Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

TRIMIS: Modular development of an integrated policy-support tool for forward-oriented transport research and innovation analysis

Anastasios Tsakalidis[a,*], Konstantinos Gkoumas[a], Ferenc Pekar[a], Monica Grosso[a], Gary Haq[a], Mitchell van Balen[a]

[a]*European Commission, Joint Research Centre (JRC), Ispra, Italy*

Abstract

The European Commission's Strategic Transport Research and Innovation Agenda (STRIA) outlines future transport research and innovation (R&I) priorities to decarbonise the European transport sector. Seven STRIA roadmaps focus on crosscutting research areas. In order to support and monitor the implementation of STRIA, the Transport Research and Innovation Monitoring and Information System (TRIMIS) has been developed. TRIMIS is an integrated transport policy-support tool with a modular design. It is an open-access information and knowledge management system as well as an inventory of transport technologies and innovations. TRIMIS provides a holistic assessment of current and emerging technologies and trends and R&I capacities in the European transport sector for all seven roadmaps incorporating foresight capabilities based on transport R&I data collection, innovation capacity mapping, technological status assessment, horizon scanning and taxonomy identification of new and emerging technologies and trends. This paper provides an overview of TRIMIS design features and added value as an integrated analytical support tool monitoring transport R&I that provides support to transport governance and decision makers.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: transport research; transport innovation; horizon scanning; emerging technologies; capacity mapping; transport taxonomy

1. Introduction

The transport sector plays a key role in the European economy responsible for an estimated EUR 651 billion in Gross Value Added (GVA) in the European Union (EU), which is almost 5% of total EU GVA (2015) (European Commission, 2017a). Apart from its economic impact, transport represents 33% of final energy consumption (Eurostat, 2017) and 19.5% of total greenhouse gas (GHG) emissions (European Environment Agency, 2016a) and is the only sector that has not seen a decrease in GHG emissions between 1990-2015 (European Environment

* Corresponding author. Tel.: +39-0332-78-5907; fax: +39-0332-78-6627.
E-mail address: anastasios.tsakalidis@ec.europa.eu

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY

Agency, 2017). Transport affects public health by being a major contributor to urban air pollution; premature deaths attributed to population exposure to particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2) and ozone (O_3) in the EU are estimated at 436,000, 68,000 and 16,000, respectively (European Environment Agency, 2016b). Moreover, the cost of road traffic congestion is estimated to be EUR 100 billion equal to 1 per cent of EU Gross Domestic Product (GDP) (European Commission, 2017b). It is clear that transport remains one of the main pillars of development having socio-economic benefits but it is also responsible for a series of externalities that negatively affect society. The existing transport policy framework and advances in transport technology have affected both the evolution of the transport sector and how it has integrated with economy and society. However, an updated legislative framework and the adoption of energy efficient and sustainable innovative transport technologies are needed if transport externalities are to be addressed.

In this context, the European Commission (EC) published in 2016 a European strategy for low-emission mobility and relevant Communications to promote clean energy innovation in Europe. The EC outlined a new approach to transport research and innovation (R&I) aimed at tackling current and future socio-economic and environmental challenges (European Commission, 2016a, 2016b, 2015a). In order to address socio-economic challenges arising from an ever-changing complex and competitive environment, new technological developments are required. This can be achieved through transport R&I that improves mobility and ensures European competitiveness. The EC has recognised the need to overcome existing barriers and seize opportunities by promoting transport R&I. In 2017, it adopted the Strategic Transport Research and Innovation Agenda (STRIA) as part of the "Europe on the Move" package (European Commission, 2017c), which highlights key transport R&I for clean, connected and competitive mobility to complement the 2015 Strategic Energy Technology (SET) Plan (European Commission, 2015b). The transport R&I priority areas are outlined in seven roadmaps:

1. Cooperative, connected and automated transport.
2. Transport electrification.
3. Vehicle design and manufacturing.
4. Low-emission alternative energy for transport.
5. Network and traffic management systems.
6. Smart mobility and services.
7. Infrastructure.

The implementation and development of STRIA requires an effective monitoring and information mechanism that provides transport R&I insights for all stakeholders. To meet this need, the EC Joint Research Centre (JRC) developed the Transport Research and Innovation Monitoring and Information System (TRIMIS) to provide a holistic assessment of technology trends, transport R&I technical and socio-economic capacities, and to publish data and analyses covering the whole European transport system. TRIMIS has been funded under the Horizon2020 Work Programme 2016-2017 on smart, green and integrated transport (European Commission, 2017d). It is an open-access information and knowledge management system that supports transport governance, policy making and research by identifying innovations with the greatest future potential. In doing so, TRIMIS assists policy makers to focus on areas where public intervention can have the highest added value (Tsakalidis et al., 2018a). In addition, the TRIMIS online platform serves as the end-user interface offering outputs by monitoring the effectiveness of European Union (EU)/Member State level funded research and assessing the level of contribution of transport research initiatives to a clean, connected and competitive European transport system. The development of TRIMIS follows a modular approach that allows the collection and analysis of transport R&I data as well as technology horizon scanning. It also provides a taxonomy of transport technologies, mapping and analysing new and emerging technologies and trends (NETT) and technological and socio-economic innovation capacities against key performance indicators (KPIs) and scoreboards.

This paper reviews the features, functionalities and benefits of TRIMIS as the European platform and analytical policy-support tool, modularly designed to support transport governance and policy making through an integrated approach to transport R&I monitoring and information.

2. Background and motivation

A policy-support tool involves identifying potentially interlaced activities and functionalities that, when arranged in a comprehensive manner, produce an effective instrument for policymaking. The transport sector covers a range

of activities with related physical and non-physical elements (e.g. infrastructure, vehicles, ICT solutions) that are inherently complex and dynamic in nature. The development of a policy-support tool therefore requires a series of technical and technological analyses that covers financial and socio-economic aspects of transport R&I in order to provide useful insights for policymakers (See Fig. 1).

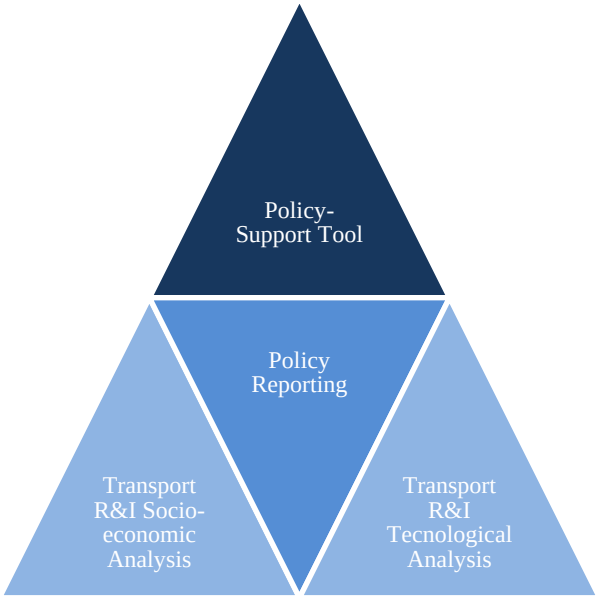

Fig. 1 Transport policy-support through R&I analyses

Although a number of tools have been used at national and international level to facilitate the development and implementation of transport policies, they vary in their features, functionalities, complexity, coverage and target audience. The main European tools include the Economics of Industrial Research and Innovation action (IRI), the Research and Innovation Observatory (RIO), the Tool for Innovation Monitoring (TIM), the EU Innovation Scoreboard, the EU Transport Scoreboard, the Strategic Energy Technologies Information System (SETIS) and mode-specific platforms such as ACARE, ALICE, ERRAC, ERTRAC and Waterborne. At the global level, the two main platforms are the Transport Research International Documentation (TRID-TRB) and the OECD Science, Technology and Innovation Outlook (European Commission, 2018a, 2018b, 2017e, 2017f, 2017g, 2016c, 2016d; National Academy of Sciences, 2017; OECD, 2016). Fig. 2 presents the main tools along with an analysis of their available characteristics.

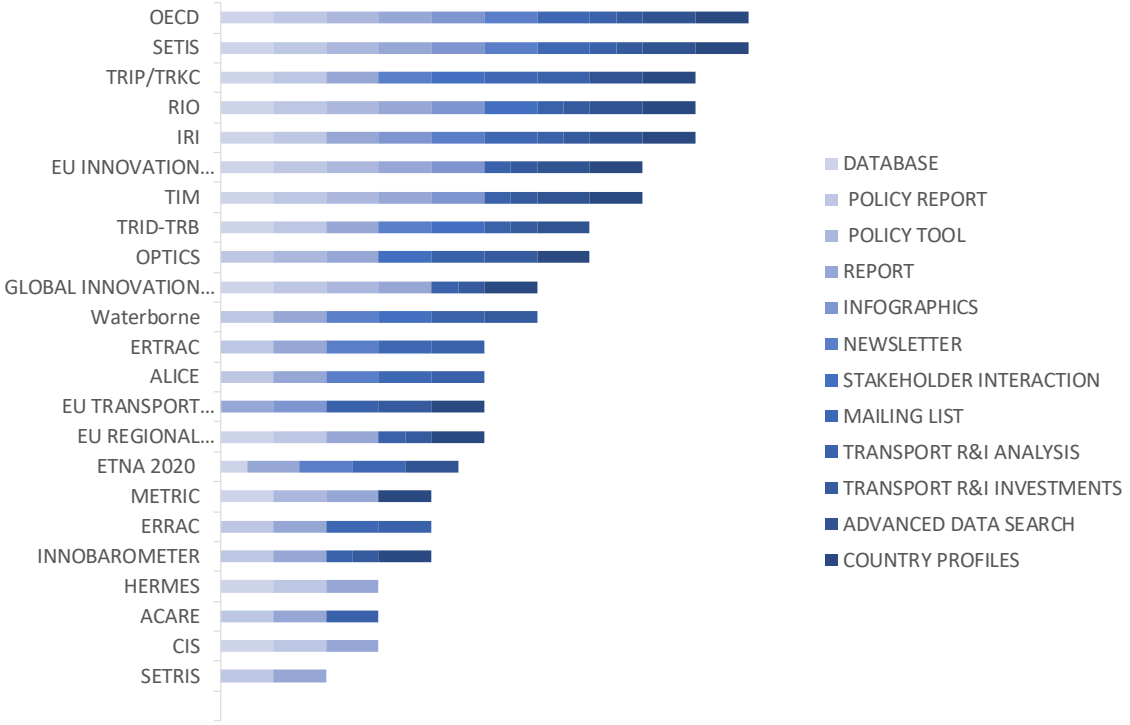

Fig. 2 Principal R&I platforms and databases (Tsakalidis et al., 2018b)

It is evident that the available platforms and tools provide varying outputs to their end-users highlighting the need for an integrated tool that can provide a holistic monitoring and analysis of R&I in the transport sector. TRIMIS was developed as a comprehensive platform and policy-support tool to cover the whole transport R&I spectrum and meet the needs of a transport stakeholders with a focus on policy-making and governance. Fig.3 provides an overview of the added value of TRIMIS per user target group.

EU Policy-makers	National Policy-makers	Researchers - Academia and Industry	Students	Technology Investors
• Publish information on the STRIA roadmaps • Set long term transport policy roadmaps • Incentivise research, development and knowledge sharing in transport • Add, update and download data • Gather information on current R&I status	• Find information on long term EC policy in transport • Understand comparative information from other countries	• Disseminate information on research projects • Find other researchers to collaborate within a specific technical area	• Find information on long term EC transport policy • Find information on research projects	• Find an inventory of NETT in the transport sector • Find information on most promising new technologies • Find information on performance of specific technologies • Find information on area-specific R&I

Fig. 3 TRIMIS user target groups and added value

3. TRIMIS structure and functionalities

TRIMIS monitors and assesses the implementation of STRIA and is the EC instrument for mapping transport technology trends and R&I capacities. It is an open-access information and knowledge management system that monitors progress against R&I roadmaps. Fig.4 provides an overview of the main TRIMIS features and functionalities. These include mapping technologies and capacities in the EU transport sector, horizon scanning, identification and inventory of NETT, dissemination of information and the development of toolboxes, etc.

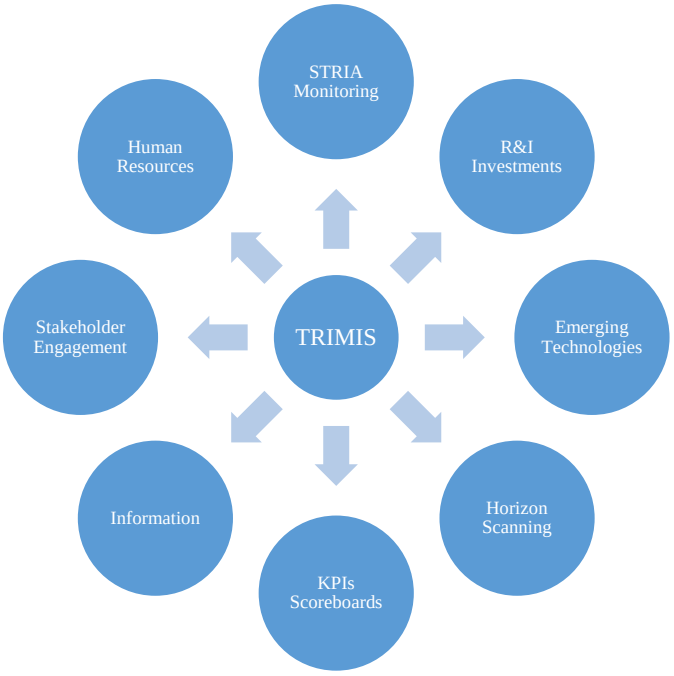

Fig. 4 TRIMIS main features and functionalities (Tsakalidis et al., 2018b)

TRIMIS covers a series of priority areas outlined in the seven STRIA roadmaps where policy intervention at European level can address transport challenges and support the EU energy and transport strategy. The transport sector aspects covered by TRIMIS include (Fig. 5):

- Policy-making and governance.
- Data collection and analysis.
- Funding information.
- Public and private investments.
- Capacity and technology mapping.
- Horizon scanning.
- New and emerging technologies and trends.
- News and updates.

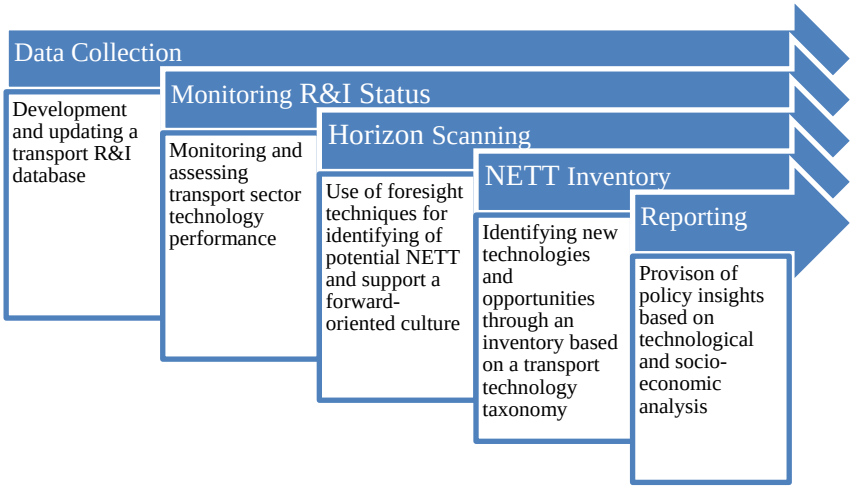

Fig. 5 TRIMIS modular development

Each module of TRIMIS and its respective characteristics are described in detail below.

4. Development and updating of a transport R&I database

TRIMIS is a general source of information and data on transport R&I, communicating the status, progress and challenges to be addressed to policy-makers and transport stakeholders. To this aim, a comprehensive database is a basic feature of TRIMIS. Data on transport R&I are being collected and added to the database either by manual user inputs or by automated links to existing repositories. The database is further enriched by data from several other sources, including the European Patent Office (EPO) and other EC and external databases. Therefore, the database includes a wide collection of data and indicators on transport technologies and innovations. This repository provides an input for the development and use of KPIs covering transport R&I and has links to established EU tools. It provides a communication channel between TRIMIS and transport stakeholders allowing additions and amendments to the database with an automated link to existing data repositories.

5. Monitoring and assessment of transport sector R&I performance

TRIMIS provides estimates of transport R&I, technical, financial and socio-economic capacities. This process includes monitoring and assessing transport sector R&I performance using KPIs to monitor the European technological, financial and socio-economic innovation capacities for each STRIA roadmap. In addition, TRIMIS monitors the progress of EU and Member State-funded R&I projects and programmes to support the assessment of the transport sector performance and maturity status. The implementation of the socio-economic analysis has included the following steps:

1. Identification of R&I data sources. The initial step requires the identification of the main data sources that will be included in the TRIMIS database. A crucial element in the selection process is the availability and the update frequency of data. Among others, the main sources of data are Eurostat (including Science and Technology Statistics, Community Innovation Survey, Structural Business Statistics on transport for each EU Member State), OECD (Science, Technology and Patent statistics) and the World Intellectual Property Office (WIPO).
2. Database building. Once the dataset is defined, it is necessary to identify the most useful and comprehensive indicators for the purpose of this analysis. The identification of the indicators will be based on their relevance to the transport field, their reliability and capability to cover the entire EU or each Member State.
3. Data analysis. The available data will be compared, classified and grouped by transport sector. A further step will be an aggregation at national level, aiming at developing a country profile for each Member State.

4. Direct contacts with relevant innovation experts in the transport field. Experts in transport R&I covering all modes of transport and a wide geographical coverage will be contacted with the aim of gathering qualitative data that could support the outputs of the quantitative analysis.
5. Report delivery based on data collection and useful information gathered through interviews. The main outcomes of this step will be the development of an annually updated capacity mapping report, an R&I investment and human resources dataset and a country profile for each Member State. The country profiles will include socio-economic aspects as well as national specificities linked to the transport research background and institutional framework, national funding and supporting initiatives and national contact points are also identified.

Once the assessment is completed, continuous monitoring of progress will continue, considering the varying levels of performance of Member States, taking as reference the work conducted by Wiesenthal et al. (2011). This analysis will be conducted at European level and for each Member State, data will be collected and analysed providing a clear and comprehensive overview of the state of the art in the EU.

6. Horizon Scanning

Foresight techniques are used to identify promising technologies that could impact the evolution of the transport sector. Such techniques support the establishment of a forward-oriented culture in transport policy-making. However, for many years strategically oriented policies have been based on insights gained through a sporadic assessment of the current status in various fields and the intuition of those in charge. This is a paradigm which is providing insufficient for the increasingly dynamic and complex field of transport innovation (Habegger, 2009). Fig. 6 presents the characteristics of the TRIMIS Horizon Scanning mechanism.

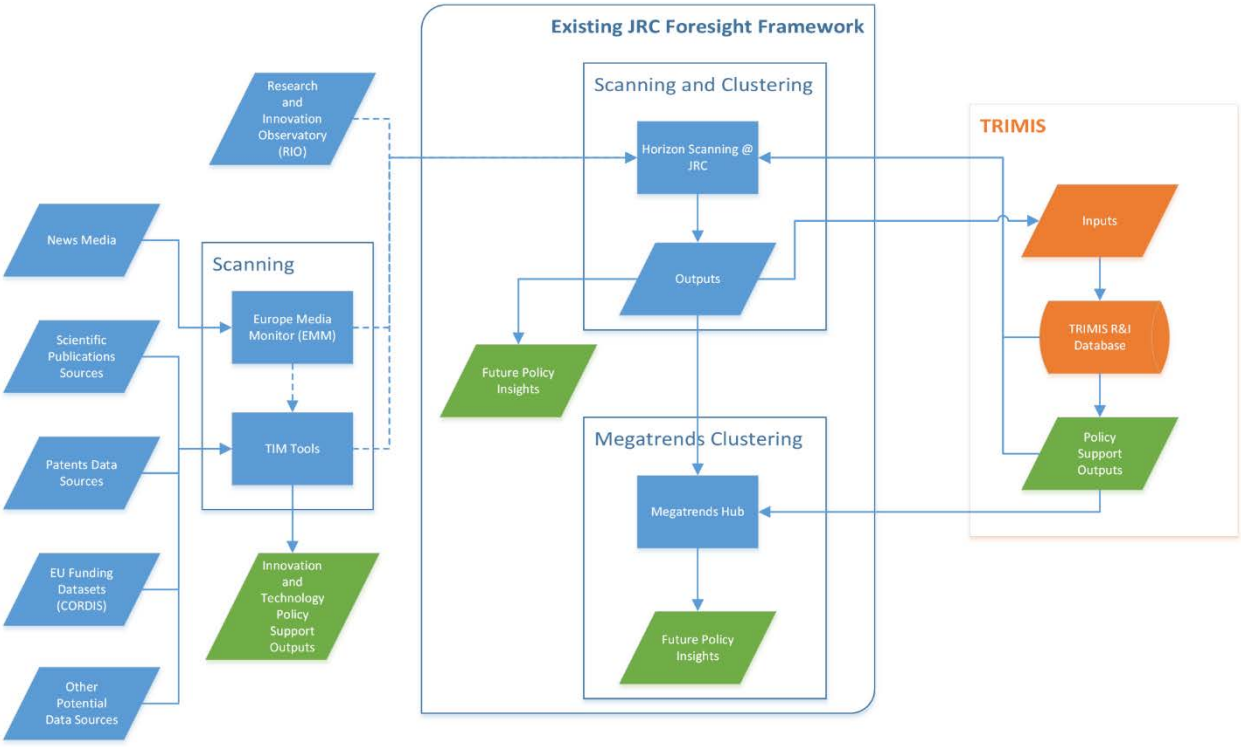

Fig. 6 TRIMIS Horizon Scanning module and interconnections (Tsakalidis et al., 2019)

Horizon scanning is a structured, forward-oriented process allowing organisations to develop an anticipatory framework of conduct and be prepared for changes that could involve significant opportunities or threats. It can therefore contribute to the TRIMIS forward-oriented R&I monitoring, assessment and information approach. Within the transport policy-making framework, horizon scanning has a twofold role supporting:

- Information of policy makers about emerging trends and developments through scanning their external environment; and
- Policy development through the promotion of network creation and information flow, while underpinning a shared overview of desired futures that will support the emergence of new and innovative policies.

The TRIMIS Horizon Scanning module will take advantage of the existing Horizon Scanning at the JRC mechanism and the Megatrends Hub creating a bidirectional data feed between TRIMIS and other schemes in order to produce policy insights and promote the transport sector along with the existing megatrends.

Horizon scanning within the TRIMIS context is part of a framework of systematic collaborative work that will create and build upon synergies and take advantage of a wide spectrum of expertise to establish an anticipatory and adaptive culture in the field of transport R&I, providing insights to the TRIMIS users and contributing to a higher-level strategic framework (Tsakalidis et al., 2019). In this way, TRIMIS supports fostering an anticipatory culture, through the systematic examination of signals such as potential threats, opportunities and early signs of future developments in media, science literature, social media, etc.

7. Identifying and assessing new and emerging transport technologies

TRIMIS identifies new technologies and opportunities that may have an impact on the transport sector. It flags mature technologies that are close to market introduction through an inventory of scientific developments of new and emerging transport technologies. The methodology is based on seven activities implemented within TRIMIS for the development of a NETT inventory (Fig. 7):

The NETT inventory does not only include technologies in the strict sense but also innovation in the transport sector in general (including innovative transport trends and initiatives).

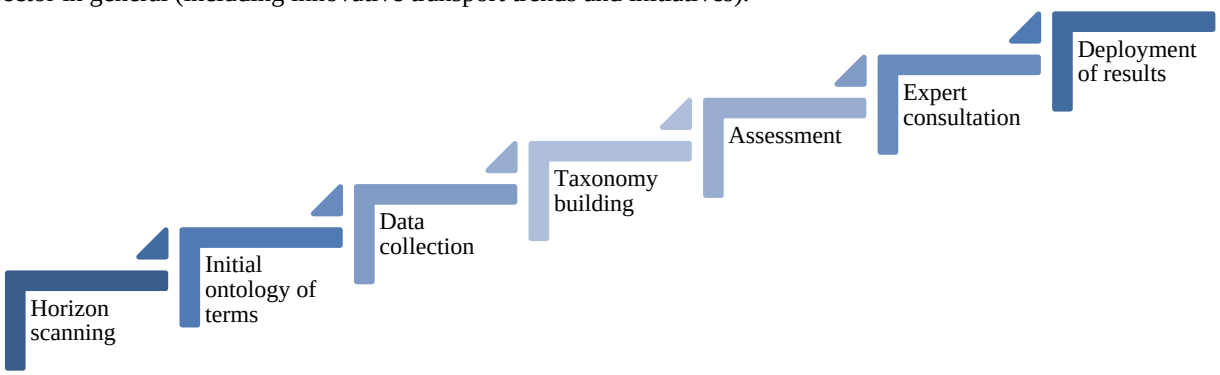

Fig. 7 Activities for creating a new and emerging technologies inventory

The inventory is updated annually, based on regular updates from the sources identified in the methodology. The identified NETT are organised and allocated to different categories. Two main categories being considered are:

- New or innovative transport modes or large-scale technologies; and
- New or innovative technologies with influence on existing transport practice.

An assessment will be undertaken to further identify the potential impact of the technology based on expert judgement from the TRIMIS team and additional experts. In the second phase of implementation, the assessment will not be based on strict socio-economic models but on other theories e.g. the Theory of Planned Behaviour (Ajzen, 1985).

The possibility to model the NETT acceptance and diffusion will be considered on the basis of current practices and Technology Acceptance Models (see for example Venkatesh et al., 2003), with criteria based on the:

- Potential impact (from marginal to disruptive); and

- Social acceptance (influenced by issues such as safety, reliability etc.).

Different methods with varying levels of detail will be used for different technology categories. For system parts or components, a simple assessment based on a set of KPIs or other indexes (e.g. efficiency index) will be sufficient. For large-scale technologies, technology acceptance models or additional surveys will be necessary.

In order to have a complete snapshot of transport technologies, a taxonomy will be developed. The taxonomy will include all possible transport technologies and applications. It will be developed in a database application, using appropriate tags. This will allow crosschecking relevance to various aspects, for example: different transport modes; the influence on groups of people (by number, age acc.) and the maturity level.

The technologies will be presented using the logic of a phylogenetic tree (Letunic and Bork, 2016), focusing on specific scales of the taxonomy. Fig. 8 provides an example for mega-scale transport elements in the form of a truncated radial graph and is to be considered as only indicative. The specific case was prepared using the Newick tree notation, imported as a text file in the Interactive Tree of Life (iTol), a web-based tool for the display, manipulation and annotation of phylogenetic trees.

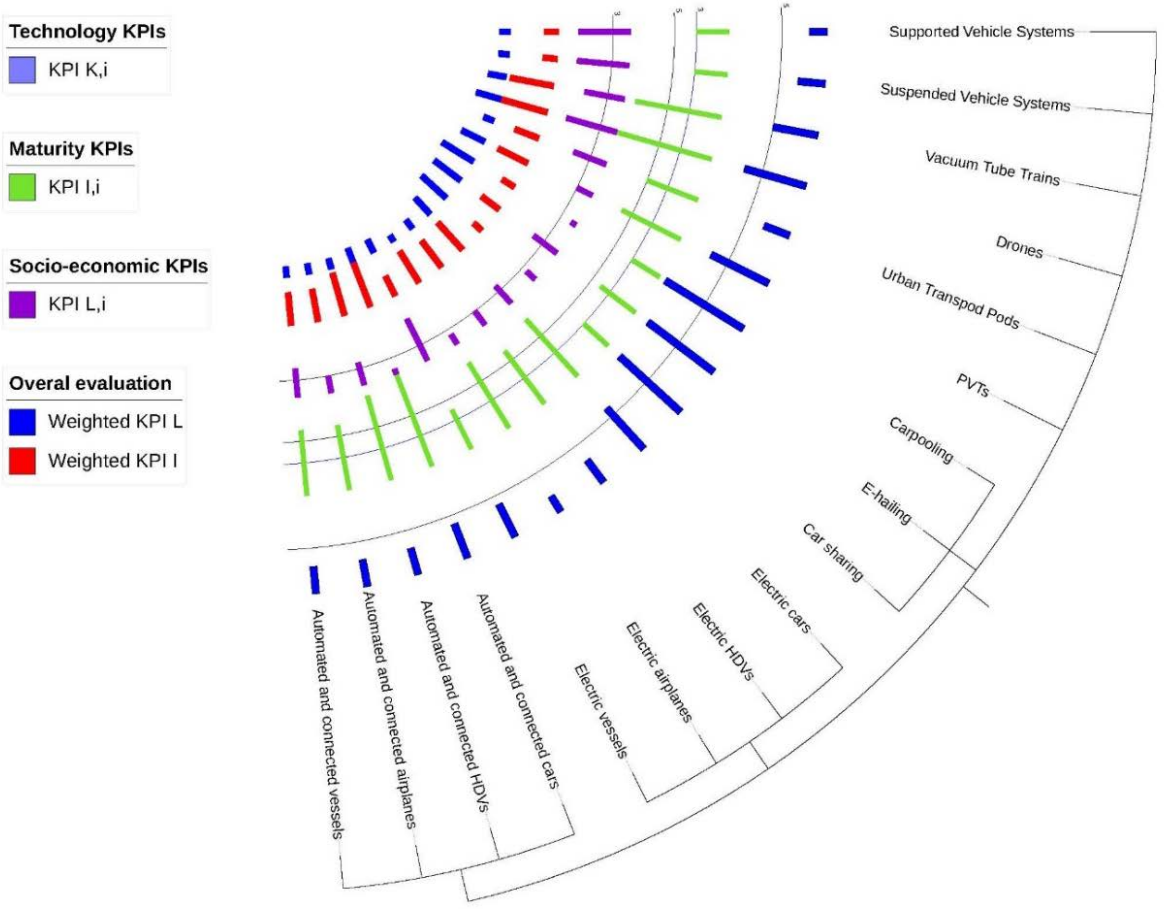

Fig. 8 Transport technologies assessment visualisation

The phylogenetic tree presents in the outer part of the circular section different elements of the taxonomy, while the element attributes provide information in a qualitative or quantitative manner. The elements can be filtered according to temporal, geographical, socio-economic or other criteria.

Element attributes can be normalised, weighted and summed-up for visualisation and assessment purposes. The intersecting lines indicate threshold values for the KPIs, which can be grouped into specific categories.

8. Reporting

In order to facilitate the final assessment of the outputs, scoreboards will be developed that will visually present the outcomes deriving from the TRIMIS database. Additionally, a set of interactive tools has been and will be developed and integrated in order to assist the output assessment and monitoring of transport R&I.

A series of roadmap assessment reports have been produced based on the data analysis, providing policy support to all stakeholders involved in the development and implementation of STRIA. Three types of reports can be identified:

- STRIA status assessment reports (Tsakalidis et al., 2018a);
- Roadmap-specific assessment reports (van Balen et al., 2019, 2018b, 2018a), one per roadmap and updated if necessary; and
- Overall STRIA roadmaps assessment report, assessing the overall performance of STRIA based on the set targets.

The data analysis provides the necessary information and input feed for interactive tools and statistics visualisations for the TRIMIS online portal.

Finally, a TRIMIS Transport R&I Scoreboard will be developed based on the data analysis step, measuring the implementation and development of STRIA and its roadmaps.

9. Conclusions

Transport R&I plays a major role in the decarbonisation of the European transport sector. STRIA has outlined R&I priorities in order to achieve a clean, connected and competitive mobility in seven roadmaps. TRIMIS has been developed as an integrated policy-support tool monitoring the implementation and further development of STRIA and providing insights to relevant transport stakeholders. In this context, it monitors the progress of the STRIA and support the development of STRIA roadmaps through the STRIA governance process (Steering Group). It will provide an up-to-date 'technology map' (state-of-the-art, barriers and potential of technologies) following the STRIA roadmaps structure and also capacity mapping.

EU and Member State funded research projects relevant to the STRIA roadmaps are being assessed against defined KPIs and scoreboards to determine progress in meeting the STRIA objectives. Moreover, socio-economic developments and their influence on transport technology and innovation are being assessed, facilitating the effective functioning of an extensive network of industry stakeholders, Member States experts and authorities, research organisations, industrial and financial communities and information collection points.

Foresight is used for the identification of potential future technologies with an impact on the transport sector since TRIMIS has developed specific approaches to horizon scanning and assessment of emerging and new transport technologies.

Compared to other transport policy tools, TRIMIS distinguishes itself by its coverage of all transport modes and its aim to support the needs of a wide range of transport stakeholders. Its current functionalities and future developments therefore make it a useful hub for researchers, practitioners and policy makers to assess and understand developments in European transport R&I.

Acknowledgements

The views expressed here are those of the authors and may not, under any circumstances, be regarded as an official position of the European Commission. The Joint Research Centre is in charge of the development of TRIMIS, and the work has been carried out under the supervision of the Directorate-General for Mobility and Transport (DG MOVE) and the Directorate-General for Research and Innovation (DG RTD) that are co-leading the Strategic Transport Research and Innovation Agenda (STRIA).

Nomenclature

ACARE	Advisory Council for Aviation Research and Innovation in Europe
ALICE	Alliance for Logistics Innovation through Collaboration in Europe
CORDIS	Community Research and Development Information Service

DG MOVE	European Commission Directorate-General for Mobility and Transport
DG RTD	European Commission Directorate-General for Research and Innovation
EC	European Commission
EPO	European Patent Office
ERRAC	European Rail Research Advisory Council
ERTRAC	European Road Transport Research Advisory Council
EU	European Union
EUR	Euro
GHG	Greenhouse Gases
GVA	Gross Value Added
JRC	Joint Research Centre
ICT	Information and Communication Technologies
IRI	Industrial Research and Innovation
KPI	Key Performance Indicator
NETT	New and Emerging Technologies and Trends
NO_2	Nitrogen Dioxide
O_3	Ozone
OECD	Organisation for Economic Co-operation and Development
PCT	Patent Cooperation Treaty
$PM_{2.5}$	Particulate Matter
R&I	Research and Innovation
RIO	Research and Innovation Observatory
SET	Strategic Energy Technology
SETIS	Strategic Energy Technologies Information System
STRIA	Strategic Transport Research and Innovation Agenda
TIM	Tools for Innovation Monitoring
TRB	Transportation Research Board
TRID	Transport Research International Documentation
TRIMIS	Transport Research and Innovation Monitoring and Information System
WIPO	World Intellectual Property Office

References

Ajzen, I., 1985. From Intentions to Actions: A Theory of Planned Behavior, in: Action Control. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 11–39. https://doi.org/10.1007/978-3-642-69746-3_2

European Commission, 2018a. IRI - The EU Industrial R&D Investment Scoreboard. Jt. Res. Cent. - IRI - Econ. Ind. Res. Innov.

European Commission, 2018b. European Innovation Scoreboard [WWW Document]. Growth - Intern. Mark. Ind. Enterpreneursh. SME's. URL http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en

European Commission, 2017a. Statistical pocketbook 2017 [WWW Document]. Mobil. Transp. - Eur. Comm. URL https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017_en

European Commission, 2017b. EUROPE ON THE MOVE - An agenda for a socially fair transition towards clean, competitive and connected mobility for all COM/2017/0283 final. Brussels.

European Commission, 2017c. Towards clean, competitive and connected mobility: the contribution of Transport Research and Innovation to the Mobility package SWD/2017/0223 final. Brussels.

European Commission, 2017d. TRIMIS Transport and Research and Innovation Monitoring and Information System [WWW Document]. Eur. - TRIMIS Transp. Res. Innov. Monit. Inf. Syst. URL https://trimis.ec.europa.eu/

European Commission, 2017e. Research and Innovation Observatory – Horizon 2020 Policy Support Facility [WWW Document]. Res. Innov. URL https://rio.jrc.ec.europa.eu/

European Commission, 2017f. EU transport Scoreboard [WWW Document]. Mobil. Transp. URL https://ec.europa.eu/transport/facts-fundings/scoreboard_en

European Commission, 2017g. SETIS Strategic Energy Technologies Information System [WWW Document]. SETIS Strateg. Energy Technol. Inf. Syst. URL https://setis.ec.europa.eu/

European Commission, 2016a. A European Strategy for Low-Emission Mobility COM/2016/0501 final. Brussels.

European Commission, 2016b. Accelerating Clean Energy Innovation COM/2016/0763 final. Brussels.

European Commission, 2016c. TIM - Tools for Innovation Monitoring [WWW Document]. TIM - Tools Innov. Monit. URL http://www.timanalytics.eu

European Commission, 2016d. European Technology Platforms [WWW Document]. Innov. Union. URL http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=etp

European Commission, 2015a. Energy Union Package - A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy COM/2015/080 final.

European Commission, 2015b. Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation C/2015/6317 final. Brussels.

European Environment Agency, 2017. Annual European Union greenhouse gas inventory 1990–2015 and inventory report 2017. European Environment Agency, Copenhagen.

European Environment Agency, 2016a. Sectoral greenhouse gas emissions by IPCC sector [WWW Document]. Data maps. URL https://www.eea.europa.eu/data-and-maps/daviz/change-of-co2-eq-emissions-2/#parent-fieldname-title

European Environment Agency, 2016b. Air quality in Europe — 2016 report. Publications Office of the European Union, Luxembourg. https://doi.org/10.2800/80982

Eurostat, 2017. Final energy consumption by sector. Prod. datasets.

Habegger, B., 2009. Horizon Scanning in Government. Centre for Security Studies, Zurich.

Letunic, I., Bork, P., 2016. Interactive tree of life (iTOL) v3: an online tool for the display and annotation of phylogenetic and other trees. Nucleic Acids Res. 44, W242--W245. https://doi.org/10.1093/nar/gkw290

National Academy of Sciences, 2017. Transport Research International Documentation - TRID [WWW Document]. TRB - Transp. Res. Board. URL https://trid.trb.org

OECD, 2016. OECD Science, Technology and Innovation Outlook 2016, OECD Science, Technology and Innovation Outlook. OECD Publishing, Paris. https://doi.org/10.1787/sti_in_outlook-2016-en

Tsakalidis, A., Gkoumas, K., Pekar, F., Grosso, M., Haq, G., Marelli, L., 2018a. EU Transport Research & Innovation Status Assessment Report 2017: An overview based on the Transport Research and Innovation Monitoring and Information System (TRIMIS) database. Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/331714

Tsakalidis, A., Gkoumas, K., Pekar, F., Grosso, M., Haq, G., Marelli, L., 2018b. Towards an integrated European platform for monitoring and analysing transport research and innovation (TRIMIS), in: Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria. https://doi.org/10.5281/zenodo.1473539

Tsakalidis, A., Gkoumas, K., van Balen, M., Haq, G., Ortega Hortelano, A., Grosso, M., Pekar, F., 2019. TRIMIS as a support tool for transport research and innovation horizon scanning: Working towards an integrated European Commission horizon scanning scheme. Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/203362

van Balen, M., Grosso, M., Gkoumas, K., Tsakalidis, A., Haq, G., Ortega Horelano, A., Pekar, F., 2019. Research and innovation capacity in transport infrastructure: An assessment based on the Transport Research and Innovation Monitoring and Information System (TRIMIS). Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/551629

van Balen, M., Grosso, M., Tsakalidis, A., Gkoumas, K., Haq, G., Ortega Horelano, A., Pekar, F., 2018a. Research and innovation capacity in smart mobility and services: An assessment based on the Transport Research and Innovation Monitoring and Information System (TRIMIS). Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/793107

van Balen, M., Grosso, M., Tsakalidis, A., Gkoumas, K., Haq, G., Pekar, F., 2018b. Research and innovation capacity in cooperative, connected and automated transport: An assessment based on the Transport Research and Innovation Monitoring and Information System (TRIMIS). Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/373466

Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D., 2003. User Acceptance of Information Technology: Toward a Unified View. MIS Q. 27, 425–478.

Wiesenthal, T., Leduc, G., Cazzola, P., Schade, W., Köhler, J., 2011. Mapping innovation in the European transport sector : An assessment of R&D efforts and priorities, institutional capacities, drivers and barriers to innovation. Luxembourg. https://doi.org/10.2791/55534