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EU Transport Research & Innovation Status Assessment Report 2017

An overview based on the Transport Research and Innovation Monitoring and Information System (TRIMIS) database

Tsakalidis, A., Gkoumas, K., Pekar, F., Grosso, M., Haq, G. and Marelli, L.

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EUR 29032 EN

Contact information
Name: Luisa Marelli
Address: European Commission, Joint Research Centre, Vie E. Fermi 2749, I-21027, Ispra (VA) - Italy
Email: luisa.marelli@ec.europa.eu
Tel.: +39 0332 786332

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Unless otherwise indicated, all figures and tables derive from JRC analysis.

EU Transport Research & Innovation Status Assessment Report 2017: An overview based on the Transport Research and Innovation Monitoring and Information System (TRIMIS) database

TRIMIS is an open-access transport information system. The TRIMIS database contains transport research and innovation projects and programmes that are arranged according to the seven Strategic Transport Research and Innovation Agenda (STRIA) roadmaps that were adopted by the European Commission in May 2017. The roadmaps cover: cooperative, connected and automated transport; transport electrification; vehicle design and manufacturing; low-emission alternative energy for transport; network and traffic management systems; smart mobility and services; infrastructure. This report provides the first overview and analyses of the TRIMIS database and identifies areas for further research.

Contents

Acknowledgements

The views expressed here are purely 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 Transport Research and Innovation Monitoring and Information System (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).

Authors

Anastasios Tsakalidis, Joint Research Centre

Konstantinos Gkoumas, Joint Research Centre

Ferenc Pekar, Joint Research Centre

Monica Grosso, Joint Research Centre

Gary Haq, Joint Research Centre

Luisa Marelli, Joint Research Centre

Executive summary

This is the initial Transport Research and Innovation Status Assessment Report following the launch of the European Commission's Transport Research and Innovation Monitoring and Information System (TRIMIS) developed by the Joint Research Centre, in the framework of a project funded by the Directorate-General Mobility and Transport.

TRIMIS maps and analyses research trends and innovation capacities across Europe's transport sector. TRIMIS supports transport policy makers and researchers by helping to identify innovations with the greatest potential for the future, and helps policy makers to focus on areas where public intervention can create the highest added value.

The TRIMIS platform monitors the effectiveness of research funded at European Union (EU) or Member State level by assessing how research projects contribute to a clean, connected and competitive European transport system. The TRIMIS web portal can be found online at https://trimis.ec.europa.eu.

TRIMIS will also include modules for mapping and analysis of new and emerging transport technologies, R&I investments and capacities, with the aim to assess their impact on the EU transport system, including current developments and future implications.

In TRIMIS, transport research projects are arranged according to the seven Strategic Transport Research and Innovation Agenda (STRIA) roadmaps that were adopted in the 'Europe on the Move' package in May 2017. These cover a number of areas, namely: cooperative, connected and automated transport; transport electrification; vehicle design and manufacturing; low-emission alternative energy for transport; network and traffic management systems; smart mobility and services; infrastructure.

The purpose of this report is to review programmes and projects available in TRIMIS database, mainly, but not exclusively, falling under the seven roadmaps. Specifically, the data analysed correspond to the following categories according to the STRIA roadmap classification:

- Cooperative, connected and automated transport;
- Transport electrification;
- Vehicle design and manufacturing;
- Low-emission alternative energy for transport;
- Network and traffic management systems;
- Smart mobility and services;
- Infrastructure;
- Others.

In this context, conclusions are drawn concerning the current transport research and innovation (R&I) status; additionally, indications for future actions and also implications for future policy development are presented.

Policy context

The development of the Strategic Transport Research and Innovation Agenda (STRIA) needs to be underpinned by an effective monitoring and reporting scheme, supporting the entire chain of development, implementation, monitoring and updating of STRIA. This is the main objective of the Transport Research and Innovation Monitoring and Information System (TRIMIS). TRIMIS aims at becoming the analytical support tool for the establishment and implementation of the STRIA, and the European Commission's instrument for mapping technology trends and research and innovation capacities in the transport field, as well as monitoring progress against the targets set for all the transport sectors. It is designed as an open-access information and knowledge management

system and is intended to fulfil multiple roles: horizon scanning, monitoring progress against R&I roadmaps, mapping technologies and capacities in the EU transport sector and support to further steps, dissemination of information, development of a set of toolboxes etc. Besides acting as a general source for information and data on transport research and innovation, it aims at facilitating information exchange between partners and serve as a monitoring system of progress against the seven initial roadmaps developed within STRIA.

Key conclusions

This report provides a first snapshot of the TRIMIS database of transport research and innovation (R&I) projects and programmes following the launch of the TRIMIS online platform in September 2017. The analysis reflects the status of the database on 25 November 2017.

In order to enable a more thorough analysis in the future, it is crucial to enhance the TRIMIS database, both in quantitative and qualitative terms. Future actions will require additions of new European and international projects/programmes, as well as, inclusion of further Member States projects/programmes. The database will become more exhaustive also with the inclusion of some additional information, addressing financial as well as socio-economic aspects. In the future TRIMIS will also provide information on country profiles.

Main findings

The TRIMIS database contained 476 programmes and 6198 projects on 25 November 2017. The programmes database contained 52 elements under the following general categories: General Information, Funding and Collaboration Context, Policy Context and Scientific Context. The projects database contained 46 elements under the following general categories: General Information, Funding and Collaboration Context, Policy Context and Scientific Context.

The programmes and projects have been analysed regarding their duration, funding source, funding type, funding origin, status, allocation by transport mode, transport policy areas and by STRIA Roadmaps. The report also provides more specific analysis of the EU funded projects in the database (section 3.2) and a detailed assessment of projects according to STRIA Roadmaps (sections 3.3 – 3.9).

Related and future JRC work

TRIMIS – including the work carried out for this report - has benefitted from ongoing work at the Joint Research Centre on sustainable transport and sustainable energy systems. Synergies will continue to be explored with related projects on connected and automated transport, electrification, emissions control as well as initiatives in the context of the Strategic Energy Technology Plan, including SETIS (Strategic Energy Technologies Information System, available at: https://setis.ec.europa.eu). The Joint Research Centre will continuously develop TRIMIS further, by adding more functionalities to the TRIMIS online platform and by carrying out scientific research to analyse transport R&I in the areas of STRIA Roadmaps. It will also provide support to the STRIA governance process and on the basis of its research, provide recommendations to policy makers.

Quick guide

TRIMIS is an open-access information system to map and analyse technology trends, research and innovation capacities, and monitor progress in the transport sector. It contains a database of transport research and innovation projects and programmes. Following the launch of TRIMIS in September 2017, this report provides the first overview and analyses of this database, it assesses the included projects and programmes, it draws conclusions and provides recommendations for policy makers and identifies areas for further research.

1 Introduction

The development of the Strategic Transport Research and Innovation Agenda (STRIA) needs to be underpinned by an effective monitoring and reporting scheme, supporting the entire chain of development, implementation, monitoring and updating of STRIA. The Transport Research and Innovation Monitoring and Information System (TRIMIS) was launched in September 2017 with the aim of supporting the implementation and monitoring of STRIA and its seven roadmaps.

1.1 Purpose of the study

TRIMIS is an open-access information system to map and analyse technology trends, research and innovation capacities, as well as monitor progress in the transport sector.

The European Commission's Joint Research Centre is responsible for the development of TRIMIS 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-chairing STRIA.

This report provides a first snapshot of the TRIMIS database of transport research and innovation (R&I) projects and programmes following the transfer of the TRIP database to TRIMIS and the launch of the TRIMIS online platform in September 2017. The analysis contained in this report reflects the status of the database on 25 November 2017.

The main objective of the report is to present a first overview of the characteristics of the TRIMIS database and the projects and programmes included therein. This analysis will be updated regularly, thus it will serve the monitoring of the TRIMIS database evolution.

1.2 EU policy addressed in this study

In 2017, the European Commission (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, 2015, 2017a).

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

1.3 Work methodology and organisation of the report

This report provides an analysis of the transport-related research and innovation data currently available in the TRIMIS database. Transport R&I data were collected through inputs in the TRIMIS portal (formerly through the Transport Research and Innovation

Portal – TRIP). The data collected were used for the building of the TRIMIS Projects and Programmes Database. Moreover, in the context of this report, data were extracted from the database, allowing an extensive analysis of the status of transport research and innovation in Europe. The results of the data analysis are presented through data visualisations that allow a better overview of the current situation in Europe according to the information gathered for TRIMIS. Finally, conclusive remarks and potential future steps related to policy implications are provided.

The report is divided into five chapters with Chapter 1 being the introductory, providing the purpose of this study and the European Union (EU) policies targeted and a presentation of the work methodology. Chapter 2 presents the aim and scope, status and current functionalities of TRIMIS and the research and innovation related data that are currently available and publicly open on the TRIMIS Projects and Programmes Database. Chapter 3 provides an assessment of the current transport R&I organised per STRIA roadmap, through an analysis of the information and data found in the Projects and Programmes Database of TRIMIS. Finally, Chapter 4 presents the final conclusions of the study concerning transport research and innovation status, potential policy implications and indications for future policy development.

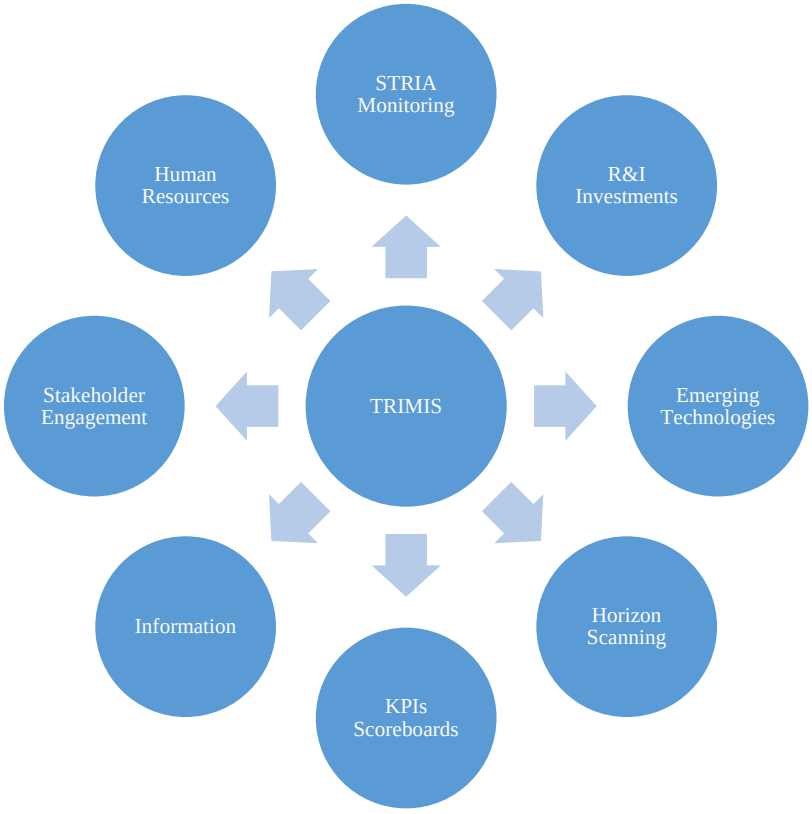
2 Scope of TRIMIS

The implementation of STRIA needs to be supported by an effective monitoring and information mechanism that assists the development and updating of STRIA and supports transport R&I (see Figure 1). 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.

It is a new 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 (KPIs) and scoreboards.

In addition, TRIMIS acts 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.

Figure 1. TRIMIS main features and functionalities.



Source: Tsakalidis et al., 2018.

TRIMIS focuses on a number of priority areas outlined in the seven STRIA roadmaps where public intervention at the 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 covers 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 KPIs in transport R&I and links to established EU tools and initiatives (e.g. SETIS and Innovation Radar). It provides a communication channel between TRIMIS and transport stakeholders allowing additions and amendments to the database with an automated link to existing EC 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. Highlighting mature technologies that are close to market introduction.

The specific objectives of TRIMIS are to:

- Support monitoring the progress of the STRIA, including support to the development of STRIA roadmaps, and support to the STRIA governance (Steering Group)
- Prepare and regularly update 'technology mapping' (state of the art, barriers and potential of technologies) following the STRIA roadmaps structure
- Define and regularly update 'capacities mapping' (financial and human resources)
- Assess funded research projects in the field of transport (with a focus to the STRIA roadmaps)
- Assist the regular reporting of the progress of the STRIA and its actions against defined KPIs and scoreboards
- Flag opportunities for new STRIA roadmaps or revised structuring of existing ones
- Monitor socio-economic developments and assess their influence on transport technology and innovation
- Facilitate the effective functioning of an extensive network of industry stakeholders, Member States experts and authorities, research organisations, industrial and financial communities, information collection points etc.

2.1 Programmes – Current database contents

As of November 2017, the programmes database contains 52 elements. The main categories and elements that were considered in this report can be summarised and grouped under the general categories: General Information, Funding and Collaboration

Context, Policy Context and Scientific Context. The categories and their respective specific contents under consideration are presented in Table 1.

Table 1. Current programmes database contents.

General Information
• Title • Programme Acronym • Programme Status • Start Year • End Year • Number of Programmes • Contacts • Programme Website
Funding and Collaboration Context
• Funding Origin(s) • Principal Funding Origin • Framework Programme • Institution Type • Institution Name • Programme Organisation • Type of Funding • Projects Covered • Total Number of Projects • Total budget • Funding arrangements and funding conditions
Policy Context
• Background & policy context • Pertinent STRIA Roadmaps • Pertinent Transport Modes • Pertinent Transport Policies • Pertinent Transport Sectors
Scientific Context
• Background and Policy Context • Objectives

2.2 Projects – Current database contents

As of November 2017, the projects database contains 46 elements. The main categories and elements that were considered in this report can be summarised and grouped under the general categories: General Information, Funding and Collaboration Context, Policy

Context and Scientific Context. The categories and their respective specific contents under consideration are presented in Table 2.

Table 2. Current projects database contents.

General Information

- Title
- Project Acronym
- Original Language Title (if different than English)
- Project Status
- Start Date
- End Date
- Contacts
- Project website

Funding and Collaboration Context

- Funding Origin
- Funding Source(s)
- Parent Programme
- Funding Type Other
- Other Countries
- Partners

Policy Context

- Background & policy context
- Pertinent STRIA Roadmaps
- Pertinent Transport Modes
- Pertinent Transport Policies
- Pertinent Transport Sectors

Scientific Context

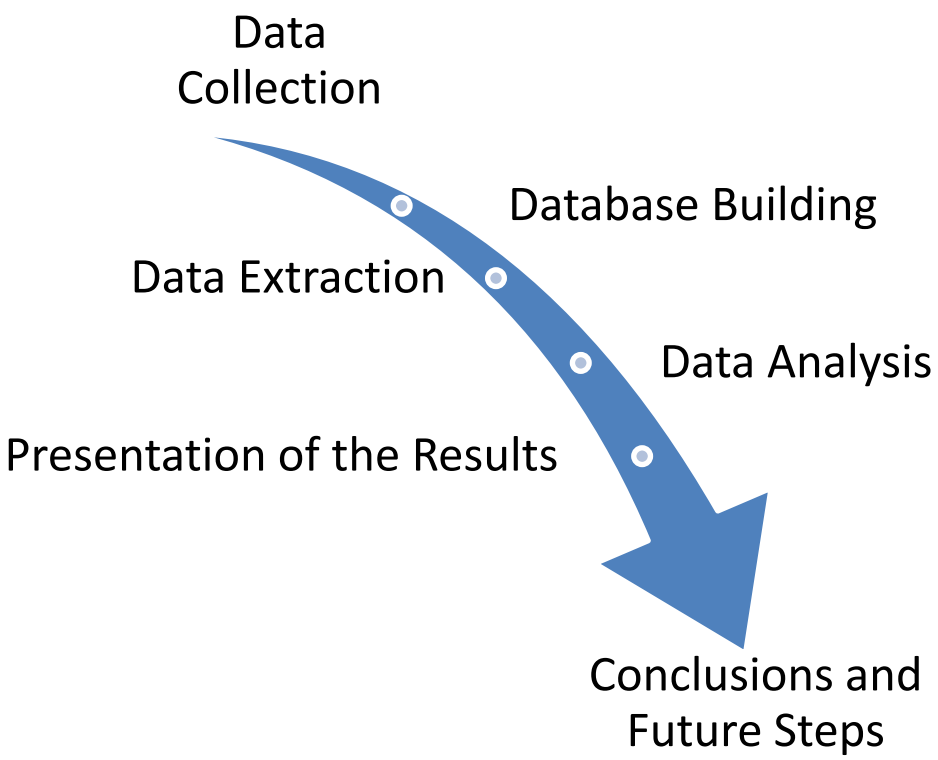
- Objectives
- Methodology

3 Assessment of current transport R&I per roadmap

3.1 Methodology of the assessment

This report aims at providing an analysis of the transport-related research and innovation data currently available in the TRIMIS database. The transport R&I data currently found in the database were collected through inputs in the TRIMIS portal and previously, until September 2017, through the Transport Research and Innovation Portal –TRIP. The steps of the methodology of the assessment are presented in Figure 2.

Figure 2. Methodological steps of the assessment.



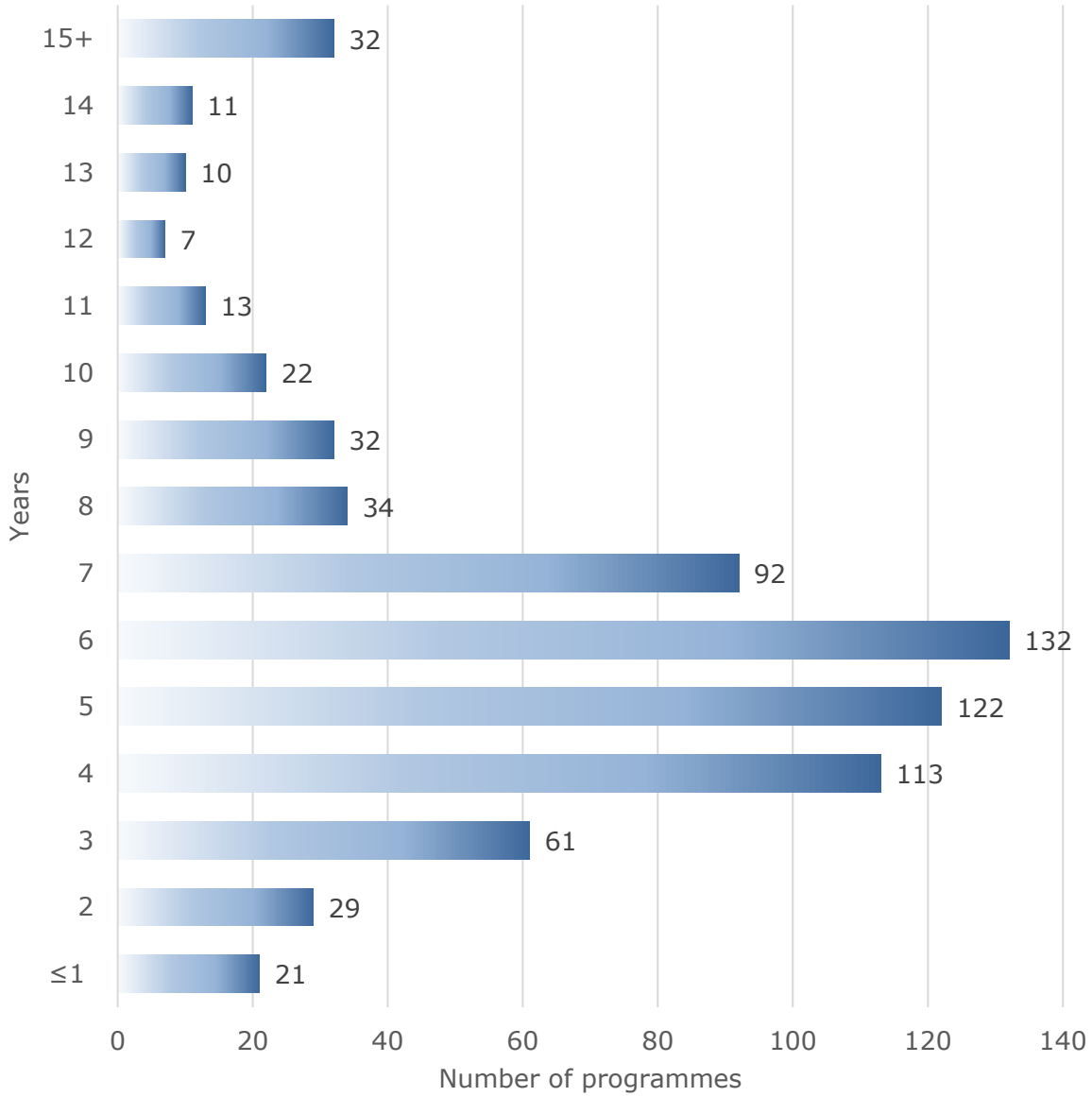
The data collected through TRIP and TRIMIS were used for the building of the TRIMIS Projects and Programmes Database. Thus, in the context of this report and for analysis reasons, the required relevant data were extracted from the database, allowing an extensive analysis of the status of transport research and innovation in Europe. The results of the data analysis are presented through data visualisations that allow a better overview of the current situation in Europe according to the information available through TRIMIS. As a final output, conclusive remarks and potential future steps related to policy implications are provided.

3.1.1 Programmes database analysis

The actual programme database snapshot refers to 25 November 2017. At this state it contains 476 programmes. 92 programmes result as active, while 384 result as completed.

Average programme duration. The majority of programmes in the database has a duration between 4 and 6 years. As the graph in Figure 3 shows, there are a number of programmes that exceed a duration of 15 years. These correspond to long term programmes (e.g. regarding the development of a rail or highway network at national level).

Figure 3. Programme duration.

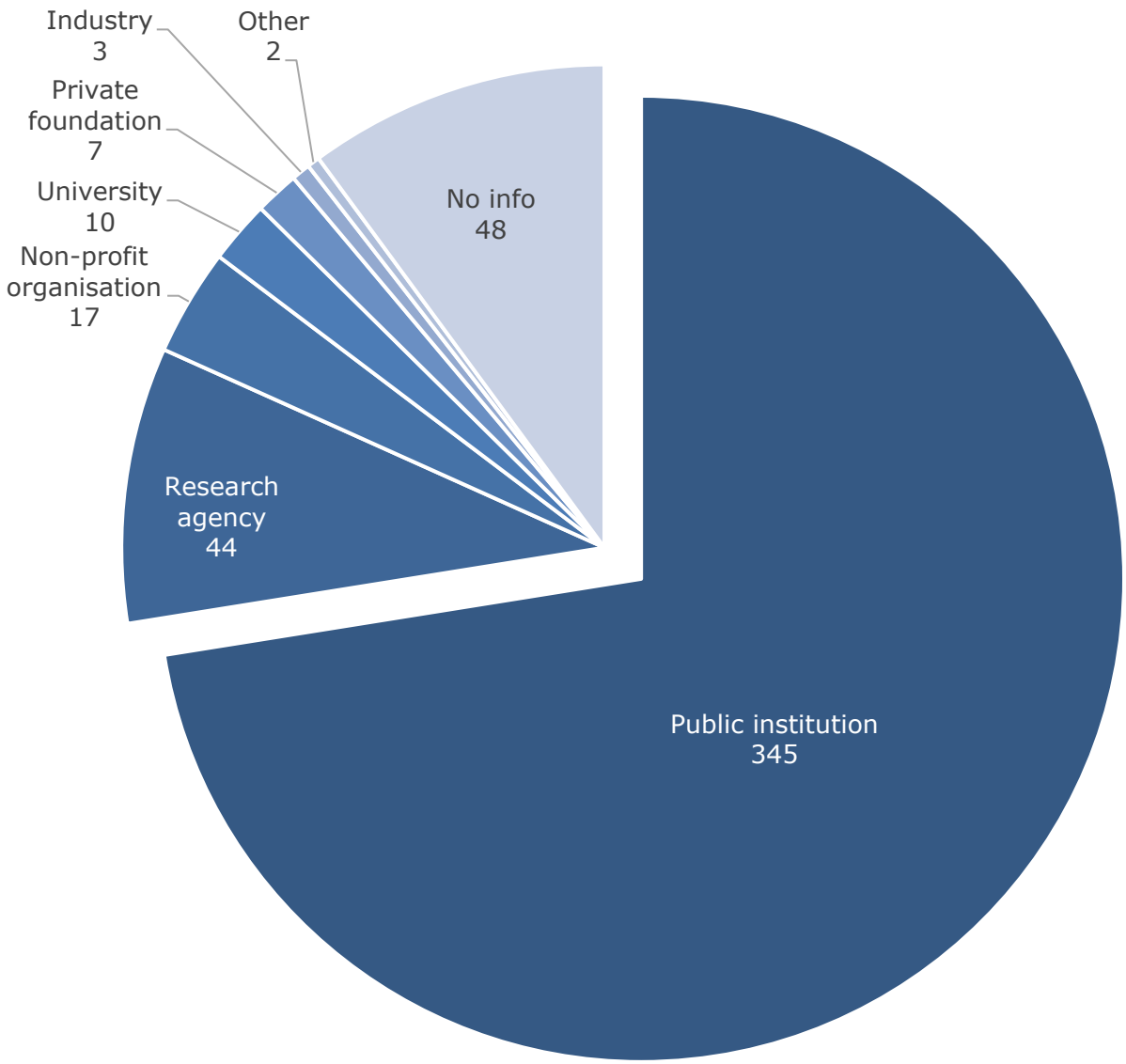


Type of programme funding. In the programme database, programmes are divided according to the funding origin. Seven principal categories are defined:

- Public institution
- Research agency
- Non-profit organisation
- University
- Private foundation
- Industry
- Other

The majority of programmes in the database (about 7 out of 10) are funded from a public institution, while about 1 out of 10 are funded by research agencies. At the current state, no funding information is available for 48 programmes. Figure 4 presents the programme funding origin by institution type.

Figure 4. Programme funding origin by institution type.



Funding sources. Programmes are also divided according to the funding type (mainly, public or private). 5 principal categories are defined:

- Public (national, regional or local)
- Public (EU)
- Industry
- Public (international sources other than the EU)
- Private

The majority of programmes in the database (about 9 out of 10) are funded by public institutions. At the current state, no information are available for 37 programmes.

Another information in the database is provided by the spatial distribution of the funding sources.

Figure 5. Programme funding by type.

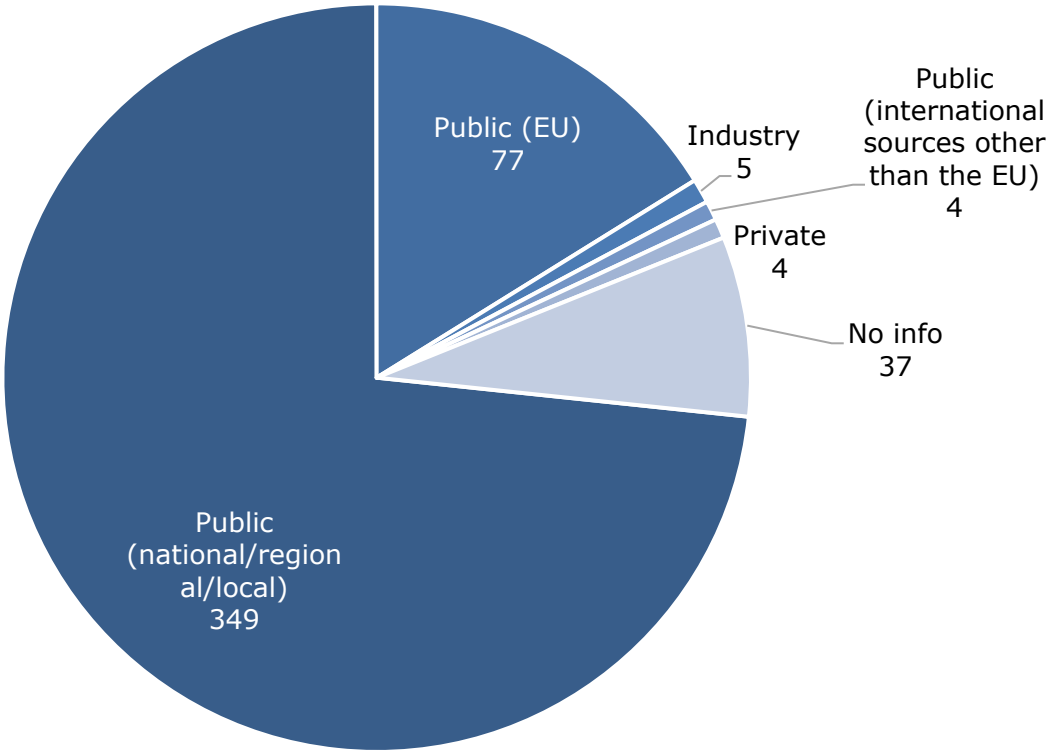
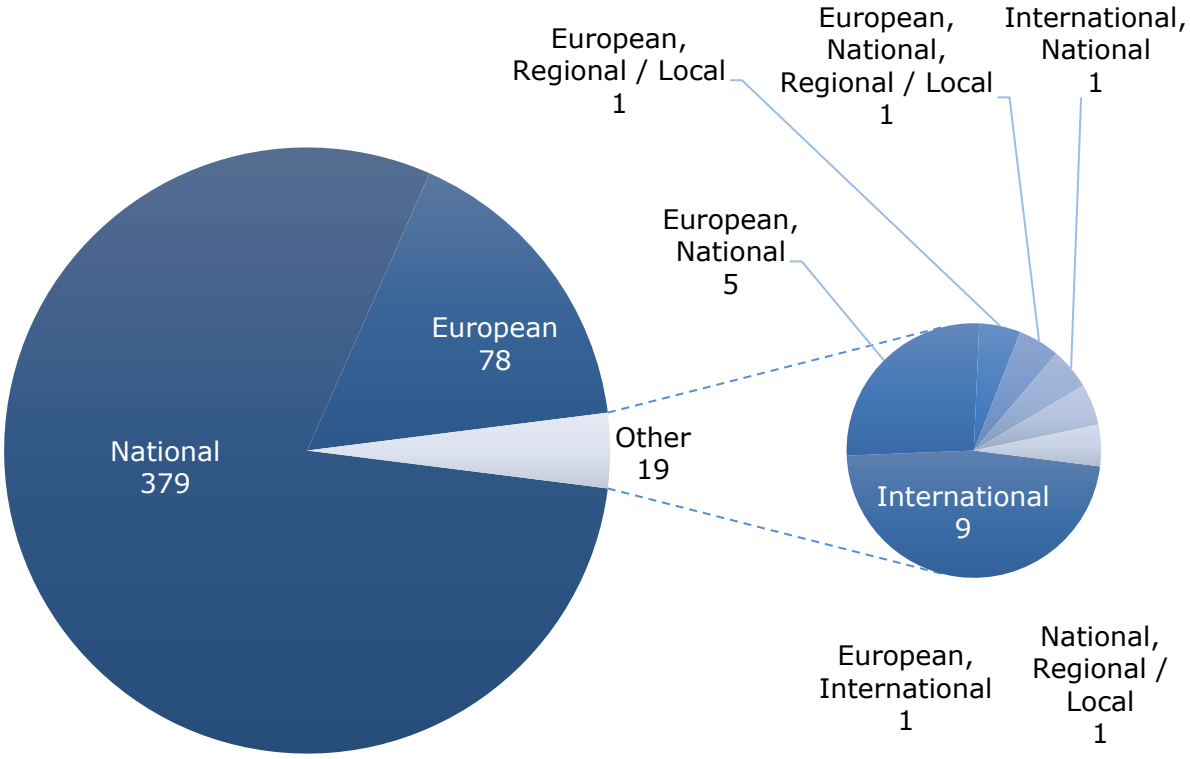


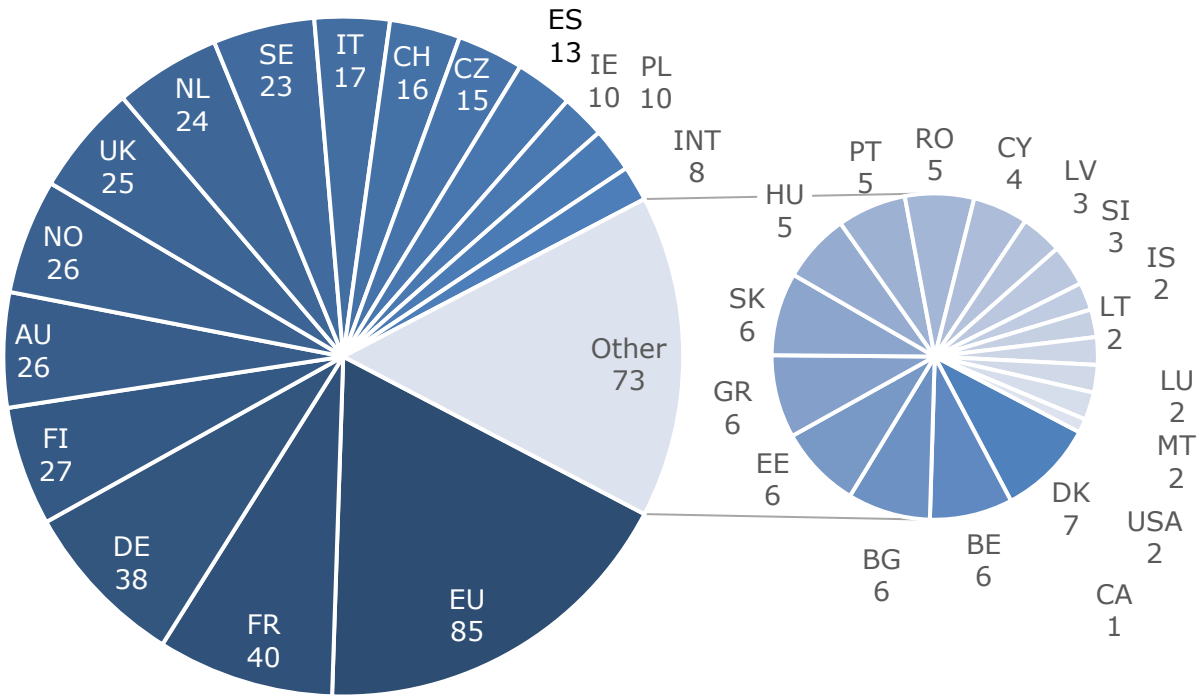
Figure 6. Programme funding by sources.



As can be observed, the majority of programmes in the database are either National (the funding origin being in a single state) or European.

Spatial distribution. The database contains information regarding the funding origin of all programmes. As can be seen in the figure below, the majority of programmes (85) are EU funded, while the other most populated funding origins in the database are France (40 programmes) and Germany (38 programmes). The database includes 8 International programmes and 2 from the USA.

Figure 7. Spatial distribution of programmes.



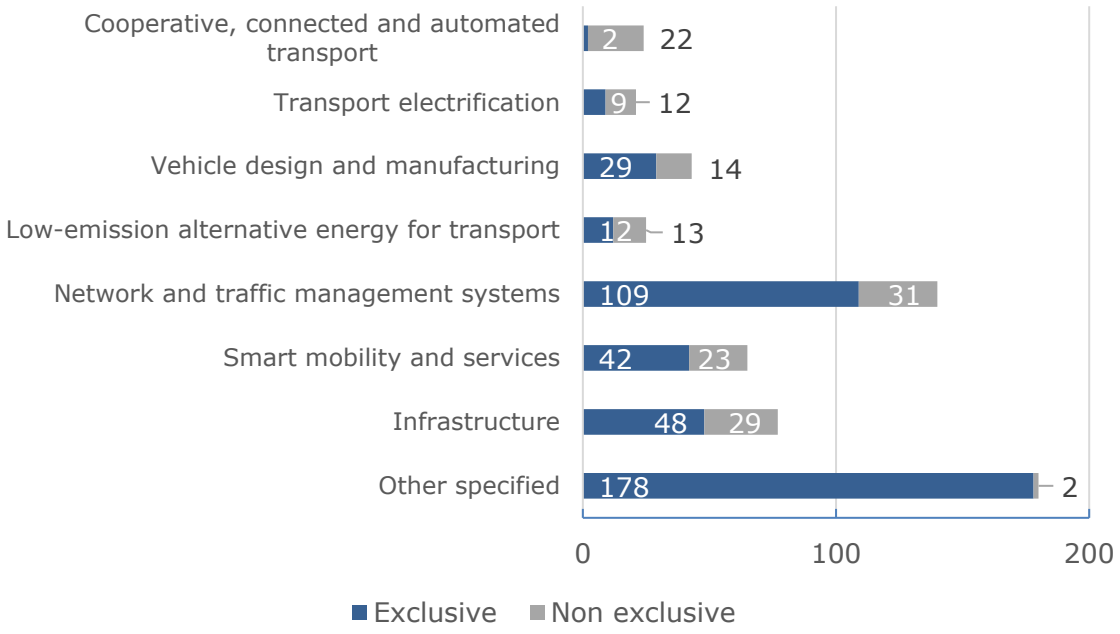
Mapping per STRIA roadmaps. All programmes in the database are linked to the seven STRIA roadmaps, specifically:

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

In addition, in order to facilitate the indexing process, an additional label ("Other specified") has been considered for programmes that contain elements difficult to associate with one or more roadmaps.

The STRIA roadmap allocation breakdown for the programmes is shown in Figure 8. The blue bar shows exclusive STRIA allocation (that is, number of projects that are allocated to a single STRIA Roadmap), while the grey bar indicates that the project belongs not only to the specific roadmap but to other roadmaps as well.

Figure 8. Programmes per STRIA roadmap.

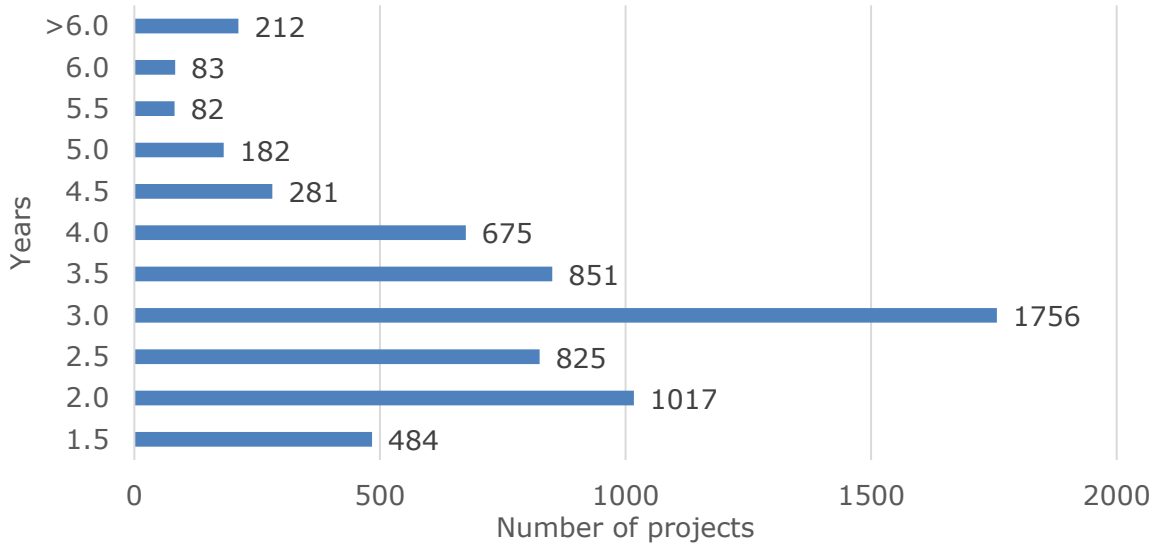


3.1.2 Projects

The actual project database snapshot refers to 25 November 2017. At this state it contains 6198 projects.

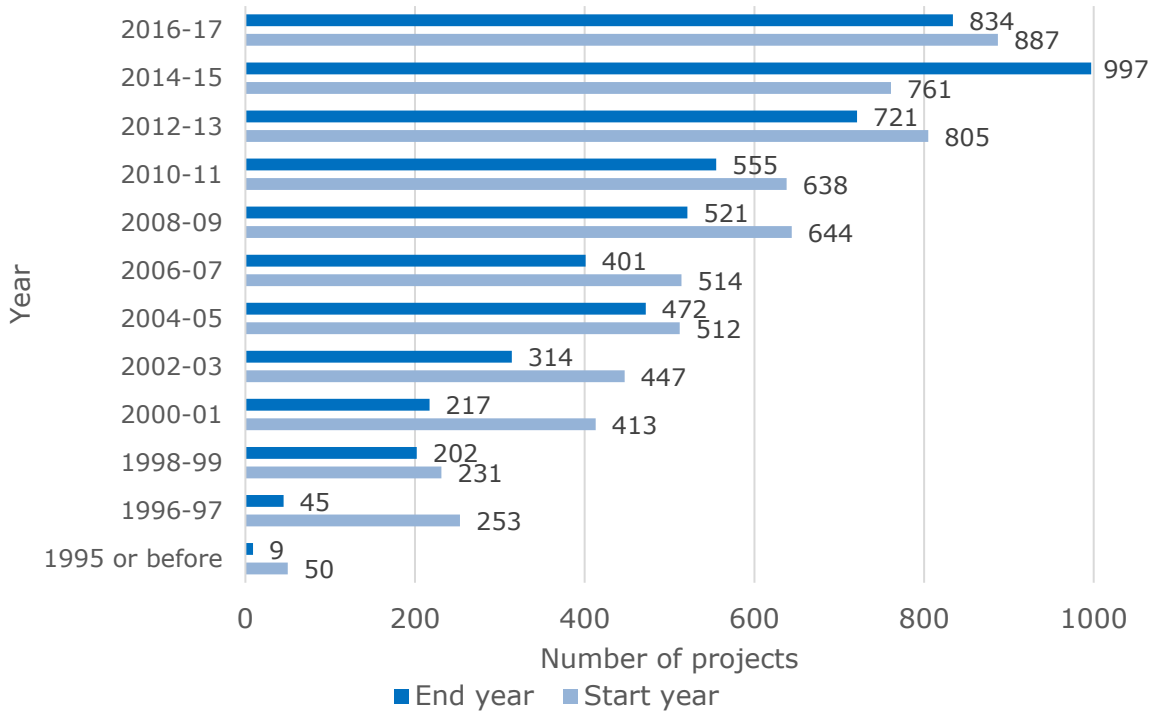
Average project duration. The figure below indicates the average project duration as reported in the database. The majority of the projects (62.1%) have a duration less than three years (36 months). There are some projects with longer duration, while very few are long term project with a duration of 6 years or longer.

Figure 9. Average project duration.



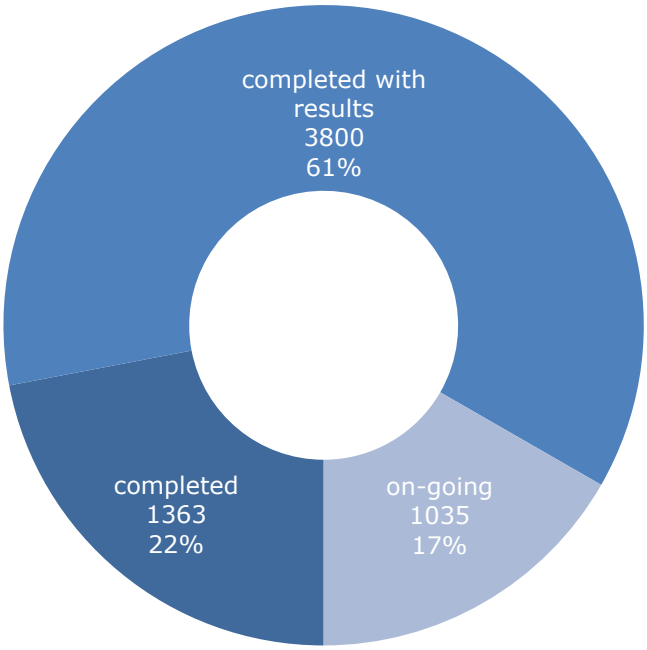
Number of projects per year. Figure 10 indicates the number of projects in the database with regard to their start and end year. It can be seen that there is a trend for newer projects in the database (considering also that only 11 months of 2017 have been accounted for in this snapshot).

Figure 10. Projects per year.



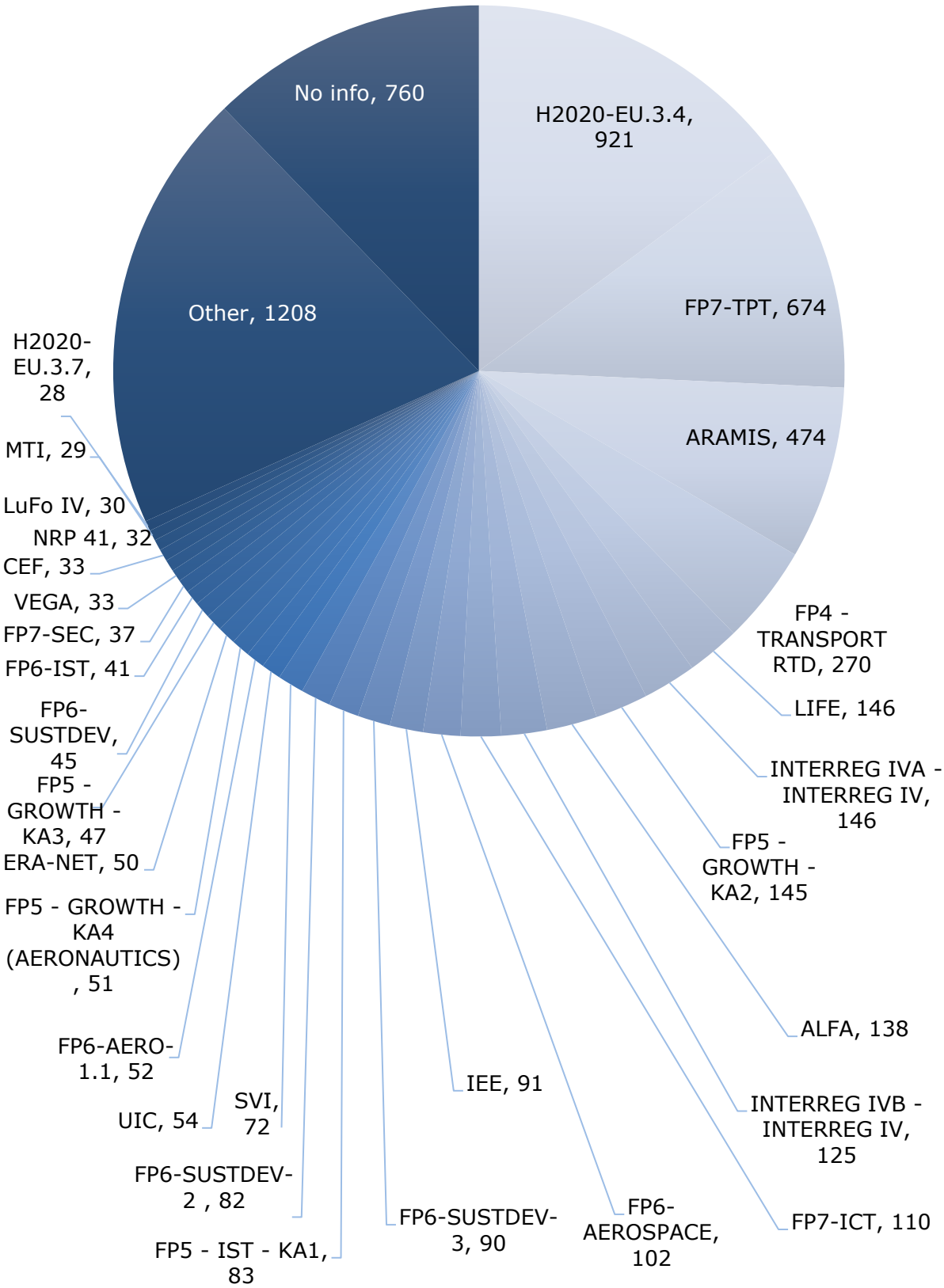
Number of complete and active projects. In the database, 1035 projects result as on-going, 1363 as completed and 3800 as completed with results.

Figure 11. Projects status.



Projects per parent programme. The projects in the database are linked with specific parent research and innovation programmes. In the current state of the database, this information is provided for 5439 projects (out of 6198), which are linked to 238 different programmes. Among those, the chart reports the top 30 programmes in terms of project numbers. These programmes are abbreviated in Table 3.

Figure 12. Projects by funding origin.



The biggest proportion of projects (921 or about 15 per cent of the projects) is associated with the Horizon 2020: Smart, Green and Integrated Transport work programme. 674 projects are associated with the thematic area "Transport (including aeronautics)" of the 7th Framework Programme for Research and Technological Development (FP7). The third most populated programme (with 474 projects) is ARAMIS of the Swiss Federal Administration.

The table below reports the top thirty programmes in terms of projects, their abbreviation and the number of containing projects.

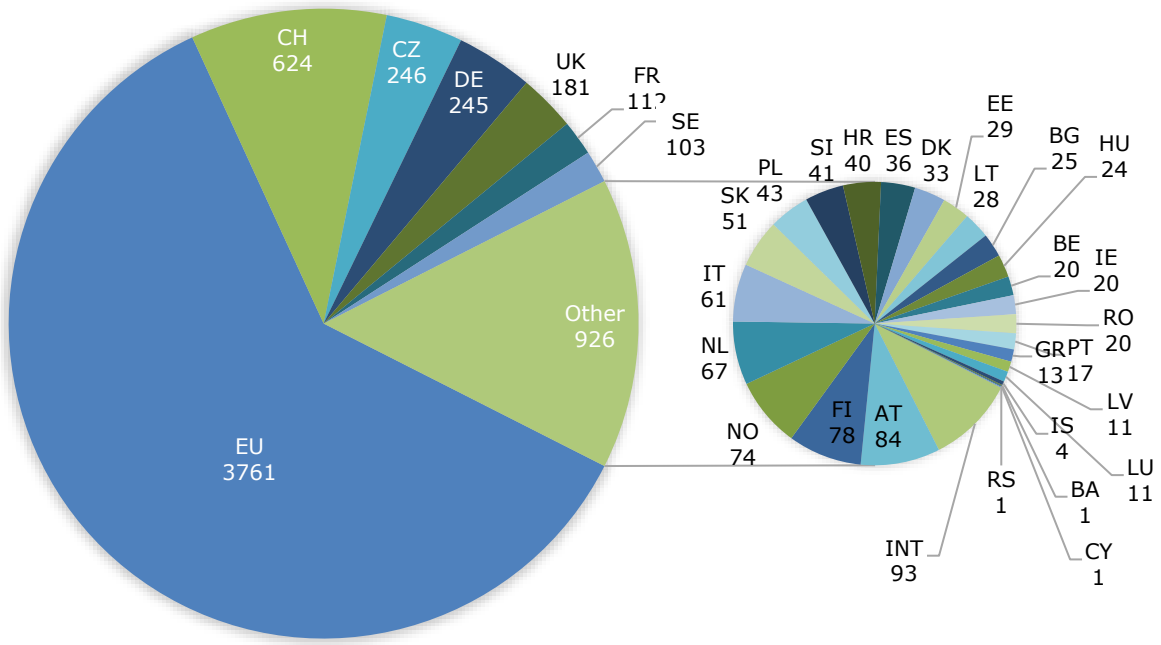
Table 3. Top 30 programmes in terms of project numbers.

	Programme name	Abbreviation	No
1	Horizon 2020: Smart, Green and Integrated Transport	H2020-EU.3.4.	921
2	Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)	FP7-TPT	674
3	ARAMIS information system	ARAMIS	474
4	Transport Research and Technological Development	FP4 - TRANSPORT RTD	270
5	EU financial instrument supporting environmental, nature conservation and climate action projects	LIFE	146
6	Cross-border programmes	INTERREG IVA - INTERREG IV	146
7	Sustainable Mobility and Intermodality	FP5 - GROWTH - KA2	145
8	ALFA PROGRAMME	ALFA	138
9	Transnational programmes	INTERREG IVB - INTERREG IV	125
10	Information and Communication Technologies	FP7-ICT	110
11	Aeronautics and Space - Priority Thematic Area 4 (PTA4)	FP6-AEROSPACE	102
12	Intelligent Energy Europe	IEE	91
13	Global Change and Ecosystems	FP6-SUSTDEV-3	90
14	Systems and services for the citizens	FP5 - IST - KA1	83
15	Sustainable Surface Transport	FP6-SUSTDEV-2	82
16	Swiss Association of Transportation Engineers (various projects)	SVI	72
17	International Union of Railways (various projects)	UIC	54
18	Strengthening competitiveness	FP6-AERO-1.1	52
19	New Perspectives in Aeronautics	FP5 - GROWTH - KA4 (AERONAUTICS)	51
20	European Research Area Net	ERA-NET	50
21	Land transport and marine technologies	FP5 - GROWTH - KA3	47
22	Sustainable Development, Global Change and Ecosystems - Priority Thematic Area 6 (PTA6)	FP6-SUSTDEV	45

	Programme name	Abbreviation	No
23	Information Society Technologies - Priority Thematic Area 2 (PTA2)	FP6-IST	41
24	Security	FP7-SEC	37
25	Scientific Grant Agency	VEGA	33
26	Transport and Environment (internal research plan)	NRP 41	32
27	Connecting Europe Facility	CEF	33
28	Federal research programme aeronautics LuFo IV	LuFo IV	30
29	Bringing Technology to the People	MTI	29
30	Horizon 2020: Secure societies - protecting freedom and security of Europe and its citizens	H2020-EU.3.7.	28

Projects by funding state. The projects are further divided by the funding state, with an additional category being projects funded by the EU. All projects in the database are associated with the source of funding. The majority of the projects (3761 projects or about 61 per cent of the projects in the database) are funded by the EU. The second largest funding source (in terms of number of projects) is Switzerland (624 projects or about 10 per cent of the projects in the database).

Figure 13. Projects by funding state.

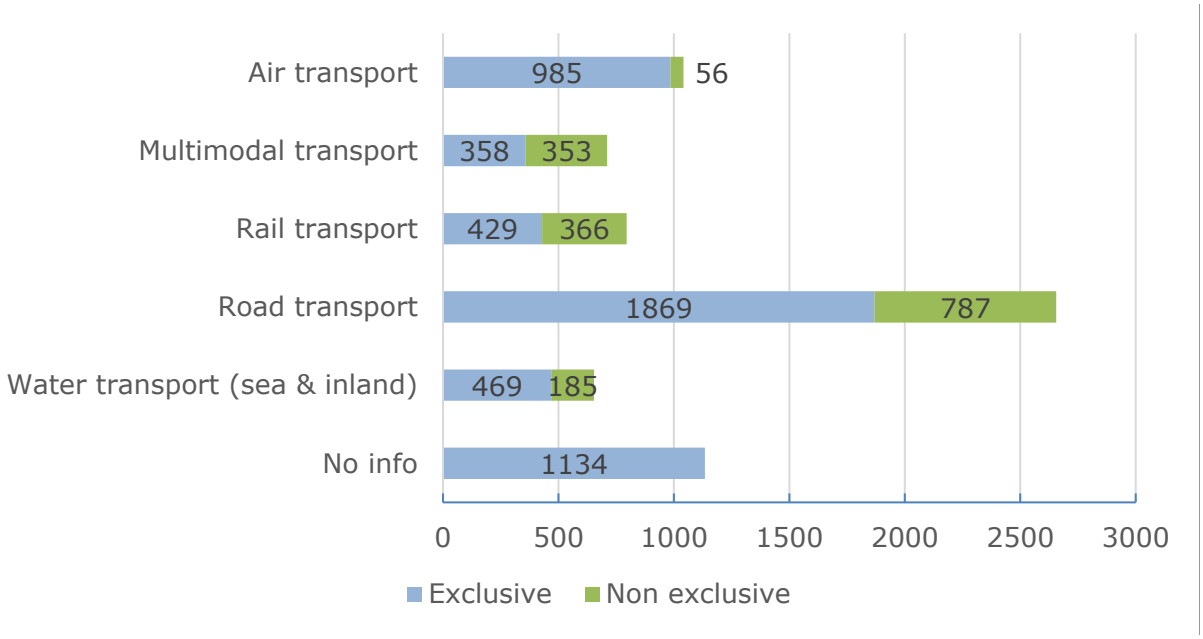


Project allocation by transport mode. Projects in the TRIMIS database are allocated according to five different transport modes:

- Air transport - Research covers passenger and freight transport by heavier-than-air and lighter-than-air vehicles. Principal means of air transport are fixed-wing aircraft, helicopters, tilt-rotors and airships. The focus is on commercial aviation by domestic and international airlines relying on dedicated airport infrastructure and air traffic management systems for regional, European and global transport. Air transport includes ground services related to these operations.
- Multimodal transport - Research on multimodal transport covers both freight and passenger transport. With respect to freight transport, the theme incorporates the movement of freight in one loading unit or road vehicle, which uses successively two or more transport modes without goods handling during modal changes. Multimodal passenger transport covers the use of different modes in a door-to-door journey chain, with the focus on modal integration in a seamless journey.
- Rail transport - Research on rail transport refers to all land-bound passenger and freight transport on dual and single fixed rail, including heavy rail, light rail, tram, metro, funicular and monorail. Personal Rapid Transit (PRT) systems on conventional rails and MAGLEV systems are not strictly 'rail' track and are included under innovative technologies.
- Road transport - Road transport research covers vehicles operating on motorways, asphalt and gravel roads, and associated infrastructure including bridges, cuttings, tunnels, parking areas and footways. Ground transport in ports and airports directly associated with air, maritime and inland waterway transport is not included. Non-motorised modes, such as walking and cycling, are included because these forms of transport largely share the same infrastructure.
- Water transport (sea & inland) - Water transport research covers maritime transport, short-sea shipping (SSS), inland navigation, estuarial shipping, and land operations that include cargo handling/ transfer between waterborne and other transport modes.

The transport mode allocation breakdown for the projects is shown in Figure 14.

Figure 14. Projects by transport mode.



The light blue bar shows exclusive transport modes (that is, number of projects that are allocated to a single mode), while the grey bar indicates that the project is part to the specific mode, as well as to one or more other modes. In addition, 737 projects are linked to research related with urban transport. It should be observed that at the present state 1122 projects (18%) in the database are not linked to any transport modes due to lack of information.

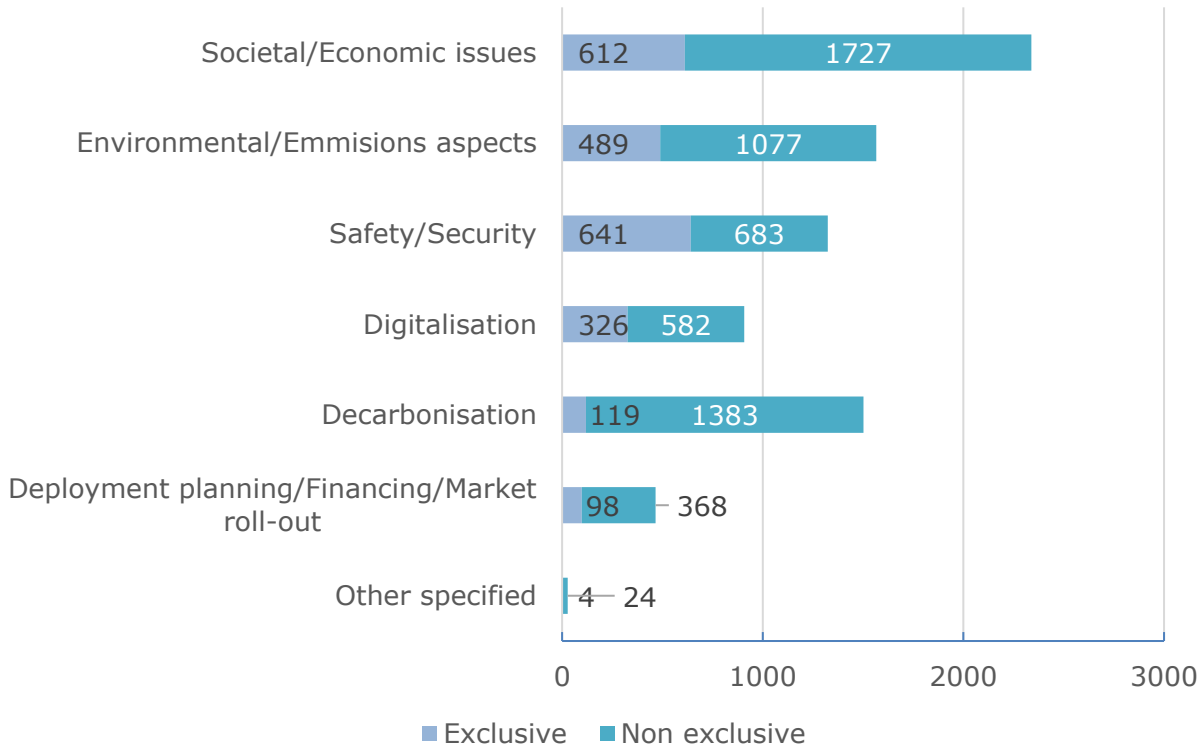
Project allocation by transport policy. Projects in the TRIMIS database are allocated according to six different transport policies

- Societal/Economic Issues - Research ranges from the role of transport users and their influence on achieving long-term objectives of transport policy to the protection of user rights and interests. It includes improving information provision to transport users and increasing user awareness of the implications of their transport choices and also reviews the needs of groups such as those on low incomes, the elderly, disabled people, and those living in deprived areas. Social inclusion primarily concerns accessibility for those without a car and people with impaired mobility. Research aims at increasing access to employment, leisure and other activities for people from different locations, and with differing access to transport. The theme embraces user perspectives on the quality of transport services, such as reliability, flexibility, comfort, affordability and convenience. This theme also covers research on macro-economic and regional economic impacts of transport policies and transport technologies. Economic and regional impacts occur mainly through the mechanisms of cost savings and improved accessibility, as a result of various EU policy measures, such as Trans European Transport Networks (TEN-T) or cohesion policy. Research focuses on methodologies and tools to estimate the impacts of policies and technologies on economic or regional patterns.
- Environmental/Emissions aspects - Research on environmental impacts addresses the adverse effects of transport, such as air and water pollution, greenhouse gas emissions, noise, vibration and waste disposal. The severity of these impacts is assessed, mitigation measures analysed and more environmentally friendly technologies developed.
- Safety/Security - Research concerns exposure of people, goods and property to potential hazards in the transport system and may vary according to transport mode. Research is accessing acceptable levels of risk according to the choices made by individuals, whether operating staff, drivers or passengers. Security research aims at protecting people, goods and transport systems from real and perceived threat of crime, terrorism, negligence, technical failures or natural disasters.
- Digitalisation - Connectivity and social media are transforming traditional concepts of mobility. New business models are emerging and giving rise to innovative mobility services including new on-line platforms for freight operations, car-pooling, car or bicycle sharing services, or smartphone applications offering real-time analytics and data on traffic conditions. Vehicles themselves are also being transformed by digital technologies. They are becoming increasingly smart as new on-board connected and cooperative services and increased levels of automation become available.
- Decarbonisation - Research is carried out in support of policies dedicated to mitigating climate change and decarbonising the transport sector, which is a central goal of EU transport policy. Policies focus on reducing greenhouse gas emissions using instruments such as emission trading systems and setting regulations. Research on energy efficiency is directed, for instance, to potential policy measures, and technological, economic and behaviour changes in order to reduce energy consumption per output indicator (such as, passenger or tonne-kilometre).

- Deployment planning/Financing/Market roll-out - Research focuses on integrated planning of transport systems and land use to identify ways to reduce traffic congestion, energy use and vehicle emissions, including financing, design, construction, operation and maintenance of infrastructure in all transport modes. The theme includes modal transfers, and information and communication networks to support traffic management. The theme also includes the development of TEN-T networks and terminals in all transport modes, which is a key aspect of the EU transport strategy. Furthermore, it covers increasing the density of settlement structures and developing land-use patterns in order to encourage provision and use of public transport, as well as to facilitate the use of soft modes.
- Other specified – Falling outside the aforementioned categories.

The transport policies allocation breakdown for the projects is shown in the figure below. The light blue bar shows exclusive transport policies (that is, number of projects that are allocated to a single policy), while the grey bar indicates that the project is allocated to the specific policy, as well as to one or more other policies. It should be observed that at the present state 1510 projects (24%) in the database are not linked to any transport policies due to lack of information.

Figure 15. Projects by transport policy.



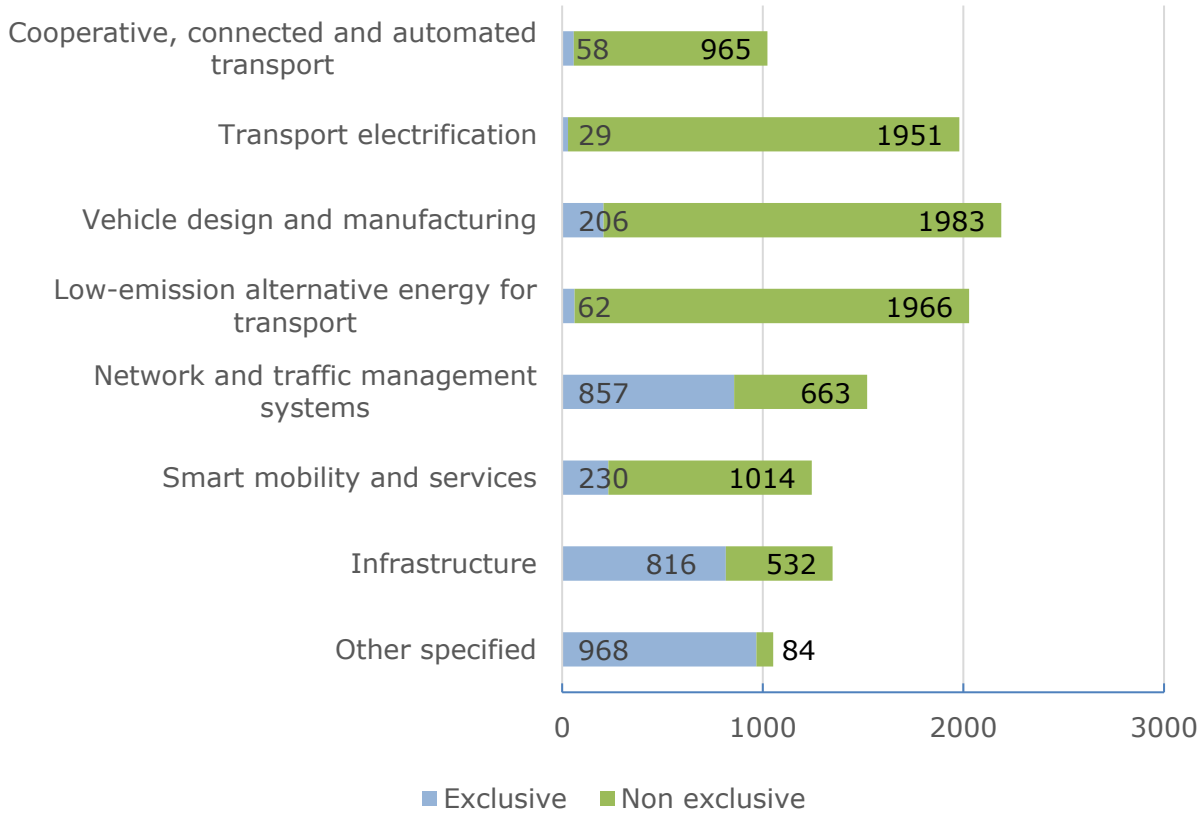
Projects per STRIA roadmaps. All projects in the database are linked to the seven STRIA roadmaps, specifically:

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

In addition, in order to facilitate the indexing process, an additional label ("Other specified") has been considered for those projects that contain elements difficult to associate with one or more roadmaps.

The STRIA roadmap allocation breakdown for the projects is shown in the figure below. The light blue bar shows exclusive STRIA allocation (that is, number of projects that are allocated to a single STRIA roadmap), while the grey bar indicates that the project belongs to the specific roadmap but to other roadmaps as well.

Figure 16. Projects per STRIA roadmaps.



3.2 Figures on EU funded projects in the database

The database contains 3761 projects that are linked to 62 European programmes. A large amount of projects are linked the Horizon 2020 Smart, Green and Integrated Transport action (921 projects). 674 projects are linked to the Transport (Including Aeronautics) action- Horizontal activities for implementation of the transport programme (TPT), of the 7th Framework Programme. A large amount of projects are linked to older FP4-FP5 instruments (1994–2002).

Regarding the funding from Framework Programmes, the database contains:

- 3 Programmes from the 4th Framework Program
- 7 Programmes from the 5th Framework Program
- 11 Programmes from the 6th Framework Program
- 16 Programmes from the 7th Framework Program
- 5 Programmes from the Horizon 2020 Framework Program

The complete list of parent programmes and the related number of projects is reported in the table below.

Table 4. EU funded projects and their parent programmes.

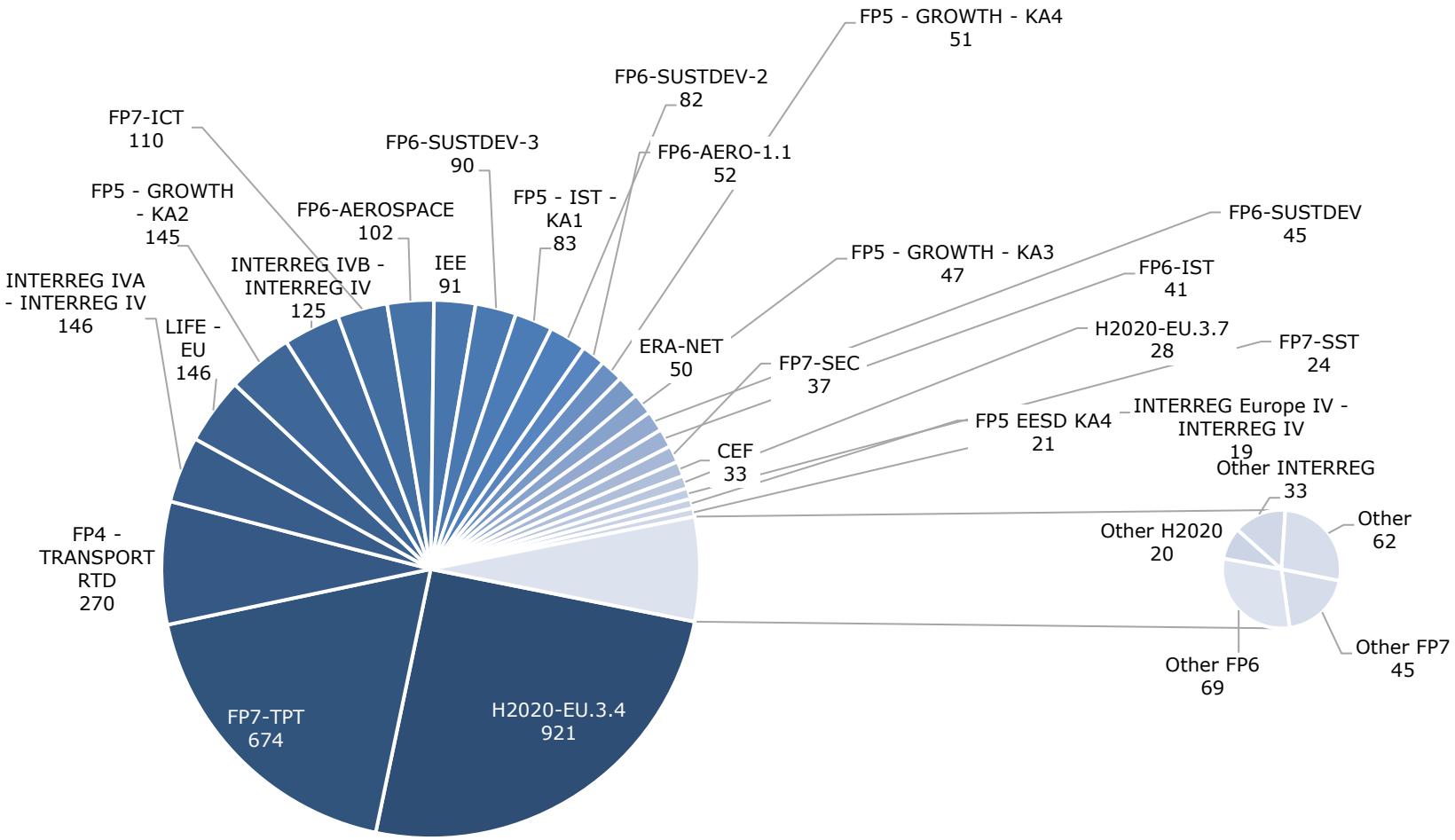
Acronym	Name	No
H2020-EU.3.4	Horizon 2020: Smart, Green and Integrated Transport	921
FP7-TPT	Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)	674
FP4 - TRANSPORT RTD	Transport Research and Technological Development	270
INTERREG IVA - INTERREG IV	Cross-border programmes	146
LIFE	EU financial instrument supporting environmental, nature conservation and climate action projects	146
FP5 - GROWTH - KA2	Sustainable Mobility and Intermodality	145
INTERREG IVB - INTERREG IV	Transnational programmes	125
FP7-ICT	Information and Communication Technologies	110
FP6-AEROSPACE	Aeronautics and Space - Priority Thematic Area 4 (PTA4)	102
IEE	Intelligent Energy Europe	91
FP6-SUSTDEV-3	Global Change and Ecosystems	90
FP5 - IST - KA1	Systems and services for the citizens	83
FP6-SUSTDEV-2	Sustainable Surface Transport	82
FP6-AERO-1.1	Strengthening competitiveness	52
FP5 - GROWTH - KA4 (AERONAUTICS)	New Perspectives in Aeronautics	51
ERA-NET	European Research Area Net	50
FP5 - GROWTH - KA3	Land transport and marine technologies	47
FP6-SUSTDEV	Sustainable Development, Global Change and Ecosystems - Priority Thematic Area 6 (PTA6)	45
FP6-IST	Information Society Technologies - Priority Thematic Area 2 (PTA2)	41
FP7-SEC	Security	37
CEF	Connecting Europe Facility	33
H2020-EU.3.7	Horizon 2020: Secure societies - protecting freedom and security of Europe and its citizens	28
FP7-SST	Sustainable Surface Transport	24
FP5 EESD KA4	City of Tomorrow and Cultural Heritage	21

Acronym	Name	No
INTERREG Europe IV - INTERREG IV	INTERREG IV - Interregional cooperation across Europe (INTERREG IVC)	19
FP7-JTI	Specific Programme "Cooperation": Joint Technology Initiatives	18
INTERREG IIIB	Trans-European cooperation (Community Initiative)	17
FP6-AERO-1.4	Increasing Operational Capacity and Safety of the Air Transport System	17
Horizon2020	Horizon2020 - The EU Framework Programme for Research and Innovation	15
FP6-AERO-1.2	Improving environmental impact with regard to emissions and noise	15
INTERREG VA - INTERREG V	INTERREG VA - INTERREG V - Cross-border programmes	14
FP6-INTEGRATING	Specific research and demonstration programme aimed at integrating and strengthening the European Research Area	14
FP6-AERO-1.3	Increasing Operational Capacity and Safety of the Air Transport System	14
FP7-AAT	Aeronautics and air transport	11
EUREKA	A network for market-oriented R&D (network)	10
DGTREN	Energy & Transport DG - Miscellaneous projects	10
CIP	Competitiveness and Innovation Framework Programme	10
MIP - MAP	Multi-annual Indicative Programme (MIP), Multi Annual Programme (MAP)	9
FP6-SUSTDEV-1	Sustainable Energy Systems	9
FP5 - EESD KA6	Economic and Efficient Energy for a Competitive Europe	8
COST	Co-operation in science and technology	8
H2020-EU.2.1.1	Leadership in enabling and industrial technologies - Information and Communication Technologies (ICT)	4
URBACT II - INTERREG IV	URBACT II - INTERREG IV - European Territorial Cooperation programme aiming to foster sustainable integrated urban development in cities across Europe	3
FP7-NMP	Specific Programme "Cooperation": Nanosciences, Nanotechnologies, Materials and new Production Technologies	3
FP7-SPACE	Specific Programme "Cooperation": Space	2
FP7-SME - FP7-SME	Specific Programme "Capacities": Research for the benefit of SMEs	2
FP7-RoK	Regions of Knowledge	2
FP7 - Environment	Environmental research under FP7	2
Electromobility+	Electromobility+ - Creating a Sustainable Framework for Electromobility in Europe	2

Acronym	Name	No
INTERREG IVC - Interreg IVC	INTERREG IVC - Interreg IVC	1
INTERREG VB - INTERREG V	INTERREG VB - INTERREG V - Transnational programmes	1
MOBI.Europe	MOBI.Europe	1
INTERREG IVB	North West Europe (NWE) Programme	1
H2020-EU.2.1.6	INDUSTRIAL LEADERSHIP - Leadership in enabling and industrial technologies ? Space	1
FP7-PEOPLE	Specific programme "People" implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities	1
FP7 - Energy - Smart Cities and Communities	FP7 - Energy - Smart Cities and Communities	1
FP7 - Energy - Energy Research under FP7	FP7 - Energy - Energy Research under FP7	1
Eurostars	Eurostars	1
EURNEX	EUropean rail Research Network of EXcellence (network)	1
ESPON 2013	INTERREG IV - ESPON 2013 Cooperation Programme	1
CIVITAS	City-Vitality-Sustainability	1
ATLANTICAREA	Atlantic Area Transnational Programme	1

The graph presented in Figure 17 reports the parent programmes breakdown for the top 25 programmes. The remaining 37 programmes are clustered in 5 categories (Other H2020, Other FP6, Other FP7, Other INTERREG and Other). 97 EU funded projects in the database are not linked to specific R&I programmes due to lack of information.

Figure 17. EU funded projects and parent programmes.



3.3 Cooperative, connected and automated transport

3.3.1 Introduction of the Roadmap

Connected and automated transport (CAT) technologies can contribute to increasing the efficiency and safety of the transport system. They can improve traffic flows, optimise infrastructure and public transport usage and foster multi-modal transport solutions.

Although a number of pilot demonstrations of CAT technologies are taking place in Europe, there is still a need for large-scale testing to determine the technological readiness, reliability and safety of automated transport functions in complex situations.

This will require addressing key issues such as the performance of innovative automated transport technologies, a regulatory framework which supports deployment of CAT solutions and technologies, acceptable levels of cybersecurity, as well as new business models.

The STRIA Roadmap for Cooperative, Connected and Automated Transport defines future research needs for developing and deploying CAT technologies and systems for all transport modes.

3.3.2 Current developments

Road: Many car and truck manufacturers are developing and rolling out vehicles with higher automation. An increasing number of European cars are already equipped with partial automation technologies, and the next step is the introduction of vehicles where the driver can choose whether to drive or not. Automated trucks and truck platooning are being tested on motorways in Europe. User-friendly automated public transport concepts have been demonstrated. Connectivity enables and will further expand automated vehicle performance by making distributed information and big data accessible.

Aviation: CAT technologies are being introduced in the civil conventional aviation sector. Smarter avionics systems are being integrated into the cockpit with increasing automation. On-board automation can provide greater levels of safety and predictability. Data connectivity in air transport is however developing at a slower pace. Connectivity offers new services to passengers and innovative ground processes that contribute to developments for increasing efficiency and reducing carbon dioxide emissions.

Waterborne: Ship automation is well advanced with most modern ships and vessels being equipped with systems such as target detecting radars, autopilots and track pilots using satellite positioning. Some autonomous ship demonstrations have been made, but technology is still on a low readiness level. Safety is a main area where automation is expected to provide improvements, e.g. by allowing to further address the human factor. Better data integration and improved monitoring will allow CAT to contribute to a competitive European shipping industry and improve security in the transport systems. However, digital connectivity is a prerequisite for further improvements to increase capacity and coverage.

Rail: CAT technologies are already embedded in rail-bound transport such as metro systems, while in some cities also automated driverless rail-bound systems can be found. However, due to a diversified European rail sector the implementation of CAT technologies is slow and lowers competitiveness. The Strategic Rail Research Innovation Agenda and related roadmaps for various parts of rail-bound systems as well as the multi-annual action plan of the *Shift2Rail* initiative address several aspects of automation and connectivity.

3.3.3 Key research and innovation pathways

The CAT roadmap focuses on eight actions that will develop technologies and support their swift deployment while ensuring competitiveness. This will provide a framework that

contributes to the decarbonisation of the European transport sector allowing EU energy and climate targets to be met.

(a) Active management of CAT technologies

The running of automated and non-automated systems in parallel is essential for the successful deployment of CAT. Transition principles will have to be developed between existing and future solutions, for each transport mode and the integrated transport system as a whole.

(b) User and societal acceptance

Targeted research for user needs and requirements based on real-life applications in a variety of settings is needed. It is necessary to develop acceptance criteria for operation of different types of autonomous vehicles, including users' confidence when no "driver" is present. Novel data sources together with analytics can be key enablers.

(c) Socio-economic impacts

Increased automation and connectivity in the transport sector will require an analysis of associated socio-economic impacts. The social perception and acceptance of automation should be considered for a transition towards higher adoption rates as well as monitoring of the potential impact on jobs both within Europe and worldwide. Training and education considerations will also need to be examined.

(d) Environmental and climate impacts

For the environmental and climate impact of these technologies it will be important to anticipate and assess how they influence mobility behaviour and what carbon dioxide emissions and resources effects it entails.

(e) Human–machine interface

New ways to design the human-machine interface in the vehicles/vessels will remain an important field of research. There is potential to exchange between transport modes experiences and best practices in this area.

(f) Innovative hybrid vehicles

Big data, automation and connectivity enable innovative hybrid vehicles. However, these new vehicles may not fit into the rigid definition of current modes in terms of underlying infrastructure, propulsion, or loads being carried. These vehicles will need further attention in terms of research and innovation, standards and regulations.

(g) Cybersecurity and data protection

There is a need for greater research understanding of transport cybersecurity and the identification of related risks associated with implementing adequate security. Acceptable levels of, and principles for, cybersecurity and data protection need to be developed and regularly updated. European guidelines and measures also need to be developed to prevent unauthorized access to data from vehicles/vessels and infrastructure.

(h) ICT infrastructure

Vehicle connectivity is essential to increase the safety and performance of CAT technologies and development of cost-efficient and reliable connectivity solutions must be supported. There is a need to coordinate investments towards reliable communication coverage and to exploit the full potential of hybrid communications.

(i) Optimised use of internet of things, data and governance

Research is needed to increase the performance and efficiency of automated transport technologies, transport systems, mobility and freight delivery services. This includes data mining, access to and innovative uses of data sources, data analytics, innovative business models, and visualisation. It is also necessary to define technical specifications

that can enable applications over variable quality of service data networks and also in remote areas.

3.3.4 Research figures on programmes and projects

In the current state of the database, there are 1023 projects on "Cooperative, connected and automated transport". Among these, 281 result as completed, 562 as completed with results and 180 as "on-going".

Figure 18. Project status – Cooperative, connected and automated transport.

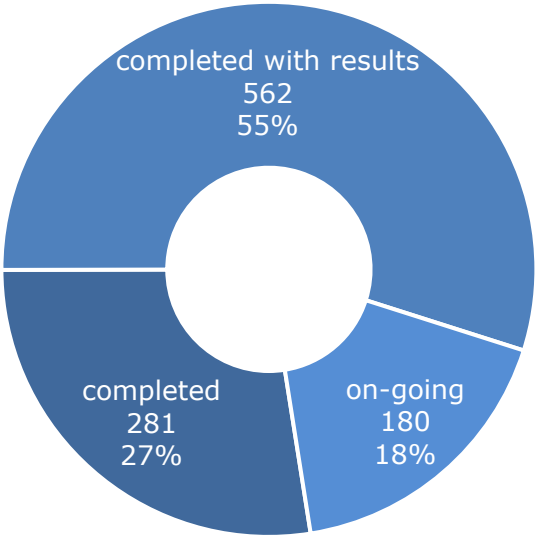
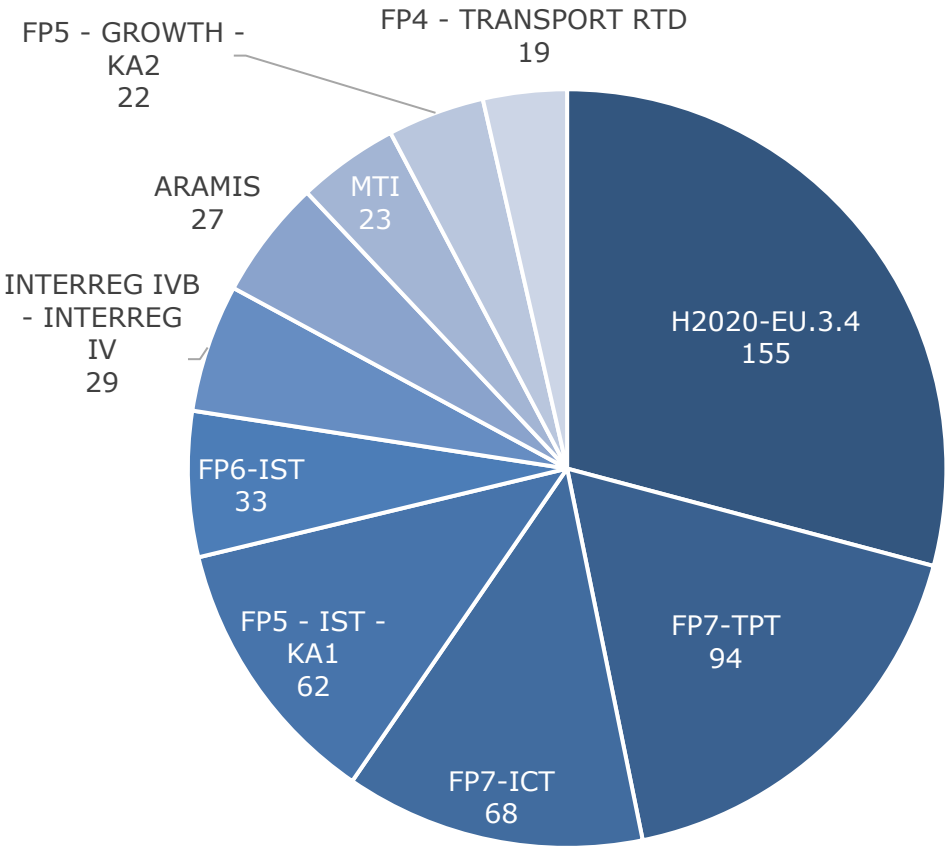


Figure 19. Top ten programmes – Cooperative, connected and automated transport.



Out of 1023 projects in the database, 881 are linked to parent research and innovation programmes. Among those, the chart reports the 10 most popular programmes. These programmes are abbreviated in a table.

Table 5. Top ten programmes – Cooperative, connected and automated transport.

	Programme name	Abbreviation	No
1	Horizon 2020: Smart, Green and Integrated Transport	H2020-EU.3.4	155
2	Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)	FP7-TPT	94
3	Information and Communication Technologies	FP7-ICT	68
4	Systems and services for the citizens	FP5 - IST - KA1	62
5	Information Society Technologies - Priority Thematic Area 2 (PTA2)	FP6-IST	33
6	Transnational programmes	INTERREG IVB - INTERREG IV	29
7	ARAMIS information system	ARAMIS	27
8	Bringing Technology to the People	MTI	23
9	Sustainable Mobility and Intermodality	FP5 - GROWTH - KA2	22
10	Transport Research and Technological Development	FP4 - TRANSPORT RTD	19

The majority of projects (155 or about 17 per cent of the projects) are associated with the Horizon 2020: Smart, Green and Integrated Transport work programme. 94 projects are associated with the thematic area "Transport (including aeronautics)" of the 7th Framework Programme for Research and Technological Development (FP7). The third most populated programme (with 60 projects) is FP7-ICT - Information and Communication Technologies.

3.4 Transport electrification

3.4.1 Introduction of the Roadmap

Transport electrification can contribute to breaking transport dependency on oil and decrease carbon dioxide emissions. The increasingly decarbonised electricity generation will provide cleaner electricity to propel electric vehicles (EVs). EVs will be able to provide storage services to the grid, favouring further expansion of renewables.

The development of energy storage technologies and devices remains the cornerstone of a fully electrified transport system integrated in a clean energy network. Decreasing battery costs while increasing their energy density and lifetime will speed up electrification of road transport. The deployment of a network of recharging points covering the whole EU road network is another key enabling condition for transport electrification.

The STRIA *Roadmap for Transport Electrification* aims to bring forward, the developments carried out in the framework of the European Green Vehicles Initiative and encourage

multi-sectorial and multi-disciplinary research and innovation activities on new materials, advanced propulsion systems and information computer technology.

3.4.2 Current developments

Road: The number of battery-electric and plug-in hybrid vehicles on the road is increasing. Vehicle manufacturers are launching dedicated models on the market, grid operators are installing public charging infrastructures and governments are funding multiple demonstrations and pilots, and creating framework conditions, regulations and incentives for the purchase and use of electric vehicles. In addition, electric bicycles and pedelecs are now more common. Electrification of road vehicles has been extended to delivery vans, light trucks and buses, and prototypes of larger electrified trucks are being developed.

Waterborne: Ships use electrical power on board to support service and loads. This includes fans, pumps, compressors, cranes, lighting, heating, electronics and computing. On-board diesel generators are used to supply these loads in port, however to improve local air quality the use of shore based plug in electrical supplies is being encouraged. Ships are propelled by mechanical and electrical means. Around 2,500 ships in the world are powered by electric propulsion including cruise liners, shuttle tankers, offshore support vessels, liquid nitrogen gas tankers and ferries. Electric propulsion offers advantages in performance and/or efficiency over traditional mechanical drives that are popular in vessels that operate over long distances. Integrated Full Electrical Propulsion systems are commonly found in ships from passenger vessels, Liquefied Natural Gas tankers, shuttle tankers, cruise ships, ferries and offshore support vessels. All electric battery powered ships are emerging for shorter ferry routes up to 50km.

Aviation: The aviation sector is in the midst of a pioneering era with regard to electro-mobility. Currently, electro-mobility for aircraft only exists in the single/twin-seater categories and consists of retrofits of existing conventional designs with reduced payload capability. Regarding fixed-wing commercial aviation, at current technology levels the development of even a hybrid-electric passenger aircraft appears challenging.

Rail: On busy lines, electrification makes economic sense. On low-density lines, there is no proven cost-efficient solution to replace diesel-powered trains. Nonetheless, when return of investment for electric wiring is not possible due to the frequency and the usage of certain lines, hydrogen and fuel cells can be considered as an alternative.

3.4.3 Key research and innovation pathways

The Roadmap sets out key priority R&I actions for electric mobility in each transport mode until 2050.

The scope of the activities in the area of transport electrification takes into account both advanced power-train technologies and new vehicles architectures, weight reduction, improved aerodynamics and rolling resistance and component development for alternative fuel vehicles.

Table 6. Key research and innovation pathways – Electrification.

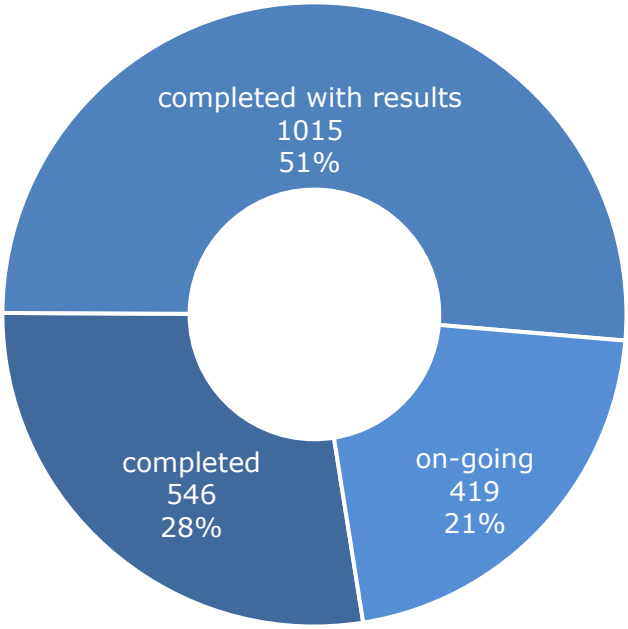
Road transport	
1	Promote a +400 kilometres range for electric passenger cars
2	Progress and demonstration in urban bus electrification
3	Public and commercial procurement of electric vehicles
4	Certification of electric vehicles performance

5	Development of small and light smart electric vehicles
6	Support local production of batteries, components and electric vehicles
7	Further development of small and light smart electric vehicles
8	Demonstration of electrified road systems for heavy duty vehicles
9	Develop electro-chemical systems for future high-density electric batteries
Rail	
1	Increase the potential of utilisation of electric motorisation
2	Intensify electric freight rail transportation
3	Harmonise energy characteristics for rails in the EU
4	Development of new motorisation
5	Increase energy savings
6	Develop light vehicles
7	Develop intermodal hubs in cities
8	Minimise the losses of electric railway infrastructure
Waterborne	
1	Raise public awareness of benefits of electrified vessel
2	Deploy new materials and technologies
3	Support education and training
4	Innovative financing tools
5	New business models
Aviation	
1	Electric aircraft design
2	Zero emission and very low noise airports
3	Ensure a specialised interdisciplinary work force
4	Decrease cost and increase product development speed
5	Energy storage systems improvement
6	Achieve maturing in High Temperature Superconductors

3.4.4 Research figures on programmes and projects

In the current state of the database, there are 1980 projects on "Transport electrification". Among these, 546 result as completed, 1015 as completed with results and 419 as "on-going".

Figure 20. Project status – Transport electrification.



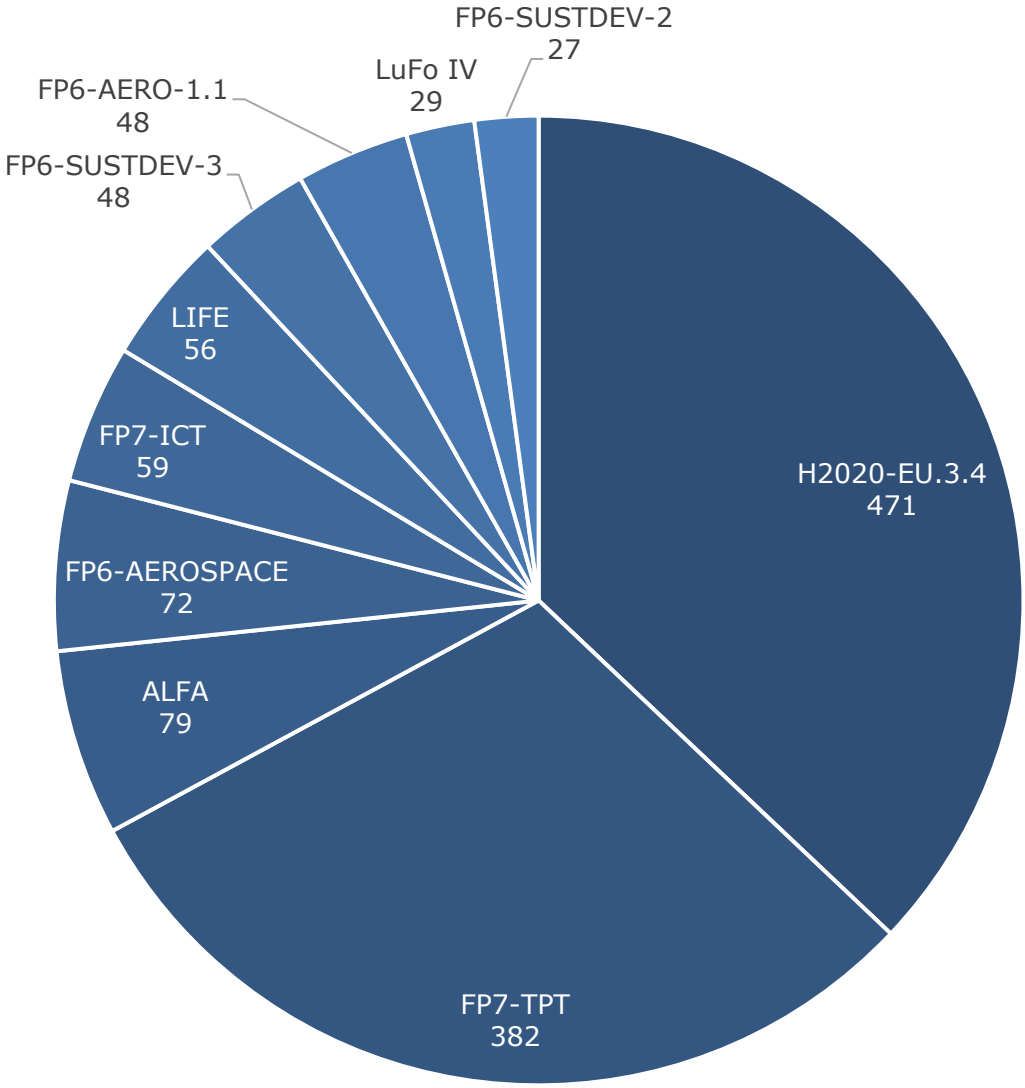
Out of 1980 projects in the database, 1769 are linked to parent research and innovation programmes. Among those, the chart reports the 10 most populated programmes. These programmes are abbreviated in a table.

Table 7. Top ten programmes – Transport electrification.

	Programme name	Abbreviation	No
1	Horizon 2020: Smart, Green and Integrated Transport	H2020-EU.3.4	471
2	Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)	FP7-TPT	382
3	ALFA PROGRAMME	ALFA	79
4	Aeronautics and Space - Priority Thematic Area 4 (PTA4)	FP6-AEROSPACE	72
5	Information and Communication Technologies	FP7-ICT	59
6	EU financial instrument supporting environmental, nature conservation and climate action projects	LIFE	56
7	Global Change and Ecosystems	FP6-SUSTDEV-3	48
8	Strengthening competitiveness	FP6-AERO-1.1	48
9	Federal research programme aeronautics LuFo IV	LuFo IV	29
10	Sustainable Surface Transport	FP6-SUSTDEV-2	27

The majority of projects (471 or about 27 per cent of the projects) are associated with the Horizon 2020: Smart, Green and Integrated Transport work programme. 382 projects are associated with the thematic area "Transport (including aeronautics)" of the 7th Framework Programme for Research and Technological Development (FP7). The third most populated programme (with 79 projects) is the ALFA PROGRAMME (Technology Agency of the Czech Republic).

Figure 21. Top programmes – Transport electrification.



3.5 Vehicle design and manufacturing

3.5.1 Introduction of the Roadmap

Transport vehicle design, development and manufacturing (VDM) is a collaborative, integrated and complex set of processes and tools that consider the whole vehicle life cycle and is a key element for the competitiveness of the European transport industry.

Continuous research and innovation are necessary for the seamless integration of digital and physical vehicle design and manufacturing processes, tools and infrastructures.

The STRIA *Roadmap for Vehicle Design and Manufacturing* aims to develop successful marketable transport vehicles with shorter development times.

3.5.2 Current developments

Road: Development time of new car models average 25 months but is expected to fall to below 20 months over the next decade. Suppliers need to be involved at the early stages of vehicle design process to eliminate inefficiencies along the whole value chain and achieve economies of scale. Advanced design tools and Product Lifecycle Management (PLM) software can play a key role in decreasing development and integration time while modularity facilitates progress that integrates physical and digital resources. In the automotive sector the main trends of VDM are:

- decrease in development time;
- development of advanced design tools;
- modular solutions;
- more integration in the supply chain;
- regulation-driven new technologies ;
- growing complexities of customized vehicles; and
- research, development and innovations.

Waterborne: The majority of modern vessels rely on some form of diesel engine for their prime propulsive power. However, the advantage of a hybrid power plant on lower activity levels could help reduce emissions and energy consumption. Another alternative is to use batteries as a temporary power source, resulting in zero emission cruising. A combination of diesel engine, generators and batteries allows the system to supply the required power more efficiently than a conventional diesel system.

A shipyard's competitiveness is dependent on the level of production management together with Design-for-Manufacturing and Design-for-Assembly capabilities. The main trends in shipbuilding are:

- integration between digital design and digital manufacturing;
- manufacturing and production planning;
- new powertrain architectures; and
- temporary power source.

Aviation: Greater use of digital and data-based business models, advanced conventional and disruptive manufacturing technologies reduce entry costs to the aviation sector. The digital, zero waste, and energy-neutral factories will use data-driven manufacturing systems to ensure high productivity, permit rapid new technology implementation, and enable product and rate flexibility through supply chain integration. New design and manufacturing integrative approaches are necessary. The market demands ever-shorter cycles for technology integration and aggressive pricing. Main aviation trends are:

- fierce international competition;
- new business models;
- energy and environmental performance;
- shorter cycles for technology integration; and
- research and innovation support and investment proportional to the goals and global leadership

3.5.3 Key research and innovation pathways

The key research and innovation pathways regarding vehicle design and manufacturing are presented in Table 8.

Table 8. Key research and innovation pathways – Vehicle design and manufacturing.

Enable & Deliver	Enable shorter vehicle design, development and manufacturing cycles	Enable new vehicle concepts, business models and modular vehicle architectures	Reduce the environmental impact and allow for higher recycling and/or remanufacturing
2020			
Action 1	Enable advances in inter and multidisciplinary VDM processes and tools. Accelerate Design for Manufacturing and Operations with industrial pilot cases and participation of the extended enterprise.		
Action 2	Embed digitalisation, big data and cybersecurity in the design and manufacturing of next generation of transport vehicles.		
Action 3	Promote design for safe operations in all-weather conditions.		
Action 4	Accelerate the development of Performance-based Standards and Certification processes for sub-systems and vehicles and promote International Cooperation.		
Action 5	Plan and develop European Strategic Research & Testing Infrastructures for future needs.		
Action 6	Integrate Research & Innovation results and support the demonstration of high-risk disruptive. technologies. Support exploratory research on new business models and services.		
Action 7	Explore Big Data analysis, Artificial Intelligence and other methods towards linking evolutionary design and operations.		
Action 8	Deliver passenger-centric modular design transport vehicles.		
2030			
Action 9	Maintain leadership in Vehicle Design and Manufacturing with digital infrastructures across the supply chain that can automatically adapt to demand.		
Action 10	Maintain and extend leadership in merging physical and digital in transport vehicle design, manufacturing, operations and regulations and their seamless integration.		
2050			
Action 11	Leadership in substantially reducing the environmental footprint from transport vehicle manufacturing and transport operations with focus also on remanufacturing and waste reuse/recycling.		
Action 12	Leadership in innovative transport inter-modal integration and business models that will respond to the expected passenger growth in 2050 and beyond.		

Source: European Commission, 2017b.

3.5.4 Research figures on programmes and projects

In the current state of the database, there are 2189 projects on "Vehicle design and manufacturing". Among these, 571 result as completed, 1114 as completed with results and 504 as "on-going".

Figure 22. Project status – Vehicle design and manufacturing.

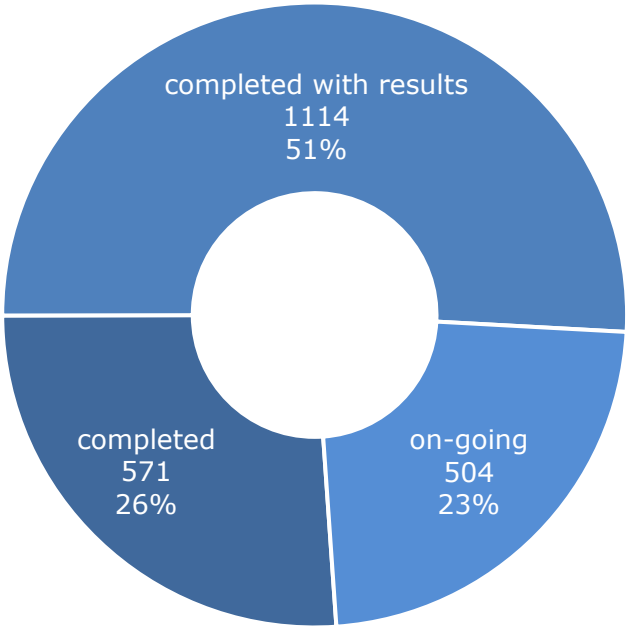
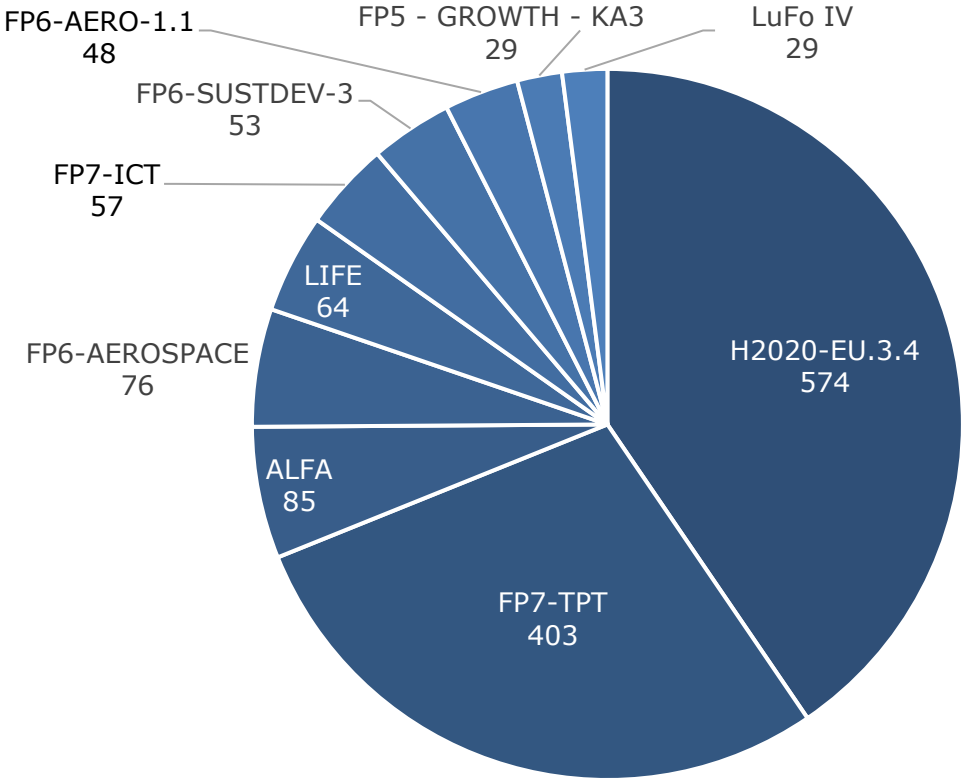


Figure 23. Top programmes – Vehicle design and manufacturing.



Out of 2189 projects in the database, 1981 are linked to parent research and innovation programmes. Among those, the chart reports the 10 most populated programmes. These programmes are abbreviated in the table below.

Table 9. Top ten programmes – Vehicle design and manufacturing.

	Programme name	Abbreviation	No
1	Horizon 2020: Smart, Green and Integrated Transport	H2020-EU.3.4	574
2	Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)	FP7-TPT	403
3	ALFA PROGRAMME	ALFA	85
4	Aeronautics and Space - Priority Thematic Area 4 (PTA4)	FP6-AEROSPACE	76
5	EU financial instrument supporting environmental, nature conservation and climate action projects	LIFE	64
6	Information and Communication Technologies	FP7-ICT	57
7	Global Change and Ecosystems	FP6-SUSTDEV-3	53
8	Strengthening competitiveness	FP6-AERO-1.1	48
9	Land transport and marine technologies	FP5 - GROWTH - KA3	29
10	Federal research programme aeronautics LuFo IV	LuFo IV	29

The majority of projects (574 or about 29 per cent of the projects) are associated with the thematic area "Smart, Green and Integrated Transport" of the Horizon 2020 programme. 403 projects are associated with the "Horizontal activities for implementation of the transport programme (TPT)" of the 7th Framework Programme for Research and Technological Development (FP7). The third most populated programme (with 85 projects) is the ALFA PROGRAMME (Technology Agency of the Czech Republic).

3.6 Low-emission alternative energy for transport

3.6.1 Introduction of the Roadmap

Electric battery and hydrogen fuel cell powertrains are now seen as a viable option for many road vehicles. However, aviation, waterborne transport and certain heavy-duty road vehicles are likely to rely on combustion engines and liquid fuels for the foreseeable future.

In order to decarbonise the transport sector it is therefore essential in the short- and medium-term to increase the use of renewable energy sources and improve the overall energy efficiency of the transport system. This will have the benefit of not only reducing greenhouse gases but also pollutants that are responsible for poor urban air quality.

Nevertheless, increasing the share of alternative low-emission energy in the transport sector poses a number of technical and environmental challenges.

The development of a new generation of powertrains will require research and innovation efforts to be focused on a step change in technology. One that allows greater and more efficient use of alternative energies to reduce greenhouse gases. For energy production, research and innovation efforts will need to focus on novel low-emission alternative energies based on renewable and sustainable sources.

The STRIA *Roadmap for Low-emission Alternative Energy for Transport* focuses on renewable fuels production, alternative fuel infrastructures as well as the impact on transport systems and services of these technologies for road, rail, waterborne transport and aviation.

3.6.2 Current developments

Light-Duty Vehicles: Developments in light-duty vehicle technology and fuels have been driven by tailpipe pollutant emission limits as well as average fleet carbon dioxide targets. So far, carbon dioxide targets and fuel taxation favouring diesel have led to the widespread uptake of diesel, especially for larger and heavier vehicles. In the medium-term, it is expected that stricter carbon dioxide targets and the implementation of a revised vehicle test procedure will also lead to the uptake of new engine and vehicle technology in the light duty vehicle sector increasing levels of electrification and hydrogen.

Heavy-Duty Vehicles: Heavy-duty vehicles such as trucks and buses are predominantly powered by diesel engines that have higher nitrogen oxide and fine particulate emissions. After-treatment systems have been used to reduce diesel engine pollution but these have been bulky and expensive. Cost-effective alternative fuels and technology that have lower after-treatment requirements could therefore play a significant role in powering future heady-duty vehicles.

Rail: Rail strategies favour further electrification, but there are routes where electrification is not economically viable. On such routes, locomotives could be fuelled with alternative energies such as hydrogen in combination with some form of electrification.

Waterborne transport: Heavy fuel oil (HFO) accounts for about 77 per cent of waterborne fuel consumption. However, it is a poor quality, low-price, high-sulphur residual fuel. The main alternative to HFO is liquid nitrogen gas (LNG) as it is considered a proven and available solution, with gas engines covering a broad range of power outputs. Current research activities in waterborne propulsion focus on combustion systems to reduce emissions and fuel consumption. In the future, LNG and ultimately hydrogen may be used in high temperature fuel cells to achieve greater engine efficiencies.

Aviation: The aviation sector has seen significant energy efficiency gains. However, these gains will not offset the expected growth in aviation or allow emission reduction targets to be met. Due to the high cost of aircraft and the long fleet replacement time, and limited infrastructure changes, the aviation sector is likely to rely on liquid fuels similar to kerosene to 2050, and is examining alternative blend fuels allowing current jet fuel specifications to be met.

3.6.3 Key research and innovation pathways

Decarbonisation of the transport sector depends on the well-to-wheel impacts of alternative energy production, which requires the use of low carbon and renewable fuels.

Research and innovation will need to focus on the efficient use of advanced biofuels, fossil fuels blended with renewable fuels as well as pure renewable fuels. It will be also necessary to match fuel and engine characteristics for specific transport modes such as heavy-duty vehicles, aviation and shipping.

Furthermore, research and innovation would need to examine applications combining electric, fuel cell and renewable fuels, for example, vehicle fuel cell concepts for the on-board generation of power from renewables.

A number of alternative fuel options could be used by each transport mode and increase energy diversification. Some transport modes such as light- and heavy-duty vehicles have the option of substantial electrification or the use of fuel cells. Therefore, the development of light-duty vehicle technology has a lower priority than those transport modes where there is no alternative.

Due to the link between the production and the use of alternative fuels, transport and energy research and innovation have to be analysed and developed together to identify viable options.

3.6.4 Research figures on programmes and projects

In the current state of the database, there are 2028 projects on "Low-emission alternative energy". Among these, 565 result as completed, 1052 as completed with results and 411 as "on-going".

Figure 24. Project status – Low-emission alternative energy for transport.

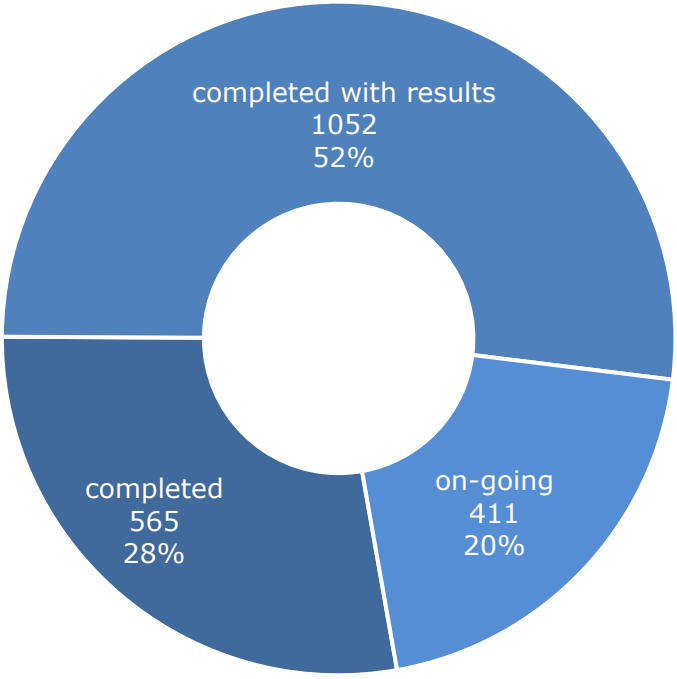
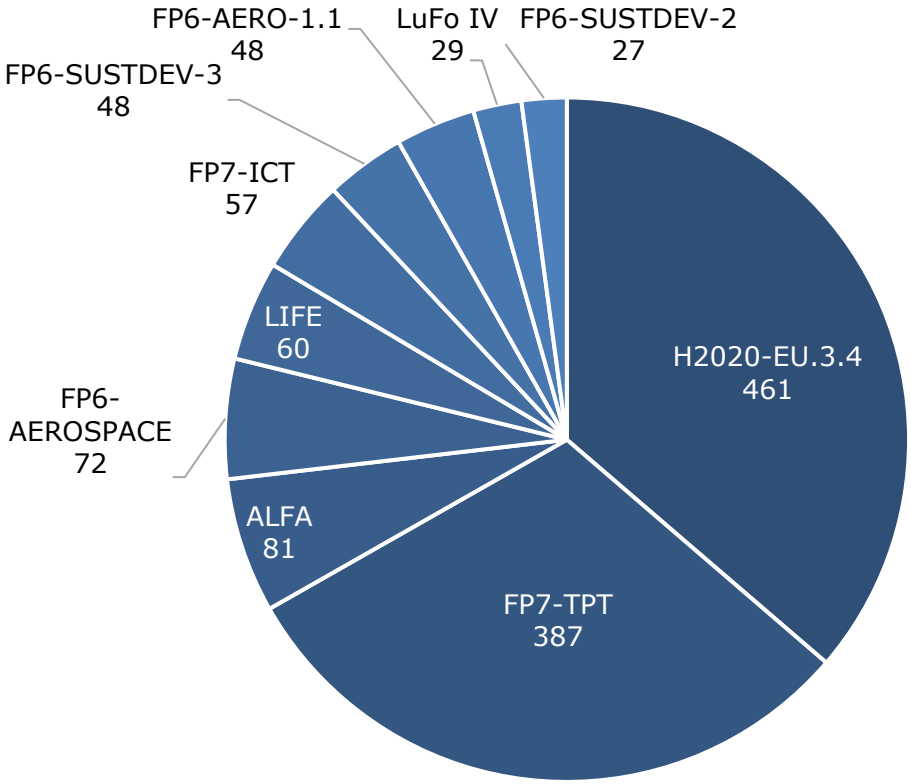


Figure 25. Top programmes – Low-emission alternative energy for transport.



Out of 2028 projects in the database, 1807 are linked with parent research and innovation programmes. Among those, the chart reports the 10 most populated programmes. These programmes are abbreviated in the table below.

Table 10. Top ten programmes – Low emission alternative energy for transport.

	Programme name	Abbreviation	No
1	Horizon 2020: Smart, Green and Integrated Transport	H2020-EU.3.4	461
2	Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)	FP7-TPT	387
3	ALFA PROGRAMME	ALFA	81
4	Aeronautics and Space - Priority Thematic Area 4 (PTA4)	FP6-AEROSPACE	72
5	EU financial instrument supporting environmental, nature conservation and climate action projects	LIFE	60
6	Information and Communication Technologies	FP7-ICT	57
7	Global Change and Ecosystems	FP6-SUSTDEV-3	48
8	Strengthening competitiveness	FP6-AERO-1.1	48
9	Federal research programme aeronautics	LuFo IV	29
10	Sustainable Surface Transport	FP6-SUSTDEV-2	27

The majority of projects (461 or about 26 per cent of the projects) are associated with the thematic area "Smart, Green and Integrated Transport" of the Horizon 2020 programme. 387 projects are associated with the "Horizontal activities for implementation of the transport programme (TPT)" of the 7th Framework Programme for Research and Technological Development (FP7). The third most populated programme (with 81 projects) is the ALFA PROGRAMME (Technology Agency of the Czech Republic).

3.7 Network and traffic management systems

3.7.1 Introduction of the Roadmap

Network and Traffic Management (NTM) systems are used for the optimisation and management of transport networks' operation. Bottlenecks across air, rail, road and water can result in system-wide capacity constraints, traffic jams and increased pollutant emissions and environmental impacts.

The transition towards an advanced multi-modal transport system requires better coordinated and organised traffic flows to optimise the entire transport network. This involves devices to detect real traffic conditions, traffic information sharing, optimisation processes and the distribution of control actions via end-user devices.

Digital technologies and the emergence of the connected traveller can influence real-time demand by encouraging off-peak travel and use of alternative routes through intelligent applications and user information services. Integrated urban traffic management and mobility information systems can therefore contribute to optimising transport flows both through cities and in rural regions.

The STRIA *Roadmap for Network and Traffic Management Systems* aims to develop an advanced multi-modal transport system by effectively optimising the entire transport network across new areas.

3.7.2 Current developments

Road: Investments in cooperative intelligent transport systems and connected driving technologies to improve the flow of road traffic on urban roads requires making progress

in the movement of goods and people. This includes better vehicle management (i.e. from conventional to autonomous vehicles), vehicle fuel technologies (i.e. from fossil to alternative fuels), bicycle and vehicle sharing, public transport, walking and cycling, especially in large urban areas. On extra-urban roads, the requirements are to achieve a safe, efficient and sustainable road transport in order to offer connected mobility, less congestion, fewer accidents, less pollution, improved levels of European-wide multi-modal travel information services.

Rail: The increase of different international and local railway traffic flows requires an improvement in planning and management. These include improving cross-border sections (especially when using different signalling and train operating systems), rail terminals connecting rail with other transport modes (e.g. advanced rail-rail trans-shipment yards) and complex and heavily used conventional railway stations for passenger trains in urban areas (e.g. hosting local/high-speed/international/freight traffic).

Waterborne: Large-scale intelligent and interoperable water traffic management and information systems will improve existing and future infrastructure to optimise traffic flows with different vehicles.

Aviation: The aviation sector aims to achieve a Single European Sky to improve EU air traffic management. The sector suffers bottlenecks in hub capacity, management operations and *en route* coordination of traffic flows between/outside European hubs. There is a need to modernise, harmonise and coordinate air traffic management systems (e.g. better aircraft trajectory and route planning).

Common cross-modal key themes are: access to data, streamlining administrative boundaries, flexibility, resilience and ability to recover from disruptions.

3.7.3 Key research and innovation pathways

The roadmap focuses on ten action areas that will contribute to the optimisation of the European transport network that will help decarbonise the transport sector and meet EU energy and climate targets.

Key Actions to 2050. The ten priorities will be implemented in three key phases.

1. Design

In the short-term, four research and innovation themes will be undertaken by the EU/industry. These are:

- Architecture and concept of operations for an efficient, resilient and adaptable multi-modal NTM system.
- Development of multi-actor organisational and business models with shared responsibilities.
- Research and validation of next-generation multi-modal NTM systems (including intra-modal optimisation and development of interfaces).
- Integration of infrastructures, vehicles, systems and services into a truly multi-modal network.

2. Optimisation

In the medium-term, three research and innovation themes will be undertaken by the EU, Member States and industry. These are:

- Demand-capacity balancing for efficient journey management (passenger and freight).
- Calibration of arbitration models for complex NTM scenarios and multi-actor settings (optimising multiple performance targets and user versus network needs).

- Traffic optimisation of conventional (semi-) automated and unmanned vehicles within a multi-modal NTM system.

3. Implementation

In the long-term, three innovation themes will be undertaken by the EU, Member States and cities and regions. These are:

- Large-scale demonstration of fully multi-modal NTM capability in any operating environment (urban and non-urban).
- Resource and asset management optimisation for advanced NTM systems.
- Piloting an efficient multi-modal NTM system across European hubs/nodes (including the integration of non-EU traffic).

European Technology Platforms. Large-scale intelligent and interoperable traffic management and information systems are key to maximising the capacity of existing and future infrastructure and optimising traffic flows with different vehicles. The following platforms allow opportunities to improve transport systems:

- SESAR. The Single European Sky Air Traffic Management Research is the collaborative decision-making and system-wide information management proposed for air traffic management.
- ERTMS. The advanced signalling and Rail Traffic Management System.
- SafeSeaNet. The Safe and Secure Maritime Traffic Monitoring and Information System.
- RIS. The Real-Time River Traffic Information System.
- C-ITS. The Cooperative Intelligent Transport Systems.
- Galileo. The European Global Navigation Satellite System.

3.7.4 Research figures on programmes and projects

In the current state of the database, there are 1520 projects on "Network and traffic management systems". Among these, 335 result as completed, 879 as completed with results and 306 as "on-going".

Figure 26. Project status – Network and traffic management systems.

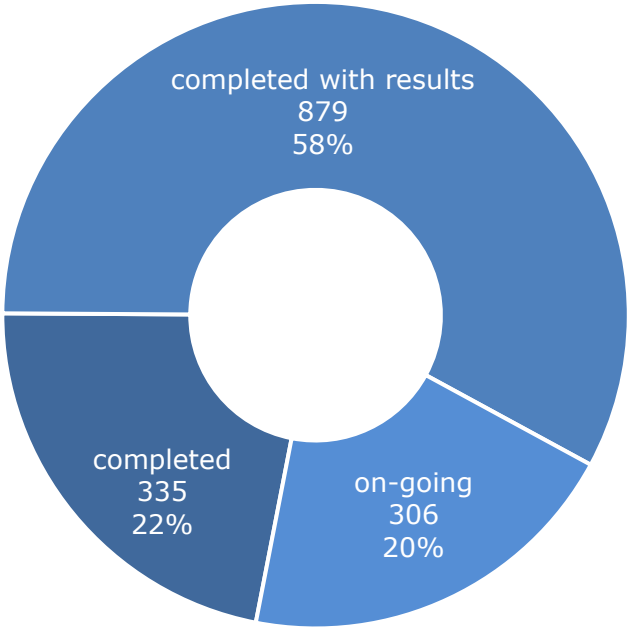
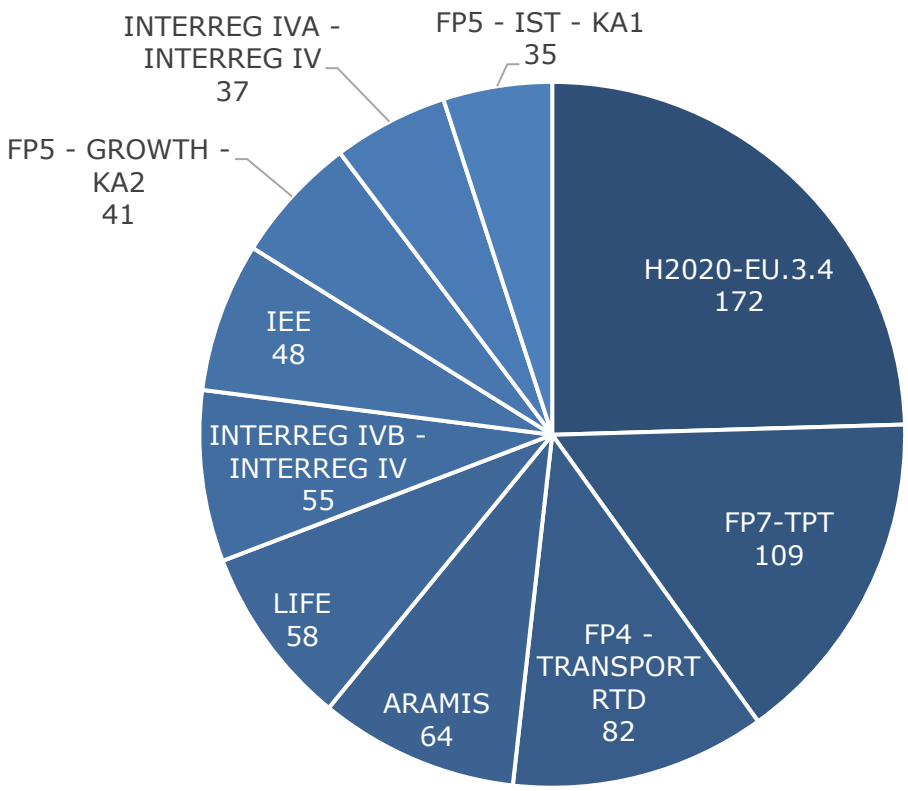


Figure 27. Top programmes – Network and traffic management systems.



Out of 1520 projects in the database, 1229 are linked to parent research and innovation programmes. Among those, the chart reports the 10 most populated programmes. These programmes are abbreviated in the table below.

Table 11. Top ten programmes – Network and traffic management systems.

	Programme name	Abbreviation	No
1	Horizon 2020: Smart, Green and Integrated Transport	H2020-EU.3.4	172
2	Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)	FP7-TPT	109
3	Transport Research and Technological Development	FP4 - TRANSPORT RTD	82
4	ARAMIS information system	ARAMIS	64
5	EU financial instrument supporting environmental, nature conservation and climate action projects	LIFE	58
6	Transnational programmes	INTERREG IVB - INTERREG	55
7	Intelligent Energy Europe	IEE	48
8	Sustainable Mobility and Intermodality	FP5- GROWTH - KA2	41
9	Cross-border programmes	INTERREG IVA - INTERREG	37
10	Systems and services for the citizens	FP5 - IST - KA1	35

The majority of projects (172 or about 14 per cent of the projects) are associated with the thematic area "Smart, Green and Integrated Transport" of the Horizon 2020 programme. 109 projects are associated with the "Horizontal activities for implementation of the transport programme (TPT)" of the 7th Framework Programme for Research and Technological Development (FP7). The third most populated programme

(with 82 projects) is Transport Research and Technological Development of the 4th Framework Programme for Research and Technological Development (FP4).

3.8 Smart mobility and services

3.8.1 Introduction of the Roadmap

Smart mobility systems and services can contribute to the decarbonisation of the European transport sector. Changes in transport behaviour and lifestyles such as the use of smart phones, mobile web applications and social media together with the trend to *use* rather than *own* a particular means of transport has opened up new pathways to sustainable mobility.

A critical link exists between new technologies, services and transport decarbonisation. However, policy and innovation efforts have focused overwhelmingly on small changes to improve vehicle technology rather than on integrated transport and mobility strategies. Breaking this path-dependency remains a key innovation challenge.

Future transport and mobility services will need to be part of smart and sustainable city strategies to improve urban resource efficiency, decarbonisation and ensure an integrated transport system.

The STRIA *Roadmap for Smart Mobility and Services* aims to assess emerging new technologies such as multi-modal, electric and autonomous vehicles, drone technology and on-demand mobility services. It will establish and assess the impacts of such technologies on transport and mobility systems and services.

3.8.2 Current developments

Road: Investments in cooperative intelligent transport systems and connected driving technologies to improve the flow of road traffic on urban roads will result in better movement of goods and people. This includes enhanced vehicle management (i.e. from conventional to autonomous vehicles), vehicle fuel technologies (i.e. from fossil to alternative fuels), bicycle and vehicle sharing, public transport, walking and cycling, especially in large urban areas. On extra-urban roads, it is necessary to achieve a safe, efficient and sustainable road transport in order to offer connected mobility, less congestion and pollution, fewer accidents and improved levels of European-wide multi-modal travel information services.

Rail: The increase of different international and local railway traffic flows requires better planning and management. These include improving cross-border sections (especially when using different signalling and train operating systems), rail terminals connecting rail with other transport modes (e.g. advanced rail-rail trans-shipment yards) and complex and heavily used conventional railway stations for passenger trains in urban areas (e.g. hosting local/high-speed/international/freight traffic).

Autonomous transport systems: Autonomous electric vehicles are expected to form a significant component of mobility as a service in urban transport. As with sharing models, autonomous vehicle technology will blend with mobility as a service model and can potentially enable widespread smart traffic management.

Drones and low-altitude aerial mobility: Drone and low-altitude aerial mobility is now technically possible for passenger transport. However, the combined demand for such vertical urban mobility solutions requires governance, regulation and infrastructure innovation.

Big and open data: Faster and cheaper processing, freely available data capacity and computing power are enabling greater energy efficiency, spatial distribution and utilisation of transport, mobility and smart city assets and systems.

Data governance: The flow of big and open data requires significant governance and regulatory design to ensure the interests of all stakeholders and that access to available data is equally protected.

Data availability and processing: Transport systems are increasingly able to aggregate and analyse data from multiple sources and networks to dynamically face demand and operate more efficiently.

3.8.3 Key research and innovation pathways

The roadmap focuses on eight action areas that will contribute to the decarbonisation of the European transport sector and meet EU energy and climate targets.

Key actions to 2050

Integrate drones and low-altitude aerial mobility in the transport system

Lightweight drone platforms can deliver economic and energy efficiencies in the short-range distribution of small goods. Effective integration of drone-based delivery systems with other urban logistics, public transport and building services infrastructure is a promising innovation. Drone and low-altitude aerial mobility is technically possible for passenger transport but will require significant governance, regulation and infrastructure innovation.

Establish better operating models

New operating models are required for essential public transport and mobility services to collaborate with private individual mobility providers to co-deliver sustainable mobility and transport systems. Municipal and regional institutions will need to be equipped with strategic capacity to transform and develop stable operational frameworks for new urban mobility. This will require innovative approaches to cross-sectoral planning, public participation and procurement and the shared use of embedded physical and technical infrastructure.

Develop integrated mobility systems

Cities, users, science and industry should develop and test solutions to complex mobility problems at a sufficient scale. Private and public sector should collaborate in research and data sharing, network and infrastructure access, and the development of inclusive user interfaces. Sharing the research and analysis burden between the private and public sectors can enable effective technological advancement and innovation.

Share data and infrastructure

Companies, governments and public entities should be encouraged to share data collected on public space and infrastructures wherever available so stakeholders can make informed decisions and innovate their applications. Aggregate dynamic mobile phone and traffic data, real-time location of buses or the train arrival times will enable third parties to integrate such information into their systems and set up 'cross-infrastructure' integrated mobility systems.

Support future interoperability

Development of European technical standards for communication and interoperability of user devices, infrastructures and vehicles will be vital for a future integrated transport system. Such standards should evolve and adapt with technologies to prevent innovation stagnation. A dialogue between users, governments, science and industry and start-ups will be important for multi-stakeholder standard setting. Such standards should be flexible and facilitate robust privacy frameworks, decarbonisation and international interoperability.

Undertake large-scale city demonstrations

Large city-scale demonstrations should integrate solutions into city operations to achieve long-term decarbonisation. Strategic capacity of municipalities and regions should be

developed to manage integrated transport systems and infrastructure. Partners from government, science, industry and users should be involved in the development of future mobility and transport services and systems that integrate new mobility service innovations into existing transport infrastructure, allowing optimal use.

Develop and test public-private mobility services

Public-private co-design of transport and mobility services should be developed and tested. Attention should be given to efficient use of existing physical transport infrastructures across sectors and modes as well as to the secure collation, management and protection of user and city data in public and commercial open data platforms and public digital infrastructures. Real-time information and operation across public and private service providers should be enabled as well as an integrated access, tariff and user interface system.

Develop and test governance, regulatory and public procurement strategies

These strategies should integrate indicators and urban plans and focus on assessing the impact on transport decarbonisation and sustainable land use. The development of such strategies will enhance and strengthen integrated planning tools and open, real-time data systems to optimise sustainable mobility as well as enable integrated public procurement across sectors.

3.8.4 Research figures on programmes and projects

In the current state of the database, there are 1244 projects on "Smart mobility and services roadmap". Among these, 325 result as completed, 689 as completed with results and 230 as "on-going".

Figure 28. Project status – Smart mobility and services.

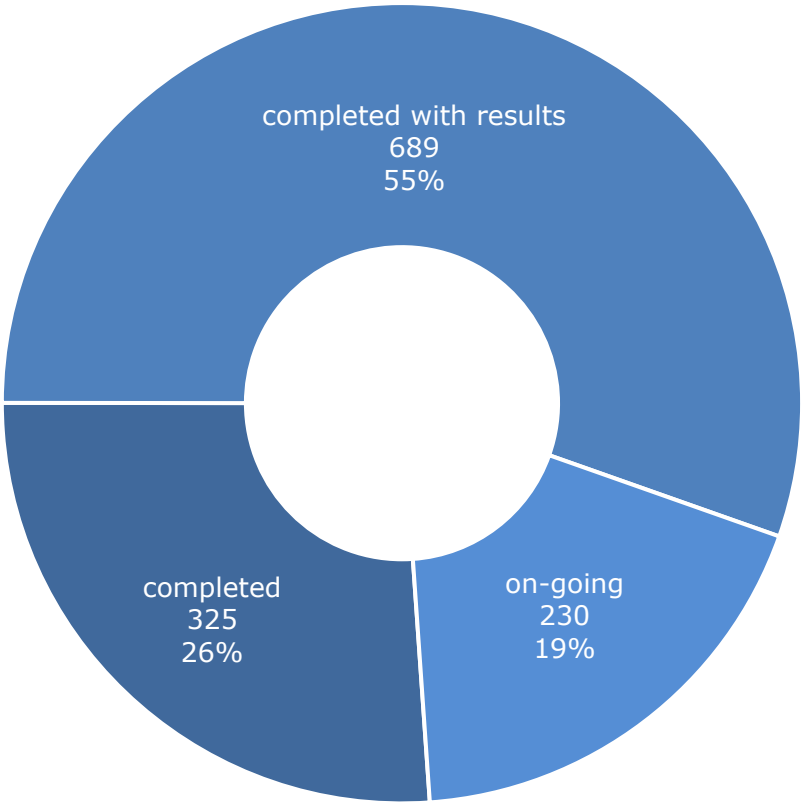
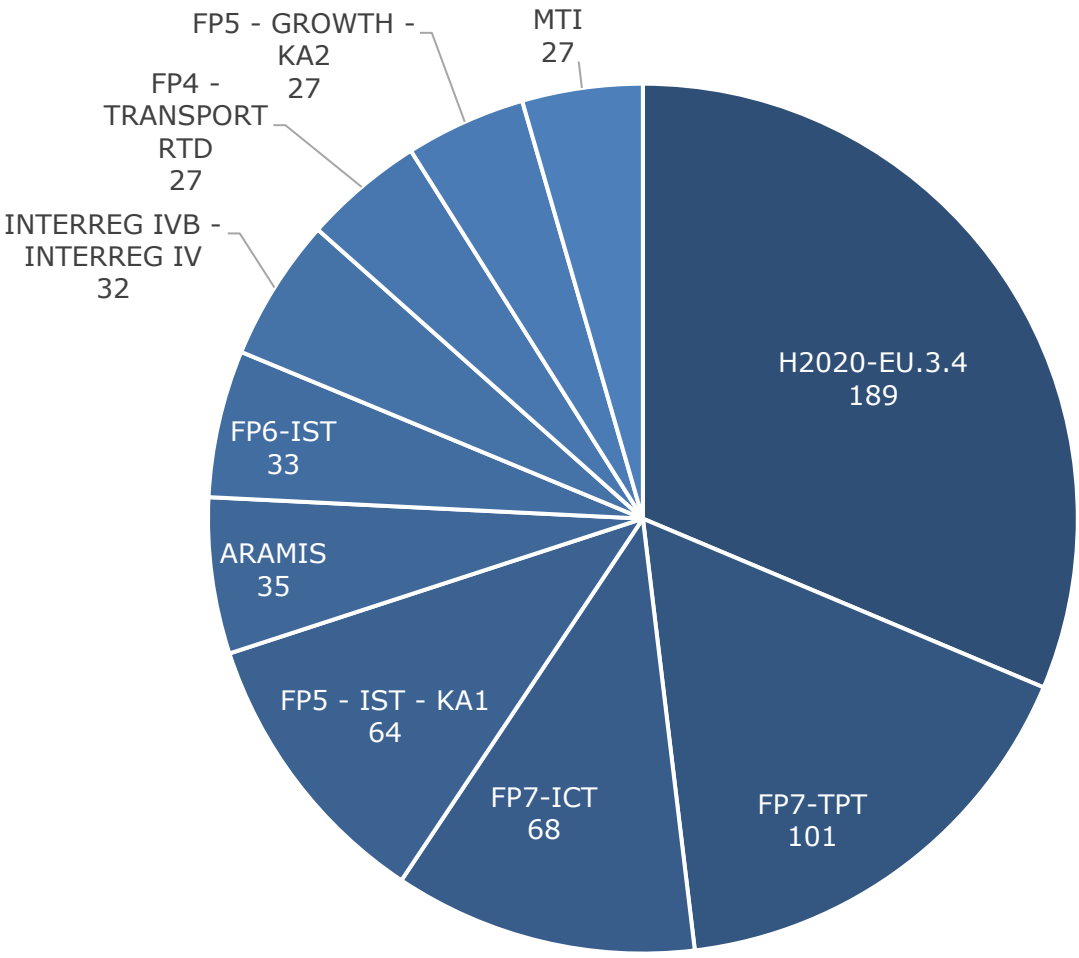


Figure 29. Top programmes – Smart mobility and services.



1048 out of 1244 projects in the database are linked to parent research and innovation programmes. Among those, the chart reports the 10 most populated programmes. These programmes are abbreviated in the table below.

Table 12. Top ten programmes – Smart mobility and services.

	Programme name	Abbreviation	No
1	Horizon 2020: Smart, Green and Integrated Transport	H2020-EU.3.4	189
2	Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)	FP7-TPT	101
3	Information and Communication Technologies	FP7-ICT	68
4	Systems and services for the citizens	FP5 - IST - KA1	64
5	ARAMIS information system	ARAMIS	35
6	Information Society Technologies - Priority Thematic Area 2 (PTA2)	FP6-IST	33
7	Transnational programmes	INTERREG IVB - INTERREG	32
8	Transport Research and Technological Development	FP4 - TRANSPORT RTD	27
9	Sustainable Mobility and Intermodality	FP5 - GROWTH - KA2	27
10	Bringing Technology to the People	MTI	27

The majority of projects (189 or about 18 per cent of the projects) are associated with the thematic area "Smart, Green and Integrated Transport" of the Horizon 2020 programme. 101 projects are associated with the "Horizontal activities for implementation of the transport programme (TPT)" of the 7th Framework Programme for Research and Technological Development (FP7). The third most populated programme (with 68 projects) is Information and Communication Technologies of the 7th Framework Programme for Research and Technological Development (FP7).

3.9 Infrastructure

3.9.1 Introduction of the Roadmap

Transport infrastructure includes physical networks, terminals and intermodal nodes, information systems and refuelling and electrical supply networks that are necessary for the safe, secure operation of road, rail, civil aviation, inland waterways and shipping.

EU transport infrastructure faces key challenges with regard to governance; pricing, taxation and finance; syncromodality, intermodality, interoperability and integration of transport systems; life cycle optimisation; and infrastructure operation.

The STRIA *Roadmap for Transport Infrastructure* aims to develop research and innovation in these key areas, test new methodologies and prepare the ground for future transport infrastructure policies.

3.9.2 Current developments

Transport infrastructure includes basic facilities and systems for operators and users. These are:

- urban public transport networks - including light rail (metro and tram), rail, bus, urban motorways and bus lanes;
- inter-urban or inter-regional - including motorways, main-line inter-city and high speed rail, inland shipping and domestic aviation;
- international gateways - airport hubs and major sea ports - along with other regional ports and airports.

In addition, there is extensive supporting infrastructure:

- traffic and transport control systems, aimed at ensuring safe, secure, efficient, reliable and resilient transport for all modes of transport;
- fuel distribution infrastructure;
- information and communication technologies used for customer information, and for tracking, charging, ticketing and billing;
- areas for logistics activities including logistics hubs, dry-ports and distriparks;
- energy facilities including electrical traction power networks necessary for infrastructure and transport operation.

The existing infrastructure continues to evolve with investment by infrastructure owners to accommodate changing demand, changing vehicle types, and to improve network performance. Examples are the construction of new container terminals to accommodate the latest generation of post-panamax large container ships, or the installation of electric vehicles charging points.

3.9.3 Key research and innovation pathways

Key actions to 2030

To meet policy objectives, research and innovation should develop and test methodologies in the following areas:

Table 13. Key research and innovation pathways – Infrastructure.

Area of work	**SYSTEMIC ANALYSIS**	
Target	**Consider the whole transport systems** to ensure decarbonisation.	
Action		Time horizon
✓	Develop a methodology for a systemic cost-benefit analysis for all transport infrastructure projects, during the whole life cycle.	2020
✓	Gain a better understanding of the carbon trade-offs of investing in infrastructure capacity.	2020
✓	Standardise the systemic cost-benefit analysis to achieve homogeneous implementation.	2020
✓	Support the development of tools for systemic cost-benefit analysis.	2020
Area of work	**TRANSPORT INFRASTRUCTURE PRICING**	
Target	Develop a methodology for a homogenous EU **carbon charging approach for all transport modes.**	
Action		Time horizon
✓	Develop and test harmonised methodologies for carbon pricing as well as a potential redefinition of vehicle taxes.	2020
✓	Use big data and activity based models to better understand users' reaction to charging.	2020
Area of work	**RESILIENCE**	
Target	**Improve the capacity of transport infrastructure to withstand disruption, absorb disturbance and adapt to changing conditions under extreme circumstances.**	
Action		Time horizon
✓	Identify and categorize main hazards to be considered for transport infrastructure resilience.	2020
✓	Develop and test new methodologies and tools to measure the resilience of transport infrastructure.	2030
Area of work	**INTERMODALITY**	
Target	**Prepare the ground for intermodality**, synchromodality, interoperability and integration of transport systems from a customer perspective.	
Action		Time horizon
✓	Conduct an analysis of the main weaknesses and bottlenecks that hinder transport integration, interoperability and intermodality.	2020
✓	Develop small-scale demonstrations to showcase technologies and new forms of information sharing.	2020
✓	Promote infrastructure innovation taking into account trends in logistics.	2020

Area of work	**INFRASTRUCTURE BREAKTHROUGH**
Target	Create the **framework to allow the required infrastructure breakthrough** to address future mobility challenges.

Action	Time horizon
✓ Develop an EU labelling system for transport infrastructure.	2020
✓ Ensure that Research and Innovation activities are linked with policy objectives for decarbonisation of transport infrastructure.	2020
✓ Prioritise technologies for carbon capture and storage, as well as the conversion of carbon in other products.	2020
✓ Provide a space for non-conventional innovation in Research Programmes.	2020
✓ Develop new contractual performance indicators, incentives, innovations and technologies to reduce transport accidents.	2020

Area of work	**CAPACITY**
Target	**Maximise asset utilisation** for transport infrastructure

Action	Time horizon
✓ Develop tools for information and data collection and management to monitor infrastructure performance.	2020
✓ Develop technologies to anticipate peak hours and provide alternatives for passengers and goods.	2020
✓ Support technology evolution to accelerate the rapid deployment of new business models.	2030

Area of work	**ENERGY**
Target	Facilitate a **progressive reduction of energy consumption of transport infrastructure** in the whole life cycle and from a systemic and intermodal perspective.

Action	Time horizon
✓ Improve the presence of innovative fields of work in Research Programmes.	2020
✓ Support the development of improved integration of transport infrastructure and energy systems.	2020

Area of work	**OPEN DATA**
Target	Facilitate the **creation of added-value services** for transport stakeholders and final customers based on the collection of data from multiple sources.

Action	Time horizon
✓ Develop technology solutions for effective data collection from decentralised sources and the creation of new customer-oriented services.	2020
✓ Examine how open data collection and use can be balanced with security issues.	2030

Source: European Commission, 2017b.

3.9.4 Research figures on programmes and projects

In the current state of the database, there are 1348 projects on "Infrastructure". Among these, 287 result as completed, 800 as completed with results and 261 as "on-going".

Figure 30. Project status - Infrastructure.

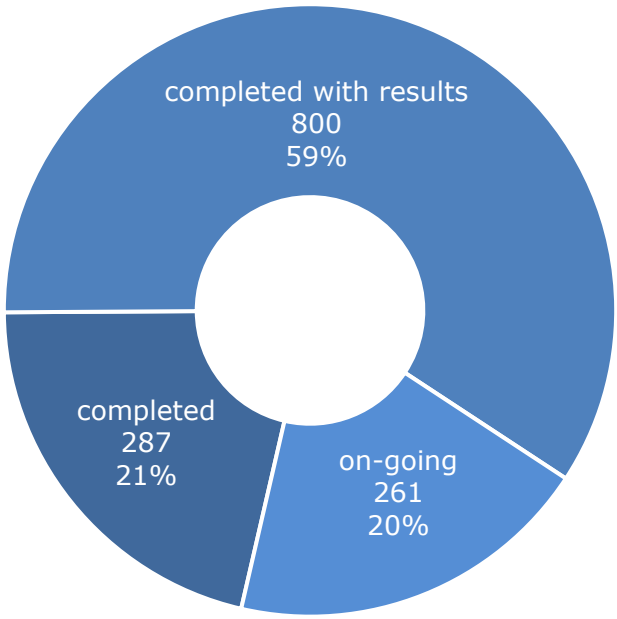
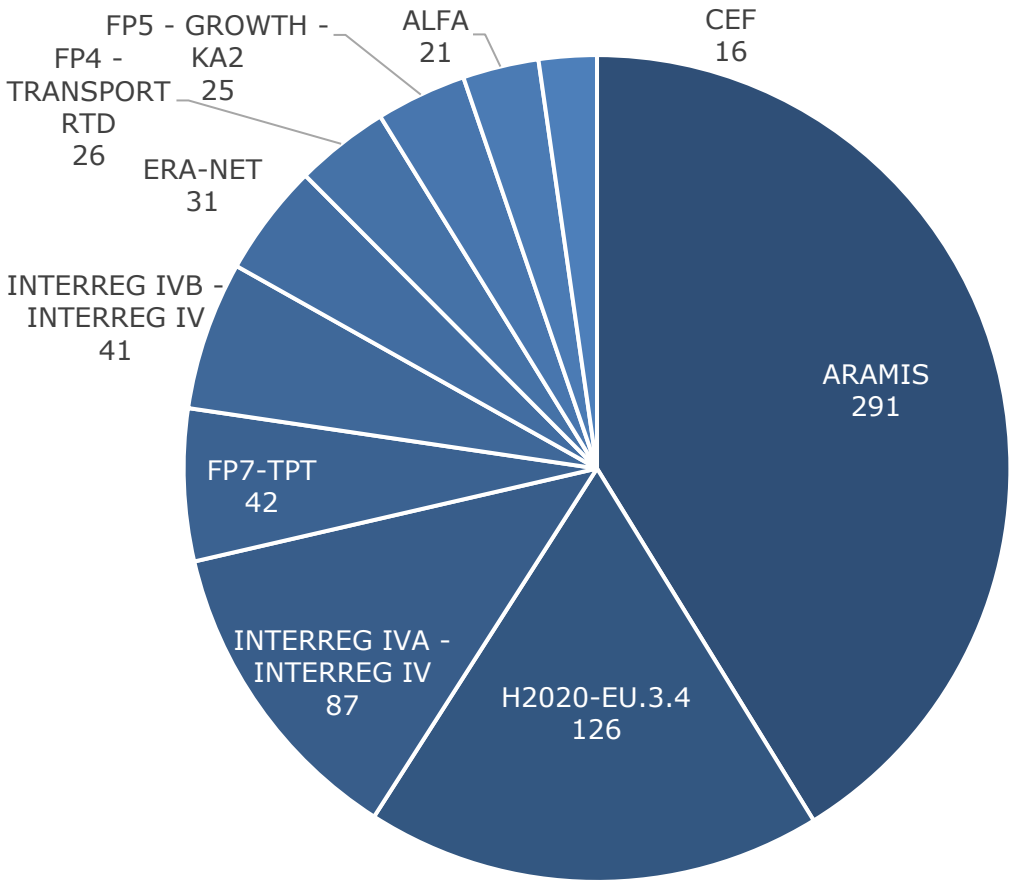


Figure 31. Top programmes - Infrastructure.



1046 out of 1348 projects in the database are linked with parent research and innovation programmes. Among those, the chart reports the 10 most populated programmes. These programmes are abbreviated in the table below.

Table 14. Top ten programmes – Infrastructure.

	Programme name	Abbreviation	No
1	ARAMIS information system	ARAMIS	291
2	Horizon 2020: Smart, Green and Integrated Transport	H2020-EU.3.4	126
3	Cross-border programmes	INTERREG IVA - INTERREG	87
4	Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)	FP7-TPT	42
5	Transnational programmes	INTERREG IVB - INTERREG	41
6	European Research Area Net	ERA-NET	31
7	Transport Research and Technological Development	FP4 - TRANSPORT RTD	26
8	Sustainable Mobility and Intermodality	FP5 - GROWTH - KA2	25
9	ALFA PROGRAMME	ALFA	21
10	Connecting Europe Facility	CEF	16

The majority of projects (291 or about 28 per cent of the projects) are associated with the ARAMIS information system. 126 projects are associated with the thematic area "Smart, Green and Integrated Transport" of the Horizon 2020 programme The third most populated programme (with 87 projects) is INTERREG IVA - INTERREG IV - Cross-border programmes.

3.10 Others

3.10.1 Introduction on data falling outside the seven existing roadmaps

In the TRIMIS database and under the STRIA roadmaps label, a number of projects and programmes are classified as "Other specified". These are projects that either fall in areas not well represented by the seven STRIA roadmaps, or are difficult to associate with the roadmaps themselves.

3.10.2 Research figures on programmes and projects

In the current state of the database, there are 1052 projects that are classified as "Other specified". Among these, 193 result as completed, 773 as completed with results and 86 as "on-going". It should be noted that among the 1052 projects, 968 are associated only with the "Other specified" tag, while 84 are associated also with at least one STRIA roadmap.

4 Conclusions

The TRIMIS database and the analysis conducted in the present document represent the initial stage of a comprehensive and detailed research that will lead the TRIMIS group to present key recommendations in terms of research needs and policy requirements and implications.

In order to enrich the analysis and add value to the study conducted, it is crucial to enhance the TRIMIS database, both in quantitative and qualitative terms. Future actions will require additions of new European and international projects and programmes, as well as, inclusion of further Member States projects and programmes; towards this direction, it will be possible to improve the database completeness.

The database will become more exhaustive also with the inclusion of some additional information that, at this initial stage are missing. Further improvement of the database will require the inclusion of financial information, as well as socio-economic aspects. Financial data are specifically referring to the allocation and origin of funds related to each project and programme; this information allows having details on the type of research and innovation financed over time. Moreover, TRIMIS will provide insights on the typology of participants involved in research and innovation projects and programmes in transport. Another aspect, that will be relevant to tackle in the future, is the assessment of human resources in this specific field of investigation. Future actions will devote further attention to specific transport topics within the roadmaps and transport modes.

In the future TRIMIS will also provide information on country profiles, after an in-depth update of the existing country data.

Once the information included in the TRIMIS database becomes more comprehensive, it will be possible to perform additional analyses regarding transport research and innovation that will further support policy development in a more exhaustive manner. The additional information should include financial and geographical information, such as:

- total budget per programme, total cost and co-financed amount per programmes/projects;
- programmes per transport mode, programmes per transport policy, programmes/projects per transport sectors;
- projects per partners involved, projects per countries involved.

The identification of these elements will allow the possibility to combine and associate different projects and programmes specification and to elaborate on additional indicators.

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List of abbreviations and definitions

AU Austria

BA Bosnia and Herzegovina

BE Belgium

BG Bulgaria

CA Canada

CAT Connected and Automated Transport

CH Switzerland

CY Cyprus

CZ Czech Republic

DE Germany

DG MOVE Directorate-General for Mobility and Transport

DG RTD Directorate-General for Research and Innovation

DK Denmark

EC European Commission

EE Estonia

ES Spain

EU European Union

FI Finland

FR France

GR Greece

HFO Heavy Fuel Oil

HR Croatia

HU Hungary

IE Ireland

INT International

IS Iceland

IT Italy

JRC Joint Research Centre

KPI Key Performance Indicator

LNG Liquid Nitrogen Gas

LT Lithuania

LU Luxembourg

LV Latvia

MT Malta

NL Netherlands

NO Norway

NTM Network and Traffic Management

PL	Poland
PLM	Product Lifecycle Management
PT	Portugal
R&I	Research and Innovation
RO	Romania
RS	Serbia
SE	Sweden
SETIS	Strategic Energy Technologies Information System
SI	Slovenia
SK	Slovakia
STRIA	Strategic Transport Research and Innovation Agenda
TEN-T	Trans European Transport Network
TRIMIS	Transport Research and Innovation Monitoring and Information System
TRIP	Transport Research and Innovation Portal
UK	United Kingdom
USA	United States of America
VDM	Vehicle Design and Manufacturing

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