under the traveler’s full control. The traveler can now experience seamlessness, not only across transport modes but also through interactions with a wealth of different service retailers and operators. The Travel Companion provides the traveler with a unified view of providers, shopping interfaces, designs, settings, procedures etc. There is no need for the traveler to handle multiple validations as those are automatically generated from the travel wallet all along the progress of the multimodal travel in one click. The traveler’s rights are automatically embodied into the operator’s travel tokens when needed. The traveler can now receive automatic notifications of significant events affecting the complete multimodal, multi-services travel (e.g. disruptions). Some rerouting and/or re-accommodation options are proposed if needed.
- ii) The retailer creates and offers smart Travel Companion services and plans tailored to individual traveler and/or travel itinerary. The retailer identifies the traveler and uses the Travel Companion as a one-to-one channel for communications and support for marketing strategies. The retailer receives a ‘richer’ travel search query allowing it to propose smarter services that take the traveler’s needs and context into account, such as personalised preferences, mobility constraints etc. The retailer can build more attractive travel solutions tailored to the traveler’s preferences and shopping cart contents, using its own and any other, possibly specialised, travel planner and any other resources available on the web of transport accessed through the interoperability framework. The retailer has access to booking information on traveler’s Travel Companion enabling it to cooperate with involved operators in caring for the traveler under disruptions and changes.
- iii) The operator gains access to the traveler’s identity and preferences, obtains a one-to-one communication channel with the traveler and can address any issues through tailored access to the Travel Companion contents. Operators are relieved from creating customer facing specialised software to accommodate specific traveler needs or tools. Demand for Operator’s services, is increased through integration with other providers of travel solutions which would otherwise be beyond the reach of the individual Operator. Operator’s own travel planner tools can be specialised and evolved independently or sourced from a market of specialists, increasing efficiency and decreasing costs. Operator’s cost in handling multiple fulfilment and/or payment processes and media is reduced. Traveler’s booking information content can be used by the operators through the analytics framework to gain insight on customers, markets and resource utilisation. Operators turn disruptions into valuable opportunities, customer care and provisioning of smarter services in cooperation with other operators and service providers.

5. Consortium

Table 1. IT2Rail consortium partners.

Participant organisation name	Country
Union des Industries Ferroviaires Européennes – UNIFE (Coordinator)	Belgium
Thales Communications & Security SAS - THA	France
Amadeus IT Group, S.A. - AMADEUS	Spain
INDRA Sistemas S.A - INDRA	Spain
SELEX ES SPA - SES	Italy
Trenitalia SPA - TRENITALIA	Italy
HaCon Ingenieurgesellschaft GmbH - HACON	Germany
Oltis Group a.s. - OG	Czech Republic
CEFRIEL - Societa Consortile A Responsabilita Limitata - CEF	Italy
Politecnico di Milano - POLIMI	Italy
Fraunhofer-Gesellschaft zur Foerderung der angewandten Forschung e.V. - FRAUNHOFER	Germany
Attoma SARL - ATT	France
Avalon Biometrics SL - AVA	France
Fundosa Accesibilidad SA. - FASA	Spain
Société Nationale des Chemins de Fer Français - SNCF	France
Universitat Politècnica de Catalunya - UPC	Spain
HERE Global B.V. - HERE	Netherlands
Commissariat à l'Energie Atomique Et Aux Energies Alternatives - CEA	France
The University of Nottingham - UNott	United Kingdom
European Passengers' Federation ivzw - EPF	Belgium
Rail Safety and Standards Board Limited - RSSB	United Kingdom
CNC Centro Nuova Comunicazione Srl - CNC	Italy
Union Internationale des Transports Publics - UITP	Belgium
VBB Verkehrsverbund Berlin-Brandenburg GMBH - VBB	Germany
Ferrocarril Metropolità de Barcelona, S.A. - TMB	Spain
D'Appolonia Spa - DAPP	Italy
Cybernetica AS - CYB	Estonia

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