

Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria

REFINET: A new era for the sustainable development of Transport infrastructures networks in Europe

Alain ZARLI^{a}, Miguel SEGARRA^b, Clemente FUGGINI^c, Thierry GOGER^d, Jesús
ISOIRD^e*

^a*Centre Scientifique et Technique du Bâtiment (CSTB)*
290 route des Lucioles, B.P. 209, 06904 Sophia Antipolis Cedex, France

^b*DRAGADOS S.A*
Avda. del Camino de Santiago 50, 28050 Madrid, Spain

^c*RINA Group S.p.A.*
Piazza Duca D'Aosta 14, 20124, Milan, Italy

^d*Forum of European Highways Research Laboratories (FEHRL)*
42 Bvd de la Woluwe, Woluwe St Lambert, 1200 Brussels, Belgium

^e*Fundación Tecnalia Research and Innovation (TECNALIA)*
Calle Geldo, Edificio 700, Parque Tecnológico de Bizkaia, 48160, Derio, Spain

Abstract

The main objective of the REFINET Coordination and Support Action has been about identifying research and innovation needs and supporting the mass-market deployment of existing innovative technologies, such as materials, components, systems and processes to support the modernisation of the European Transport Infrastructure using a multimodal approach to support investment decisions. To achieve its objectives, REFINET has in particular developed solutions enabling infrastructures decision-makers (e.g. Public Bodies, Ministries, the European Commission, Infrastructure Managers and Operators, etc.) to carry out an integrated evaluation, selection of projects and programs and monitoring them. This paper introduces to the main outcomes of REFINET, in particular the REFINET multi-modal transport infrastructure model, vision and Strategic Implementation Plan for research and innovation priorities.

Keywords: Transport Infrastructures (TI) vision and deployment plan; research and innovation priorities; technology mapping; TI knowledge geo-clustering.

* Corresponding author. Tel.: +33-493-956-736 ; fax: +33-493-956-733.
E-mail address: alain.zarli@cstb.fr

1. Introduction

The main objective of the REFINET Coordination and Support Action (<http://www.refinet.eu/>), funded by the European Commission (GA 653789) under its H2020 framework programme and under the auspices of the ECTP (*European Construction Technology Platform* – www.ectp.org), has been about creating a sustainable network that integrates relevant stakeholder's representatives of all transport modes and infrastructure sectors in order to nurture a unique and shared European vision of how should be specified, designed, built or renovated, and maintained the multimodal European Transport Infrastructure (TI) network of the future: this vision aims at integrating and prioritizing short-, medium- & long-term research and innovation targets, with a focus on the entrepreneurial consideration of infrastructures that targets the architectural, engineering and contracting ecosystem, including socio-economic aspects of the development and the management of infrastructures. The European transport infrastructure network is considered as the lifeblood of European trade and society, and is commonly regarded as a shared heritage of great economic value. But it is also recognised today that this network is composed of many existing infrastructures that no longer fulfil the current and future functional requirements and today's safety and quality standards, and requires refurbishment and increased capacities, potentially relying on innovative technologies, components and systems. REFINET is an instrument having initiated the organization of the future development and delivery of innovative design, construction, maintenance and upgrading concepts and solutions that promote and strengthen seamless transport links for passenger and freight - relying on a sustainable research network that integrates relevant stakeholders' representatives of all transport modes (road, railway, maritime, fluvial, air...) and transport infrastructure sectors. The primary and key objective has been to initiate a shared European vision of how the multimodal European transport infrastructure network of the future should be specified, designed, built, renovated, and maintained, and elaborate a SIP (Strategic Implementation Plan) defining the innovation activities required to make this shared vision a reality, with an approach towards deployment of this SIP. The main outcomes of REFINET have been:

1. A growing and **sustainable network of 838 stakeholders** in Europe and beyond (especially from the US), from all transport modes and the infrastructure industry;
2. A **multi-modal transport infrastructure model** - offering a generic simple vision that can be shared by all transport stakeholders and research related organisations, since being a high-level non transport-mode specific model that should be a living reference for the establishment of objectives and sustained criteria for defining the design and operation specification of infrastructure projects in Europe;
3. A **Collection of Best Practices** relying on a taxonomy of use-cases and reference practices in design, construction and maintenance of transport infrastructures that have already been deployed in practice;
4. A **Catalogue of technologies** for transport infrastructure, relying on a taxonomy framework that provides a mean to capture, classify and monitor currently available and emerging technologies;
5. A **Vision for the European transport infrastructure network** - so as to create a common understanding among the REFINET network members about the blueprint and characteristics of the multimodal European transport infrastructure network of the future - and the consequent R&I demands to evolve the current European transport networks according to this vision;
6. A **Strategic Implementation Plan** with prioritised R&I (Research & Innovation) actions, recommendations and guidelines containing actions and initiatives at different levels to be taken to design, maintain and operate transport infrastructures following the REFINET multi-modal transport infrastructure model, and cooperation between all stakeholders (transport modes & infrastructures);
7. A **framework for monitoring R&I projects** – all projects being developed in Europe (H2020 MOBILITY FOR GROWTH – Infrastructure calls, INFRAVATION, national R&I...) being analysed in order to assess their alignment with the REFINET Vision, identify their main results and support them in the dissemination and exploitation of these results;
8. A **TI-TechMapper** (a Geo-Clustering based platform) **for the visualization (mapping), search, query, analysis of technological demands**, to identify which technology/ies, practice/s etc. are more applicable, according to predefined criteria, to the purpose of the investigation, for a specific asset, in a specific environment, with specific boundaries (e.g. Key Performance Indicators, standards, etc.). In this sense the platform is a key enabler of the deployment strategy of REFINET, being the tool for the analysis and mapping of technological demands (e.g. related projects, existing technologies, best practice, EU funding schemes, etc.). It may also become a monitoring tool for policy makers to understand impact of funded innovation projects. The tool is one central vehicle to ensure all REFINET outputs are accessible to all TI stakeholders - Public Bodies, Members States Ministry, The European Commission, Infrastructure Managers and Operators – to make better-informed decisions and identify the technologies they need to

improve/update/upgrade the European TI. The TI-TechMapper is available <http://www.dappolonia-innovation.com/refinet/>, and on the REFINET website (<http://refinet.eu/ti-techmapper/>).

9. A set of **Recommendations for mobilizing R&I programs and ESIF** (European Structural and Investment Fund 2014-2020 (ESIF)[†]): REFINET has analysed the different European, national and regional initiatives that could support the deployment of the SIP.

All these elements, along with additional data coming from the FOX and USE-IT CSAs [Vaitkus & all 2017] [Zofka & all 2018], constitute the “knowledge” collected, stored and classified (as a database) in the REFINET TI-TechMapper [Refinet1 2017] [Refinet2 2017], being a web-based tool that enable clusterization, mapping, search and query of the aforementioned information. The Platform provides the Stakeholders of the sector (e.g. construction companies, TI operators and managers, public bodies / ministries, policy makers, research, academia, etc.) an easy-to-use tool to dig-up and analyze best practices, high-potential technologies / innovations in TI, outcomes from R&D funded projects, funding instruments and smart specialization strategies.

The REFINET platform is in particular at disposal of the network of European and international stakeholder representatives of all transport modes and transport infrastructure sectors created by REFINET, setting up the mechanism to reinforce networking among stakeholders in all modes in order to enhance the effectiveness of the transport sector: the REFINET network is about gathering together various stakeholders from quite different profiles and expertise involved in increasingly complex infrastructures and services – sustaining the improvement and effectiveness of the sector. The current REFINET community is very strong. Around 838 stakeholders are already part of the REFINET community or network (see Figure 1). The statistics also shows that the current distribution of stakeholders is well balanced in terms of geographical distribution, types of stakeholders, modal and cross-modal distribution and international dimension. This good achievement comes from the successful cooperation between the three CSA projects REFINET, FOX and USE-iT, which have joined forces in order to establish a representative REFINET Network of multi-modal transport infrastructure stakeholders. Such cooperation between the three CSAs brings forth the dissemination of project results to a wide community of stakeholders. The REFINET network helped to deliver a shared European vision of how to specify, design, build or renovate, and maintain the multimodal European transport infrastructure network of the future along with innovative processes so as to enhance the effectiveness of the transport sector. The REFINET network will continue to enable stakeholders to network with each other’s, and to contribute developing the shared vision on the future of the European transport infrastructure.

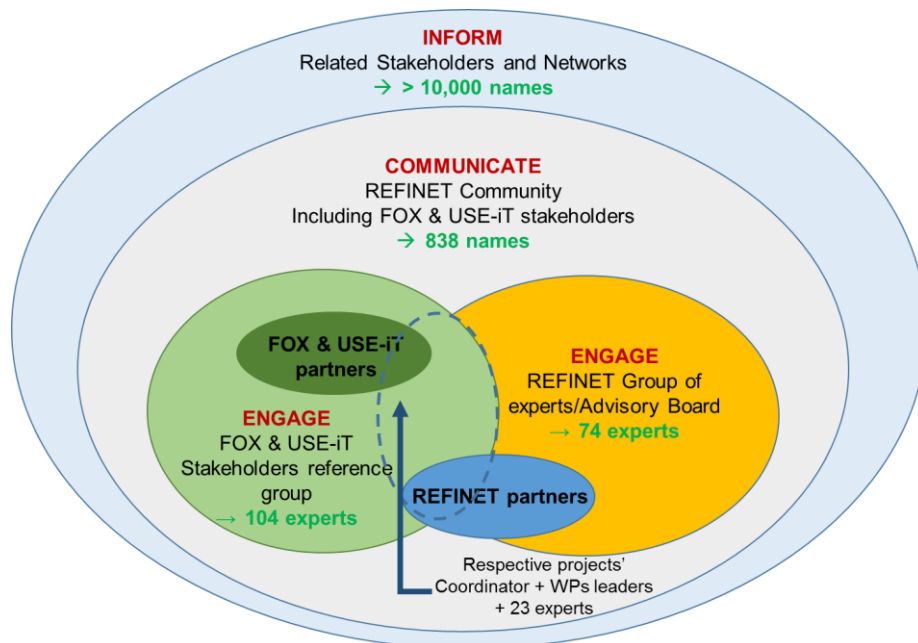


Fig. 1 The REFINET Network (August 2017)

[†] Enabling synergies between European Structural and Investment Funds, Horizon 2020 and other research, innovation and competitiveness-related Union programmes. <http://ec.europa.eu/digital-agenda/en/news/enabling-synergies-between-european-structural-and-investment-funds-horizon-2020-and-other>.

The paper provides with a description of the REFINET key outcomes, namely the REFINET multi-modal transport infrastructure model, vision and Strategic Implementation Plan, and further concludes with recommendations for future work and initiatives to be nurtured to support the sustainable development of European multi-modal transport infrastructures.

2. The REFINET multi-modal transport infrastructure model

The REFINET Multi-Modal Transport Infrastructure model (RMMTI) offers a generic vision that can be shared by all transport stakeholders and research organisations. It is a high-level non transport-mode specific model that should be a living reference for the establishment of objectives and sustained criteria for defining the design and operation specification of TI projects in Europe. The RMMTI model has been organised around three key levels:

1. Vision: level of service standards and performance measures;
2. Targets: systemic approach;
3. Priorities: technological gaps.

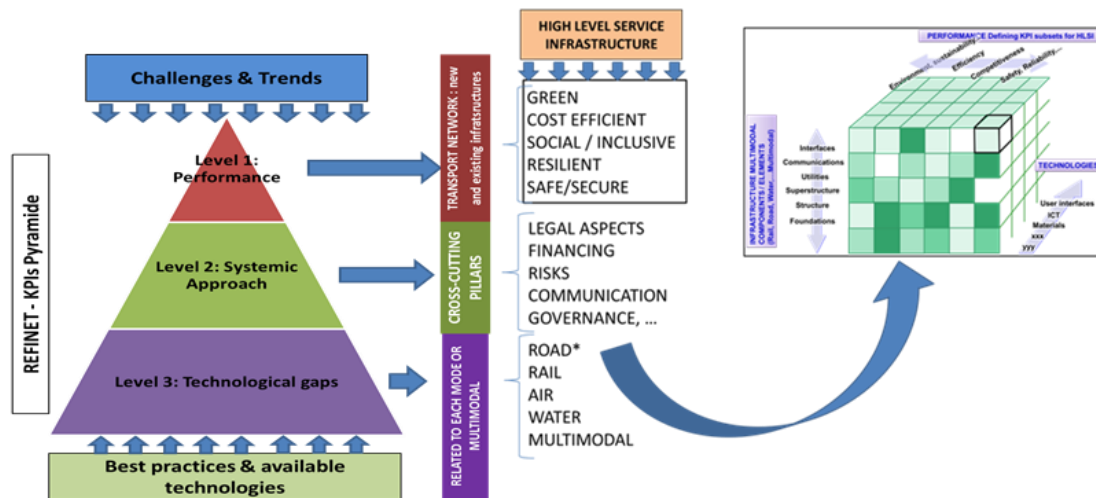


Fig. 2 The RMMTI model

→ LEVEL 1: Level of service standards and performance measures

“Level of service” (LOS) means an indicator of the network performance. Efficiency, Reliability and Productivity (LOS) analysis is used in planning to determine available capacities based on existing and anticipated travel demands. Multimodal level of service standards ensure that the operating characteristics of all modes are maintained or improved to a locally desirable level. Standards may relate to a variety of operational characteristics of importance to each mode [Williams & all 2014].

→ LEVEL 2: Systemic Approach

The second level of the structure of the REFINET model is from a whole system perspective in the design, construction, operation and maintenance stages of a new generation of intermodal networks and infrastructure.

→ LEVEL 3: Technological Gaps and Financial Models

The technology gaps process begins by collecting information / inventorying and analysing existing transportation conditions. This highlights both the needs of the current transportation system as well as improvements needed to accommodate growth. Analysis of both current and future needs share several commonalities, such as quality/level of service analysis for all modes, analysis for network planning, and evaluating transit needs. Local vision statements and supporting goals and objectives can provide a framework for evaluating alternatives and for selecting appropriate projects and strategies for a European multimodal transport infrastructure, including potential innovative business models.

In addition, the RMMTI model includes Performance indicators (also called measures of effectiveness) which are specific measurable outcomes used to evaluate progress toward established goals and objectives. The following ones are some examples of the KPIs proposed from the RMMTI approach:

- Speed/user time savings: network congestion indexes;

- Reliability of networks: variability of travel times;
- Capacity use of networks: in terms of traffic volumes, measured by vehicle-kilometres travelled per network kilometre or passenger boardings (patronage) per seat-km of services operated;
- Safety: primary indicators of multimodal networks overall safety are fatalities and injuries expressed per vehicle-kilometre or per capita or passenger boardings (patronage) per seat-km of services operated;
- Cost/Price alignment for road infrastructure: cost recovery for roads is through petrol excise and the road user weight/distance charge for diesel and heavy vehicles (although this is in the process of being simplified);
- Productivity for road infrastructure: annual user output supported by roads, as the vehicle-kilometres travelled, as a ratio of the annual recurrent costs of operation and maintenance of the road network;
- Productivity for passenger transport: an indicator of revenue passenger kilometres divided by public transport provision costs (estimated as fare-box revenue plus subsidy);
- Environmental performance: growth in total of CO₂ emissions from transport and on a per capita basis, total emissions of fine particulates (PM10 & possibly PM2.5) on a similar growth and per capita basis.

The model itself can be exploited in two main ways:

- A) **As an infrastructure performance index:** a potential and future main outcome will be the “REFINET index” that could be applied to different infrastructure types. This index would evaluate the performance of an infrastructure and network against the five performance criteria identified in the REFINET MMTI model. It could also contribute to benchmarking best practices among infrastructure managers and operators. It could be used at EU, Member State or regional level. Individual infrastructure owners / managers should establish their individual targets but it could be a EU wide tool to evaluate and improve the European Transport Network with a common perspective and it would be a coherent way to identify the areas of investment and evaluate the impacts. This model should be tailored to each case and further research is needed to identify and select appropriated KPIs, weights and measures. In this sense, new projects such as CityKeys, in smart cities, or PRIME, the platform of rail infrastructure managers in Europe, should be necessary to follow up with the KPIs development below the defined REFINET MMTI framework in order to cover the needed research. The following figure is an example of a potential use of the REFINET MMTI:

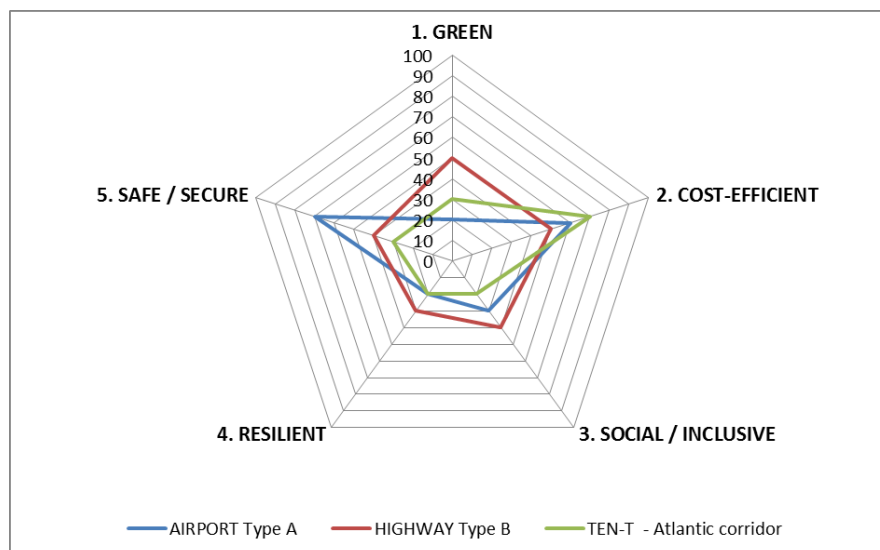


Fig. 3 Illustrative example of an evaluation based on the REFINET MMTI

Ideally, the exploitation of this outcome should be through consultancy services provided by the consortia members. The strategy to implement the model in a real case would be:

- Identification of the strategic vision and targets of the infrastructure owner / operator;
- Definition of the time line;
- Identification of KPIs to measure the performance;
- Establishing links and weights;
- Identification of the current scenario;

- Definition of actions, projects and initiatives to accomplish the vision;
- Monitoring the performance, evolution towards the ambition.

Furthermore, this outcome is public; therefore the community can make use and create a leverage effect on it both at EU level and at Member State level. In fact, the European Commission itself would be a strong promoter of the model if it is further developed and adopted by the European Commission to monitor the evolution and benchmark the transport infrastructure network as well as a monitoring tool for research and innovation projects.

B) As the guidance for the European multimodal transport infrastructure network: in this case, the model serves as the guiding principle and strategy for defining a long-term research and innovation programme for the European transport infrastructure. The model serves as guidance and structure of the programme. Defining challenges, actions and impacts for the five elements of the model (Green, Cost Efficient, Social / Inclusive, Resilient and Safe / Secure). This approach is applied to the three applications: urban mobility, multimodal hubs and long distance corridors. It is expected that ECTP and ENCORDER will trigger the discussion and collaborations with relevant stakeholders for the evolution of the RMMTI model and in particular with the European Commission, considering that this model could be implemented by the European Commission to define and monitor the future research programmes in infrastructures. Potential future use of the REFINET MMTI if further developed is:

Table 1. Use of the RMTTI according stakeholder profiles.

<i>Stakeholder</i>	<i>Potential use</i>
European Commission and Member States	<ul style="list-style-type: none"> - Monitoring and benchmarking of EU transport infrastructure network. It could evolve towards a Quality label. - Monitoring of research projects and evaluating their impact against strategic objectives.
Researchers	Starting point for future research activities related to KPIs, monitoring techniques, data acquisition and treatment, analytics,...
Infrastructure managers and operators	Methodology and decision support system to establish strategic objectives.
ECTP and other European Technology platforms	Definition of research and innovation programmes oriented to a coherent and sustained vision.
Industrial Association and initiatives such as ENCORDER	Promote the development of technologies and solutions that improve the implementation of the model and the strategic challenges.

3. The REFINET Vision

Transport infrastructure is fundamental for the mobility of people and goods, which in turn facilitates economic growth, competitiveness and territorial cohesion of Europe. It is faced with challenges including growing mobility needs, reducing impact on the environment, increasing energy-efficiency and resilience against climate change and extreme weather events and ensuring high safety and security levels. These are all constrained by the limitations on economic budgets. The European transport infrastructure network is one of the densest and most developed in the world. According to the Statistical Pocketbook 2014 of the European Commission[‡], the magnitude of European transport infrastructure accounts for:

- Roads: More than 70,000 km of motorways in a total road network of approximately 5 million km in the 28 European Union Member States.
- Railways: with a total length of lines around 215,734 km across EU28, of which 115,508 km are electrified and 7,343 km are high speed lines.
- Waterways: 41,000 km of navigable inland waterways across EU28.
- Airports: Almost 400 airports, 92 of those carrying from 15,000 to 100,000 passengers per year in EU28 [EU Transport Scoreboard].

However, as stated by ECTP[§] most of this infrastructure was constructed in the period 1960-1970 and was designed for a working life of 50 years. They now seem to be often strained far beyond their intended capacities in terms of traffic flows and loads and are reaching the end of their lifetime.

[‡] <http://ec.europa.eu/transport/facts-fundings/statistics/doc/2014/pocketbook2014.pdf>

[§] ECTP Refine Initiative (2012) Building up Infrastructure Networks of a Sustainable Europe – Strategic Targets

REFINET intends to create a sustainable network of European and international stakeholders' representatives of all transport modes and transport infrastructure sectors in order to deliver a shared European vision of how to specify, design, build or renovate, and maintain the multimodal European transport infrastructure network of the future along with innovative processes to enhance the effectiveness of the sector.

The following vision statement is the result of set of the analysis of existing studies from different European Technology Platforms and specific research agendas, understanding the main transport EU policies, identifying key global challenges, detecting barriers for innovation, conducting a SWOT analysis of the European multimodal transport infrastructure, and establishing priority areas and specific Research and Development needs based on Transport 2050 Roadmap and contributions from REFINET Stakeholders community and the other two CSAs (FOX and USE-IT).

The vision of REFINET stands for:

By 2050, a new **European multimodal transport infrastructure network** will ensure efficient transport of goods and passengers through the **High Level Service Infrastructure** concept spread out by **urban mobility, multimodal hubs and long-distance corridors** with the performances of **GREEN, COST-EFFICIENT, SOCIAL/INCLUSIVE, RESILIENT and SAFE / SECURE**, based on development of advanced technologies and by means of a **systemic approach perspective**, considering **GOVERNANCE, COMMUNICATION, FINANCIAL/ECONOMIC, LEGAL / STANDARDS and RISKS / INTERDEPENDENCY** aspects.

This REFINET vision is expressed through the development of High Level Service Infrastructure** concept, which was developed in the frame of the European Construction Technology Platform, and considers the following aspects:

- Providing infrastructure for **high quality mobility services** for people and goods while using resources more efficiently.
- Ensuring overall better service and performance, **including multimodal integration and intermodal continuity for the end-user**, less congestion, optimised transport time, etc.
- Higher degree of convergence and enforcement of **social, health, safety, security and environmental rules for infrastructure**, with the adequate service standards at all times.
- Interconnected solutions for the next **generation of multimodal transport management**, including information services and systems for all infrastructures.

The following objectives and targets, through the identification of KPIs, have been defined in order to improve technological level and to deploy them in the real transport infrastructure network:

- ✓ **GREEN**: Corresponding to the increased environmental awareness and the current impacts and contribution of transport sector. Contributing to take into account the entire life cycle and including in all its stages environmentally-friendly construction materials and processes.
- ✓ **COST-EFFICIENT**: Focusing on the economic constraints that oblige to optimise construction and maintenance costs, specially taking into account the whole life cycle of transport infrastructure and the availability and cost of energy associated.
- ✓ **SOCIAL/INCLUSIVE**: Connected to the challenge of ageing society, which requires adapting the transport infrastructure to be more accessible for all citizens. Not only in a physical way, but also to be accessible in all social and economic aspects.
- ✓ **RESILIENT**: Addressing the need to ensure performance during the long life of the transport infrastructure and the new challenges, disruptive events and requirements ensuring high quality service and continuity.
- ✓ **SAFE/SECURE**: Ensuring a high quality and safe / secure service. The transport infrastructure should contribute with respect to reduction of accidents, fatal events and severe injuries. Including other aspects such as cargo lost, theft and damage, by means of improved highly efficient management and operation of the networks.

and Expected Impacts

http://www.ectp.org/cws/params/ectp/download_files/39D2434v1_reFINE_Targets&Impacts.pdf

** Building Up Infrastructure Networks of a Sustainable Europe The reFINE Roadmap (2013)

http://refinet.eu/fileadmin/user_upload/documents/ECTP_reFINE_Roadmap__May_2013_.pdf

After defining this vision, one of the main outcomes of REFINET is the development of the REFINET Strategic Implementation Plan, which gathers a set of specific Research and Innovation needs organised according to the REFINET MultiModal Transport Infrastructure (RMMTI) model. The specific actions formulated by Research and Innovation needs have been structured providing information about different fields: specific challenges, scope, impacts, required level of investment, priority level and geographic scale.

4. The REFINET Strategic Implementation Plan: deployment of the outcomes

In the REFINET Strategic Implementation Plan (SIP), the RMMTI Model (see chapter above), a key output of REFINET, helps structure the various paths towards the achievement of the project Vision. In addition, built upon the RMMTI Model, other bespoke REFINET solutions have been generated to help achieve the project Vision. They are as follows and will be presented in detail in this document:

- The Framework for the Monitoring R&I projects
- The Catalogue of Best Practices
- The Catalogue of High Potential Technologies
- The Geo-Clustering Platform
- Identified future R&I priorities

These solutions are now going to be disseminated through a deployment strategy to help stakeholders – Public Bodies, Members States Ministries, The European Commission, Infrastructure Managers and Operators – make better-informed decisions and identify the technologies they need to improve their TI.

The deployment of the REFINET SIP will be characterized by two time-scales:

1. A short-term approach to support TI Managers and Operators in identifying solutions to their current needs by enabling the transfer of existing and incoming innovative technologies, such as materials, components, IT systems and processes, etc. to support Transport Infrastructure (TI) update, modernization, etc..
2. A medium to long-term approach to support Policy Makers including the European Commission and Public Authorities in Members States in identifying future research topics in TI based on an analysis of the current existing technology offer and the future demands.

Finally, supporting and enabling both the short term and long-term perspectives, dedicated “roadmaps” have been conceived as described in the following sections.

4.1. Short to Medium-term deployment of the REFINET outcomes and its roadmap

The aim is to support Stakeholders in Transport Infrastructure in identifying short-term (from now to 8 years) solutions to their immediate needs by enabling the transfer of existing and incoming innovative technologies, such as materials, components, IT systems and processes, etc. to support Transport Infrastructure (TI) update and modernization. Priority for the deployment in the short to medium-term is in geographic areas needing most support, i.e. medium and low performers as far as quality of the TI is concerned, as REFINET aims at “reducing the current disparities among countries or in the worst case ensuring that the existing gaps will not be enlarged”. The REFINET Multi-Modal Transport Infrastructure (RMMTI) model and the Strategic Implementation Plan (SIP) will help guide TI managers and operators, as well as contractors, in their investment decisions for what concerns i) the deployment or adaptation (before deployment) of available technologies and ii) the need for research and innovation in new technologies with the support of EU, national and regional funding. The TI-TechMapper platform will help them identify these innovations and understand how to access them, using the platform to enable a four-step process as follows.

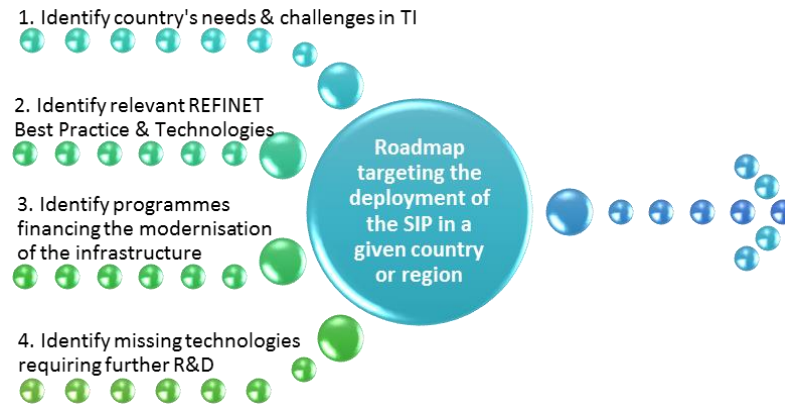


Figure 4. REFINET Short to Medium-term deployment of the REFINET outcomes

4.1.1. Roadmap

A concrete goal for the deployment of the REFINET outcomes would be to see, within 3 year from the end of the project, a technology transfer taking place through the use of the REFINET “TI-TechMapper” Platform. To achieve this goal, REFINET proposes the following roadmap with a detailed strategy for the first critical 12 months after the end of the project.

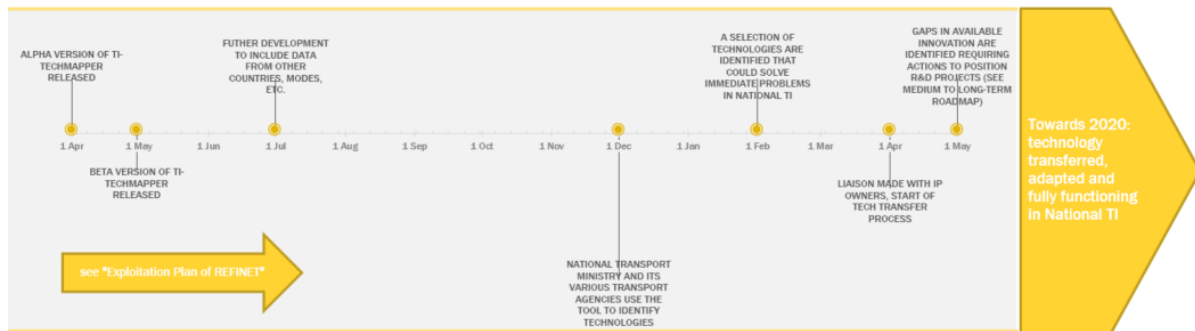


Figure 2. REFINET Short to Medium-Term Roadmap

The TI-TechMapper is a central element of the deployment of the REFINET outcomes in the short to medium-term. However, it is still under development. To reach its full capacity as analysis and mapping tool, it will require being uploaded with additional data covering more transport modes and more geographic areas. Two main routes may enable the further development, population and maintenance of the tool:

- Through the on-going and future funded H2020 Research and Innovations projects, in agreement with the European Commission, DG MOVE and the Innovation and Networks Executive Agency (INEA).
- Through relevant TI associations at EU and national levels, led by ECTP and its I&M Committee, but also possibly including FEHRL, and other Transport Technology Platforms and networks. The ECTP I&M Committee has committed to lead the effort of updating various of the REFINET outputs such as the catalogue of Best Practices and High Potential Technologies, to keep these alive and turn them into valuable references for the future of construction. Updating the TRL for each high potential technology will help continuously monitor their maturity and market readiness. The additional task of defining KPIs for TI will also be very relevant as well, requiring proper actions and funding support to be properly taken.

4.2. Medium to long-term deployment of REFINET outcomes and its roadmap

This second timeframe aims at relaying information to Policy Makers at Member States and at EU Level (including Transport Authorities) to support the medium to long-term development (from 8 to 20 years) of Transport Infrastructure in the EU and at National level through Research, Development and Innovations plans, based on an analysis of the existing technology offer and the future demands. Ultimately REFINET aims at guiding the long-term evolution of the TI at European and National level. After the project end, the research

priorities and actions identified through REFINET will be promoted at EU-wide level through recommendations as well as strategy and position papers to various key actors who will be able to use these results strategically to help them contribute to shaping the European Multi-modal TI of the future. These actors include:

- The European Commission, as well as the European Parliament.
- The 28 Member States (through their Ministries of Transport and Infrastructure).
- Public Authorities and Decision Bodies (e.g. authorities in charge of Transport Safety, in charge of transport policy for adaptation to climate changes, etc.).
- The European Technology Platforms in Transport & Infrastructures (ACARE, ERRAC, ERTRAC, Waterborne, ALICE, ECTP, etc.) and their related and relevant committees (e.g. the Infrastructure and Mobility (I&M) Committee of ECTP).
- Other Relevant Associations such as the European Network of Construction Companies for Research and Development (ENCORD), the European Infrastructure Managers (EIM), the Community of European Railway and Infrastructure companies (CER), the European Union Road Federation (ERF), International Road Federation (IRF), World Road Organization (PIARC), Airports Council International Europe (ACI EUROPE), European Sea Ports Organisation (ESPO), European Association for Battery, Hybrid and Fuel Cell Electric Vehicles (AVERE), European Federation of Inland Ports (EFIP), European Federation for Transport and Environment (T&E), UNIFE as the European rail manufacturing industry representing body, European Construction Industry Federation (FIEC) , European Passengers Federation, among others.

The actual deployment of the SIP will be implemented post-REFINET by a consensus among these actors.

4.2.1. Roadmap

A concrete goal for the medium to long-term deployment of the REFINET outcomes would be to see, within 4 years, included as topics of the first calls and work programmes of FP9 (follow-on programme to H2020 for R&I) some of the priorities identified and promoted through the SIP common vision. This would lead by 2023-2025 (maximum 8 years from the end of REFINET) to the first projects having worked on priorities set through REFINET being complete and working towards commercial application and exploitation and by 2028-2030 the first new technologies reaching the market to solve gaps in the current TI technology offer. The actions in the roadmap below are all linked to promoting R&I priorities to relevant decision-makers and primarily the European Commission and the European Parliament, through relevant intermediaries, first and foremost ECTP and its I&M Committee, and others such as the National Technology Platforms, networks, associations and platforms (e.g. FEHRL) to help them analyse current existing technology offering, incoming innovations (Monitoring R&I projects) and future demands (Challenges & Trends).

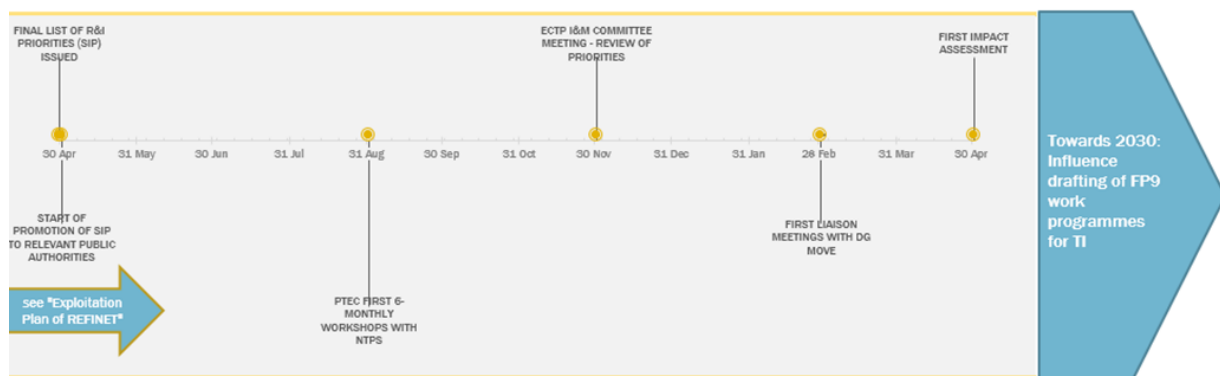


Fig. 5 REFINET SIP Medium to Long-Term Deployment Roadmap

A first milestone associated to this medium to long-term roadmap will be an impact assessment performed by ECTP's I&M Committee, around a year after the end of REFINET, to check on progress in promoting the REFINET R&I topics. The second milestone is for some of the 50 topics identified by REFINET to be called in the first FP9 work programme around 2020/2021.

To secure the wider impact and the successful implementation of the aforementioned actions, the involvement of the REFINET Sustainable Network will be crucial. In this sense it is foreseen that the most active part of the REFINET Network, namely the REFINET Group of Experts and the FOX & USE-iT Stakeholders reference

group, would form the basis for the establishment of an Expert Group. This group will be in charge to develop a strategic programme which should integrate the output from the CSAs REFINET, FOX and USE-iT, and enhance the work achieved within the projects.

5. Conclusion

REFINET has been a CSA project conceived to support on-going work of the ECTP's REFINE initiative and is continuing after its completion as part of ECTP's technology foresighting programme. There is an increasing awareness of technology convergence for improving future's transport infrastructure performance. However, the vision of the transport infrastructure of the future has been growing in silos or islands, many times linked to transport modes. One of the main objectives of REFINET was to make these silo visions also converge. For that matter, the central idea of REFINET was to take the concept of multimodality as the departing point for common understanding in the transport infrastructure community. Even there is still a long way to go, much has been gained during the project's lifetime and the objective of having a large community of transport infrastructure stakeholders contributing to the REFINET vision has been achieved.

Interestingly, during the project an aid to allow technologies to converge has been developed. The TI-TechMapper, being a web-based tool, enables clusterisation, mapping, search and query of best practices, R&D results, funding opportunities, etc. for transport infrastructure stakeholders, be them public administrators or private organizations or individuals, so they can make better informed decisions about their own transport infrastructure concerns. In addition, a set of prioritised actions to realise the REFINET vision (the SIP) and a set of guidelines and recommendations for mobilising research programmes have been produced in a joint community effort. REFINET had a vocation of public service. All the deliverables of the project are accessible from the ECTP's Infrastructure and Mobility Committee website. It has been after all not just the work of the project partners but that of many external contributors as well. Altogether, REFINET represents an opportunity for the future of TI and for the next R&D framework programme. It has provided a common space for TI professionals, academia and related stakeholders to meet and share ideas. Going back to the idea of technology convergence, it should also be the place for discussion and knowledge sharing where Transport Infrastructure technologies and people and freight Transportation technologies meet to realise mobility of the next decades.

Acknowledgements

The authors wish to acknowledge the financial support of the European Commission under the H2020 programme, and are grateful to the REFINET Consortium partners, namely Fundación TECNALIA, D'Appolonia S.p.A., FEHRL, UIC, Fundación Plataforma Tecnológica Española de Construcción, DRAGADOS SA, CSTB and Ove Arup & Partners International Limited.

References

- Audrius Vaitkus, Tadas Andriejauskas, Viktoras Vorobjovas, Miglė Paliukaitė, Thierry Goger. 2017. FOX and USE-IT: Harmonized and interoperable transport infrastructure across all transport modes, 29th International Baltic Road Conference, 28-30th August, 2017. Tallinn, Estonia.
- Ewa Zofka, Adam Zofka, Sarah Reeves, Isabela Erdelean, Ursula Blume, Martin Lamb, Thierry Goger, Miglė Paliukaitė. A New Approach to Integrated Cross-Modal Transport – the FOX and USE-iT Experience. Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria.
- Refinet1 2017 - <http://www.fehrl.org/knowledge-transfer/workshop-and-seminars/firm2017>
- Refinet2 2017 - <http://www.rinaconsulting.org/en/events?item=56>
- Williams, K. M., Seggerman, K. E. (2014), Multimodal Transportation Best Practices and Model Element, National Center for Transit Research, Center for Urban Transportation Research (CUTR), University of South Florida
- EU Transport Scoreboard <http://ec.europa.eu/transport/facts-fundings/scoreboard/>