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## **Towards an integrated European platform for monitoring and analysing transport research and innovation (TRIMIS)**

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### **Abstract**

The European Commission has outlined future transport research and innovation (R&I) priorities to decarbonise the European transport sector in its Strategic Transport Research and Innovation Agenda (STRIA) that includes seven roadmaps in seven priority areas that cut across transport modes. In order to support the implementation of STRIA, a Transport Research and Innovation Monitoring and Information System (TRIMIS) has been developed. This paper reviews the features and added value of TRIMIS as an integrated analytical support tool and platform that monitors transport R&I and provides feedback to policy and decision makers. TRIMIS is an open-access information and knowledge management system, and includes a database of transport projects and programmes, as well as an inventory of transport technologies and innovations. It goes beyond previously available tools by providing a holistic assessment of emerging technologies and R&I capacities in the transport sector in all seven priority areas, and by developing analytical tools on the European transport sector.

**Keywords:** transport research; transport innovation; monitoring; horizon scanning; STRIA; roadmap.

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## **1. Introduction**

Transport is a key economic sector with an estimated EUR 651 billion in Gross Value Added (GVA) for the transport and storage services in the European Union (EU) or 5.0% of total EU GVA (2015) (European Commission, 2017a). It represents 33% of the final energy consumption (Eurostat, 2017) and 19.5% of the total greenhouse gas (GHG) emissions (European Environment Agency, 2016a) and is the only sector that has not seen a decrease in GHG emissions (1990-2015) (European Environment Agency, 2017). Transport is also a major contributor to urban air pollution with premature deaths in the EU attributed to population exposure to particulate matter (PM<sub>2.5</sub>), nitrogen dioxide (NO<sub>2</sub>) and ozone (O<sub>3</sub>) estimated to be 436,000, 68,000 and 16,000, respectively (European Environment Agency, 2016b). Moreover, congestion from road transport causes huge inefficiencies estimated at 1 per cent of EU Gross Domestic Product (EUR 100 billion) and rising (European Commission, 2017b). Given the central role of transport and its impact on the economy and quality of life, there is need for a revised legislative framework and the adoption of energy efficient innovative transport technologies.

In 2016, the European Commission (EC) published a European strategy for low-emission mobility and Communications on accelerating clean energy innovation in Europe that outlined a new transport research and innovation approach to address current and future socio-environmental challenges (European Commission, 2015a, 2016a, 2016b). In 2017, the EC adopted the Strategic Transport Research and Innovation Agenda (STRIA) as part of the "Europe on the move" package, which highlights main transport research and innovation (R&I) areas and priorities for clean, connected and competitive mobility to complement the 2015 Strategic Energy Technology Plan (European Commission, 2015b, 2017c).

In order to address current socio-economic challenges within an ever-changing complex and competitive environment, the transport sector requires new technological developments. This will be achieved through R&I that will allow new quality standards in mobility of people and goods and ensure European competitiveness. To decarbonise transport and mobility, the EC has identified the need to overcome barriers and seize opportunities arising through the promotion of transport R&I. Towards this goal, the STRIA has identified priority areas with specific actions for future R&I, 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 of STRIA needs to be supported by an effective monitoring and information mechanism that will assist the development and updating of STRIA and support transport R&I. The Transport Research and Innovation Monitoring and Information System (TRIMIS) has been developed at the EC Joint Research Centre (JRC) to provide a holistic assessment of technology trends, transport R&I capacities, to publish information, data and to develop analytical tools on the 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 a new JRC tool which should benefit the entire European transport system. TRIMIS is an open-access information and knowledge management system and includes a database of transport projects and programmes, as well as an inventory of transport technologies and innovations. It collates and disseminates information on the status of transport R&I to ensure a systematic horizon scanning and monitors progress of the seven roadmaps against a set of relevant key performance indicators and scoreboards.

In addition, TRIMIS will act as a general source of information and data on transport R&I, communicating progress and issues to be addressed to policy makers and to a wider audience, including industry stakeholders, Member States experts and authorities, research organisations and financial communities. This paper reviews the functionalities and added value of TRIMIS as a European platform and analytical support tool that takes an integrated approach to transport R&I monitoring and information.

## 2. Background and motivation

A policy tool involves identifying activities and functionalities that when arranged in a comprehensive manner, produce an effective tool for policy making (see Fig. 1.) Although a range of policy support tools have been developed at national, European and international level to facilitate the development and implementation of transport policy, they have not always been comprehensive or met all the specific needs of stakeholders interested in transport R&I, such as policy makers, transport industry, investors, research organisations and the general user.

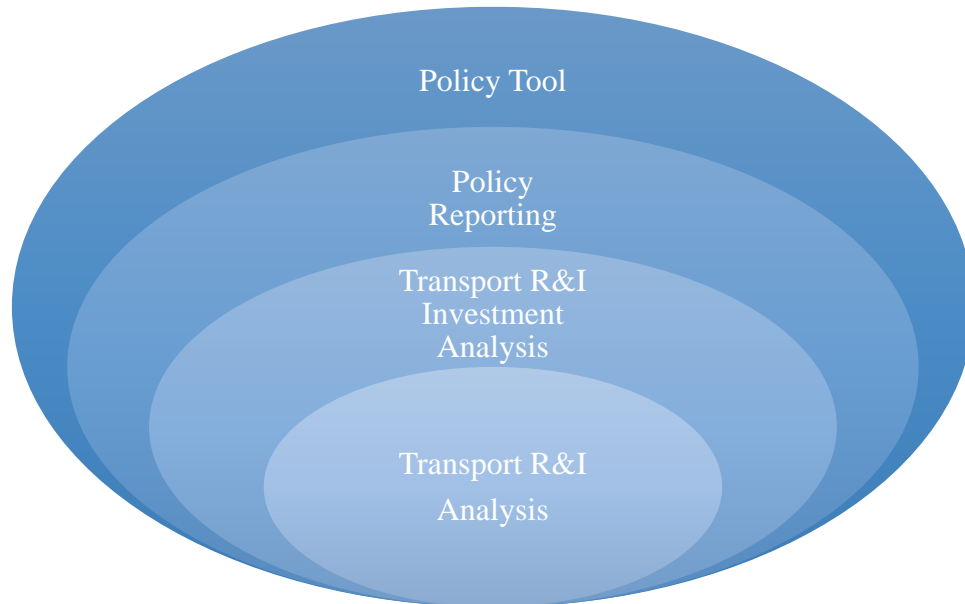


Fig. 1 Transport monitoring and information: from simple R&I analyses to policy tools

European and international initiatives related to R&I include projects, databases and tools that have focused on stakeholder communication, dissemination and external involvement, while others have examined the data, reports or country profiles, and analysed investments. Within European initiatives, an additional distinction can be made between European co-funded projects, official European tools and scoreboards developed by the EC or European technology platforms dedicated to transport. However, some of these initiatives are no longer active or are only periodically updated.

Fig. 2 provides a chart with some principal sources i.e. active R&I platforms and databases. In the chart, several aspects have been considered. As an example, the availability of databases or the publication of general reports are among the most commonly available features. On the contrary, there are just a few examples of tools that provide infographics, policy reports or country profiles. These include some EC tools, such as, the Economics of Industrial Research and Innovation action (IRI) (European Commission, 2016c), the Research and Innovation Observatory (RIO) (European Commission, 2017e), the Tool for Innovation Monitoring (TIM) (European Commission, 2016d), the EU Innovation Scoreboard (European Commission, 2017f), the EU Transport Scoreboard (European Commission, 2017g) and the SETIS tool (European Commission, 2017h). A very relevant aspect that was taken into consideration is the possibility to access transport R&I analysis, a functionality currently present in few of the sources analysed, specifically the EU Technology Platforms (European Commission, 2016e): ACARE, ALICE, ERRAC, ERTRAC and Waterborne. Moreover, very few tools provide the possibility to access data through an advanced data search. Among international initiatives it is worth mentioning the OECD website (OECD, 2016) and the TRID-TRB tool (National Academy of Sciences, 2017).

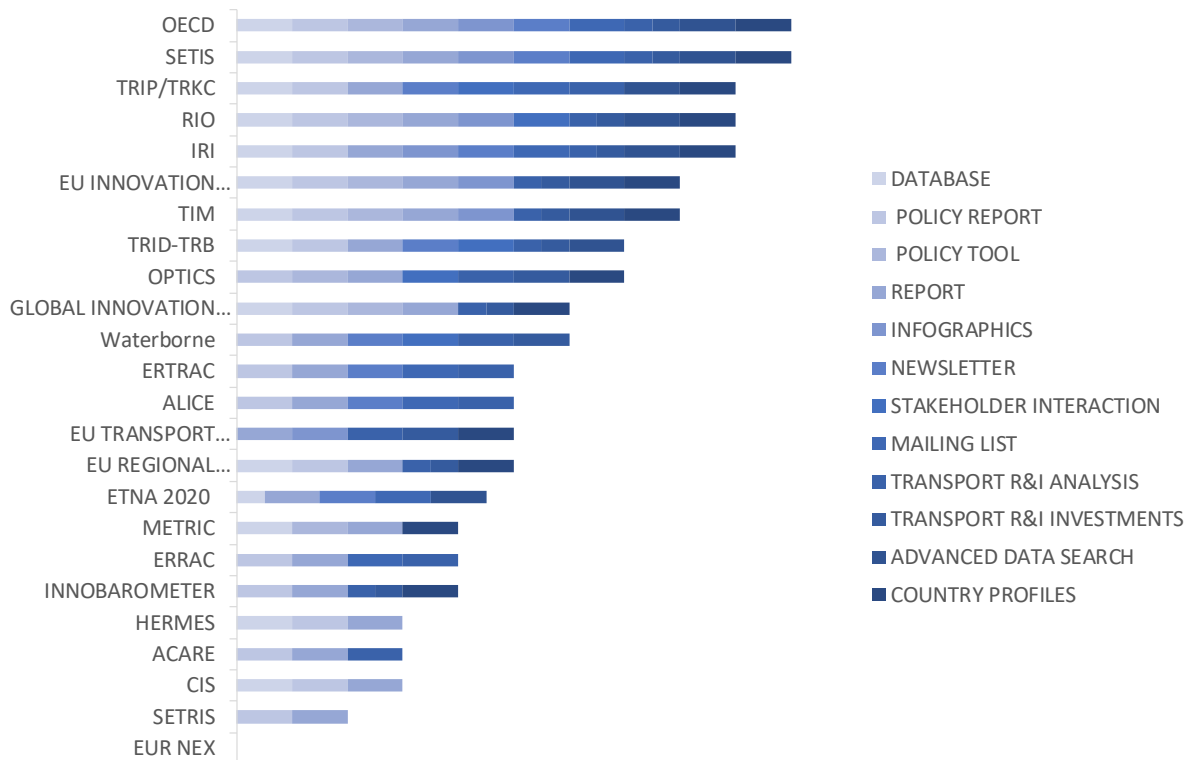


Fig. 2 Principal R&amp;I platforms and databases

Given the heterogeneous nature of such initiatives, very few are able to be considered comprehensive in what they do, since they are missing one or more key aspects (e.g. databases, policy reports, infographics, newsletters, interaction with stakeholders, transport R&I analysis, investment analysis, mailing list, data search and country profiles) that support R&I and meet the needs of all stakeholders. The audience of TRIMIS covers all transport stakeholders, ranging from policy makers to students, aiming at fulfilling their needs in terms of data acquisition and information gathering and dissemination. The table below illustrates a non-exhaustive list of user categories and the benefits that users can obtain from the TRIMIS website.

Table 1 Categories and benefits users can obtain from the TRIMIS website

EU policy makers	National policy makers	Researchers - both academic and industry	Students	Investors in technology
<ul style="list-style-type: none"> <li>• Publish information on the STRIA roadmaps</li> <li>• Set long term transport policy roadmaps</li> <li>• Incentivise research, development and knowledge sharing in transport</li> <li>• Add, update and download data</li> <li>• Gather information on current R&amp;I status</li> </ul>	<ul style="list-style-type: none"> <li>• Find information on long term EC policy in transport</li> <li>• Understand comparative information from other countries</li> </ul>	<ul style="list-style-type: none"> <li>• Disseminate information on research projects</li> <li>• Find other researchers to collaborate within a specific technical area</li> </ul>	<ul style="list-style-type: none"> <li>• Find information on long term EC transport policy</li> <li>• Find information on research projects</li> </ul>	<ul style="list-style-type: none"> <li>• Find information on most promising new technologies</li> <li>• Find information on performance of specific technologies</li> <li>• Find information on research and innovation in a specific area</li> </ul>

In light of these considerations, it is evident that a complete, thorough and up-to-date tool is missing. In the next section a detailed description of the TRIMIS structure and functionalities will be presented demonstrating its added value. Subsequently, the preliminary methodologies for the assessment of new and emerging transport technologies and R&I, financial and human capacities of the transport sector are presented.

### 3. TRIMIS structure and functionalities

TRIMIS has been developed as a policy tool to support the monitoring and implementation of the STRIA by mapping technology trends and R&I capacities in the EU transport sector (see Fig. 3). It has been designed as an open-access information and knowledge management system and will undertake horizon scanning, monitoring progress against R&I roadmaps, mapping technologies and capacities in the EU transport sector and support information dissemination and the development of a set of policy tools. Besides acting as a general source of information and data on transport R&I, it will facilitate information exchange between stakeholders.

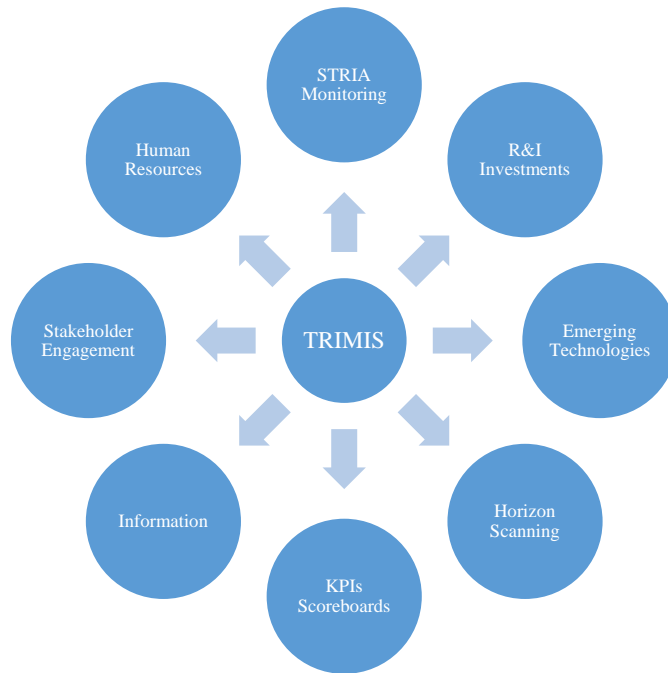


Fig. 3 TRIMIS main features and functionalities

TRIMIS focuses on a number of priority areas outlined in the seven STRIA roadmaps where public intervention at European level can create added value in order to overcome weaknesses, including socio-economic factors of transport innovation and increase competitiveness while addressing the broad goals of the EU energy and transport strategy. In particular, it will cover the following aspects of the transport sector:

- Policies
- Data/analysis
- Funding information of projects
- Public and private investments
- Capacity and technology mapping
- Horizon scanning
- News/updates

Moreover, TRIMIS tracks the status and developments in the field of transport, identifies innovative technologies and assesses their potential future impact. This process involves:

1. Updating and maintaining a transport R&I database that includes projects and programmes on transport technologies and innovations. This repository provides an input for the assessment of key performance indicators (KPIs) in transport R&I and links to established EU tools and initiatives (e.g. SETIS, ICT Innovation Radar etc.). It provides a communication channel between TRIMIS and transport stakeholders

allowing additions and amendments to the database with an automated link to existing repositories (i.e. CORDIS).

2. Monitoring and assessing transport sector technology performance using a set of KPIs to monitor the European innovation capacities for each STRIA roadmap. As well as monitoring the progress of European R&I projects to support the assessment of the transport sector performance and maturity status.
3. Identifying new technologies and opportunities that may have an impact on the transport sector through an inventory of scientific developments of new and emerging technologies relevant to the future of the EU transport sector.
4. Flagging mature technologies that are close to market introduction.

TRIMIS offers an active dissemination and information-gathering service with its on-line portal, providing a series of functionalities:

- Extensive searchable information on EC and nationally funded R&I projects and programmes;
- Country profiles providing information on national institutions and organisations responsible for funding, promoting and supporting transport research;
- Submission and storage of newsletters, disseminating news, events and any new information on R&I projects and programmes;
- Information on R&I events;
- Information on up to date news;
- Thematic policy reports and publications.

#### 4. Identifying and assessing new and emerging transport technologies

A preliminary methodology for creating an inventory of new and emerging transport technologies (NETTs) under TRIMIS has been developed. The methodology is based principally on four activities (see Fig. 4):

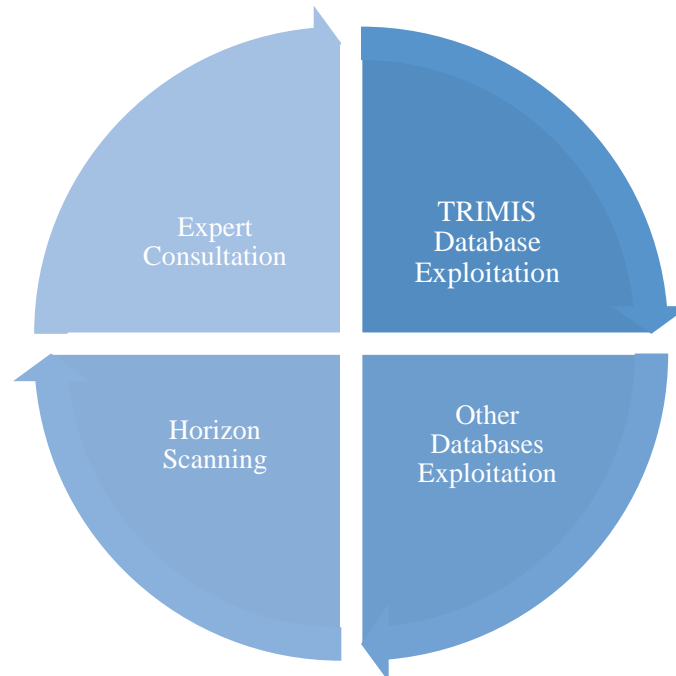


Fig. 4 Activities for the inventory creation

1. Expert consultation. Initially the identification and assessment of NETTs is performed internally. After this, external experts are chosen that cover all seven STRIA roadmaps and all modes of transport.

2. Exploitation of the TRIMIS database. Since the database at the present state contains mostly European projects and programmes, for which a time lag exists between the inception and the dissemination of deliverables, the contribution on newer technologies can be limited. However, directions of possible outcomes are obtainable from the project objectives. In addition, programmes outside the EU can provide hints on new technology developments.
3. Exploitation of other databases. The SCOPUS database is a reference resource for scientific research. Although not without drawbacks, it forms the principal pool of information for the inventory. The main issues that need to be addressed are linked to the limited accessibility (only some metadata are available, including abstracts) and the absence of many conference papers.
4. Horizon scanning. This is an integral part of the TRIMIS methodology, fostering an anticipation culture, through the systematic examination of signals (potential threats, opportunities and early signs of future developments) in non-mainstream media and science literature, interviews, blogs, magazines, news, social media etc.

The inventory will be updated at least once a year, based on regular updates from the sources identified in the methodology. Due to limited resources, initially technologies limited to one or two STRIA roadmaps will be examined.

The identified NETTs will need to be organised and allocated to different categories. Two main categories are being considered:

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

For example, an entirely new mode of transport (e.g. a vacuum train) will fall into the first category, while, a new battery technology for electric cars will fall into the second category. Furthermore, a technology can provide incremental changes or be radical and ground-breaking. In the above example, a vacuum train has the potential to be radical, while for a new battery technology, further considerations are needed (e.g. looking at the efficiency and comparing it to current practice values).

An assessment is undertaken to further identify the impact of the technology (in terms of potential impact) 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 by Ajzen (1985).

The possibility to model the NETTs' 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);
- Social acceptance (influenced by issues such as safety, reliability etc.).

Different methods with different 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 enough. For large-scale technologies, technology acceptance models or surveys will be necessary.

In order to have an as much as possible complete snapshot of the sets of transport technologies, a taxonomy will be developed. The taxonomy will be built with the purpose to include all possible transport technologies and applications and will be developed at several levels.

It will be developed in a database application, using appropriate tags. This will allow crosschecking instantly the relevance to different aspects, for example:

- The different transport modes;
- The influence on groups of people (by number, age acc.);
- The maturity level.

In the first phase of implementation, the taxonomy will follow a strict model, in the form of a hierarchical network diagram, in the sense provided in the original paper by Simon (1962). The taxonomy will be developed using a hybrid top-down and bottom-up method.

The possibility to use a taxonomy in the form of a time-dependent phylogenetic (evolutionary) tree (see for example Letunic and Bork, 2007) will be examined in order to highlight the implementation phases of each technology, its predecessors and its descendants (see Fig. 5 for an example).

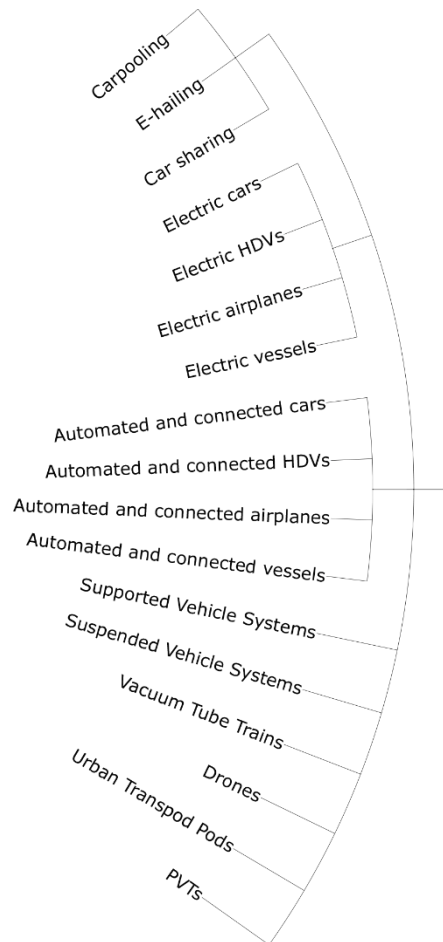


Fig. 5 Transport technologies taxonomy (excerpt)

## 5. Estimating the R&I, financial and human capacities of the transport sector

An important feature of TRIMIS is to provide an estimate of R&I, financial and human capacities of the transport sector. This activity is particularly relevant, especially in relation to the insight that will be provided concerning EU investments in transport innovations (see also Wiesenthal et al., 2015), the role and characteristics of the human resources involved in transport research activities and the socio-economics aspects linked to innovation and research in transport.

The implementation of the analysis, after a thorough revision of former studies on capacity assessment of transport R&I, will follow a well-defined methodology that is composed by the following steps:

1. **Identification of R&I data sources.** The initial phase of the work consists of identifying the main sources of information that will constitute the reference databases. In the selection process, a crucial aspect is the availability and the frequency of updating the data. Among the relevant datasets, the ones that can mostly contribute to the assessment are: Eurostat (the Science and Technology Statistics, the 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. Among the possible indicators, some are certainly relevant and fundamental to gather and analyse, e.g.: business and public R&I expenditure, business and public R&I intensity, total R&I personnel, PCT patent applications, innovative enterprises, employees in high-growth enterprises, etc.

3. Data analysis and elaborations. The available data will be compared, classified and, if possible, will be grouped for transport sector and services. A further step will be an aggregation at national level, aiming at building up a country profile for each Member State. Possible comparisons, both among Member States and at international level will be developed.
4. Direct contacts with relevant innovation experts in the transport field. Experts in transport research and innovation will be contacted with the aim of gathering qualitative data that could support the outcome of the former quantitative analysis. The objective of this activity is to have wide knowledge and geographical coverage, obtaining feedback and input from experts covering all modes of transport, as well as the entire EU.
5. Report delivery based on data collection and useful information gathered through interviews. The main outcomes of this activity will be: an annually updated capacity map report, an R&I investment and human resources database 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. Moreover, details on national funding and supporting initiatives for transport research and national contact points will be provided.

Once the assessment has been undertaken, it will be necessary to ensure continuous monitoring of progress, considering also the different 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 whole EU.

## **6. Conclusions**

Transport R&I plays a major role in the decarbonisation of the European transport sector. The EC STRIA has outlined R&I priorities in order to achieve a clean, connected and competitive mobility in seven roadmaps. TRIMIS has been developed as a comprehensive policy tool to support the implementation and monitoring of STRIA. Unlike other R&I initiatives, TRIMIS covers all transport modes and provides a comprehensive approach that aims to cater for the needs of a wide range of stakeholders.

TRIMIS has developed specific approaches to horizon scanning and assessment of emerging and new transport technologies. Currently, TRIMIS has a database of approximately 10,000 projects and programmes and has a user list of 1,500 individuals from a wide range of stakeholders.

Over the coming years, TRIMIS aims to become the key source of transport R&I information, engaging stakeholders and undertaking technology analyses that will support policy development and will be beneficial for all stakeholders.

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