D2.5 Report on International Competition and Best Practices in Road Transport Innovation

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Summary

The Horizon 2020 project FUTURE-RADAR is a support action that aims to create and implement the needed research and innovation strategies for a sustainable and competitive European road transport system. In this deliverable, the work done by analysing the automotive RTD landscape in four major economies outside of Europe (the USA, China, Japan and Brazil) is reported, providing inspiration for possible future RTD strategies and programmes in Europe.

This report includes the results of two activities. The first activity was an assessment of the national funding mechanisms for road transport RTD in the USA, China, Japan and Brazil. Secondly, within the framework of the reported task, best practice funding programmes or calls have been identified and assessed for each of the countries.

Assessment of national funding mechanisms

The RTD funding mechanisms for each of the four countries are described along the following steps:

1. Overview of strategic plans (such as national policy documents or technology roadmaps) related to road transport RTD.
2. The governance system of RTD and the hierarchy of the funding landscape.
3. The main funding organisations and public or private stakeholders that influence RTD in road transport
4. Detail on grant programmes and open calls for projects on specific calls related to topics such as electric vehicles and automated driving
5. Overview of international RTD collaboration ongoing with other countries.
6. Summary of the main findings per country and identification of funding good practices examples per country. These will be benchmarked against a pre-defined best practice

Main findings – road transport RTD

The USA, China and Japan have specific research programmes (and calls) for automotive research in the field of electric vehicles, hydrogen fuelled vehicles and automated vehicles. In all three countries there is a strong interest to remain world leader in one or more fields of automotive research. In Brazil, the efforts towards breakthrough automotive research are less visible although the country has been leading in the development and production of biofuels.

Research priorities in the USA, China and Japan are also influenced by other, e.g. societal, issues. In Japan, the aging of the population is one of the drivers for research programmes in the field of automated driving. Increasing safety requirements is a reason for the US to invest in similar research. In China, air pollution has led to strong support for electric vehicles: a dedicated programme for RTD in the field of “new energy vehicles” is one of the elements of this support.

When looking at the TRL of the funded research, it can be seen that the USA are funding research of relatively low TRL (up to 5), commercialisation is generally left to the private sector. Cooperation between researchers and private sector is, however, promoted through different programmes of national funding

agencies. Japan, China and Brazil are also supporting research of higher TRL (5 and above). The contribution of private parties is higher in this type of research than in fundamental research.

Regarding the duration of the funding application process, this differs per country and per call. Detailed information was gained from the USA and from the NKP calls in China. In both countries, the total process from funding announcement to award notification takes on average 6 months, with some programmes slightly longer (up to 9 months). A two-phase award process, with submission of a concept paper, preliminary selection and submission of full proposals is broadly applied in the USA and in China.

Additional interesting findings per country are the following:

- In the United States, the Advanced Research Projects Agency-Energy (ARPA-E) of DOE, is tasked with funding research and development of advanced energy and transport technologies. ARPA-E has established both tailor-made programmes on topics from connected and automated vehicles to renewable transport fuels as well as open calls to fund potentially disruptive technologies in the energy and transportation sector. By combining these two ways of funding RTD, ARPA-E is seen as an agency that can more effectively generate new ideas to innovation that other, more established, agencies.
- Automotive research in Japan in mainly supported by the Ministry of Economy, Trade and Industry (METI) and its agency NEDO. Outside those organisations, a new cross-ministerial programme was established (SIP), covering research in energy and infrastructure. Transport topics like innovative combustion technology and automated driving systems are included here. The SIP programme is highlighted in Japan due to its holistic approach that unites research, testing, demonstration and implementation in one single governmental programme (and bringing together multiple other stakeholders).
- In Japan, there is strong attention of organisations like NEDO for commercialisation of project results. Another interesting feature of the programmes of NEDO is that the agency is doing follow-up monitoring of already finished projects until 5 years after project end.
- In China, transport related RTD is primarily financed by National Key Programmes (NKP). Since 2016, there is a specific NKP for new energy vehicles (supporting research on hybrid and electric vehicles). In 2018, two new transport related NKPs were published, one on Comprehensive Transportation and Smart Transports and the other on Key Technology and Demonstration of Internet of Things and Smart Cities.
- In China, a new funding mechanism is the Technology Innovation Guidance Fund. An interesting element of this Fund is that it enables to commercialise results of other funding programmes (e.g. those funding fundamental research) and support the establishment of start-ups.
- In Brazil, RTD funding programmes are of a more general nature and promote the innovative potential for industry as a whole. Interesting good practices in the field of transport policy can be identified, however. Examples are the Brazilian Ethanol Programme and the National Program for Production and Use of Biodiesel.

When looking at research budgets of different automotive RTD programmes, we can see that the USA, Japan and China invest significant amounts:

- In the USA, for specific calls / research programmes aimed at specific technologies, such as CAV, ITS or battery research budgets of about 10 – 30 million € are available. These budgets are based on calls (e.g. Funding Opportunity Announcements) with a relatively narrow scope, i.e. research topics are specifically defined. Overall funding programmes for transport related RTD can have budgets around 50 – 100 million € per year. The whole ARPA-E annual budget for energy and transport research was around 250 – 300 million € per year (years 2016 to 2018).
- In Japan, the inter-ministerial SIP Programme has a total annual budget of about 250 million € annual budget, for each of the 11 themes (such as automated driving), there is about 25 million € per year.
- The multi-annual NEDO programmes have budgets of up to 100 million €, depending on the duration and the topic. The research programme “Technologies for hydrogen usage” invests about 140 million € over a 5-year period (2013-2017), while the “Energy Storage” research budget is about 100 million € over a three-year period.
- In China, the budgets for transport related within the NKP calls are the following:
  - New Energy Vehicles: 128 million € for 2016 and 90 million € for 2017
  - Advance Rail Traffic: 154 million € for 2016 and 60 million € for 2017
  - Comprehensive transportation and smart transports: 55 million € for 2018

At first glance, project budgets are significantly larger in China than in USA and Japan, but when looking at the call texts, one sees that each call covers a much broader scope of research topics than similar calls in the USA and Japan. Nevertheless, each of the Chinese NKPs should include 5 separate calls (once a year from 2016 to 2020), so the total research budget for topics like electric vehicles and intelligent transport systems are expected to significantly exceed those in the USA and Japan.

Identification of best practice funding

It would have been possible to carry out the best practice assessment for four specific entity types, 1) Funding organisations, 2) Funding programmes, 3) Funding calls and 4) Funded projects. In this study, the choice was made for the assessment of 3) Funding calls.

In total eight best practice criteria were determined based on literature research. Therefrom, a best practice example was defined against which other programmes were benchmarked and rated (qualitatively and, for six criteria, on a relative scale). As a result of this exercise, examples of best practice in existing funding programmes were identified. The six best practice criteria that were rated relatively are:

- How are targets or objectives defined?
- What are the financing guidelines of the programme?
- What commercialisation of project results is expected?
- How are the project results to be verified?
- How open is the funding programme?
- What is the duration and flexibility of the application process?

In addition, the best practice assessment also included two not relatively rated criteria, the TRL of the funding programme and the coverage of the programme (e.g. an overall RTD programme versus a programme specifically addressing one specific automotive research topic).

Main conclusions – best practice

The best practice assessment was carried out for 13 funding calls in the USA, Japan, China and Brazil. Programmes (programme calls) were selected that at least partly fund transport related research. These RTD programmes were benchmarked against the best practice based on a relative scoring of +2 (fully in line with best practice) to – 2 (not in line at all with best practice). Based on the six criteria perfect score, best practice for all criteria, would mean a score of +12. The results of the benchmarking are shown below.

Country	Funding organisation	Programme	Description	Score
USA	ARPA-E	NEXTCAR	Next generation energy technologies for connected and automated vehicles	8
USA	NSF	Energy, Power, Control and Networks (EPCN)	Innovative research on emerging technologies in the energy and transportation sector	4
USA	DOE – EERE	Advanced Vehicle Technologies Research	Early-stage research enabling future private sector development and commercialisation of affordable, energy efficient transportation technologies.	5
USA	DOT – VOLPE	DOT's SBIR program	Development of innovative solutions in the transport sector (e.g. intelligent transport systems)	6
Japan	CSTI&NEDO	SIP-ADUS	An innovation programme on connected and automated driving systems (including safety and cyber security)	6
Japan	NEDO	Technologies for hydrogen usage	Acceleration of market access of hydrogen technology	7
Japan	NEDO	Energy storage	R&D programme on the development of advanced and revolutionary batteries	8
China	Ministry of Science and Technology	NKP New Energy Vehicles	The programme promotes the transformation towards pure electric drive	6
China	Ministry of Science and Technology	NKP Integrated Transportation and Intelligent Transportation	Development of an intelligent, integrated transportation system using different transport modes.	4

China	Ministry of Science and Technology	NKP – Key Technology and Demonstration of Internet of Things and Smart Cities	Development of IT applications for smart cities in China	3
Brazil	ANEEL	ANEEL R&D programme	R&D programme funded by energy companies. One of the sectors supported is electromobility	2
Brazil	BNDES	BNDES – Support to National Engineering	BNDES innovation line grants loans for investments in innovative projects (cross-sectoral)	3
Brazil	EMBRAPII	EMBRAPII R&D Programme	Funding of industrial innovation projects. Sub-programme covering R&D for intelligent Automotive systems	4

The assessment of the funding programmes showed that the best scoring programmes (based on the six rated criteria) were the US ARPA-E programme NEXTCAR (addressing CAV) and the Japanese programme of NEDO on battery development. The main reasons that these programmes are closest to "ideal best practice" was that they include:

- Clearly stated objectives and performance indicators for the research that the programme is willing to finance
- Clearly stated information about the verification of research results
- Clear commercialisation objectives for the research results

Very clear and specific performance indicators can also be seen in the Chinese National Key Programme (NKP) on New Energy Vehicles, covering electric, hybrid and hydrogen fuelled vehicles.

Other elements of good practice included the openness and transparency of the funding programme, the online availability of all call documents and details about earlier funded programmes.

Recommendations

In order to develop a RTD funding programme close to best practice, several guidelines should be taken into account.

- RTD funding programmes should include clearly defined objectives and (performance) targets, such that the specifically envisaged results might be achieved. This also enables easier verification and evaluation.
- Programme targets that are in line with the (long-term) objectives of the (automotive) industry have a better chance of commercialisation.
- Monitoring of the use of project results for a specific amount of time after the end of the funding could show if the research projects funded lead to the (long-term) results that were stated at the

start of the work. Such monitoring may better identify lessons learned from existing funding practices and improve upcoming funding programmes.
- Promoting the use of research results by setting up a fund for commercialisation (with financial contributions from both public and private actors) could be the right way of ensuring that RTD project results are adopted.
- Openness and transparency of the application process helps applicants to orient themselves quickly in the different grant funding opportunities. The United States, China and Japan have all established nationwide platforms that provide information about funding opportunities in a structured way.

The activities reported here will be continued within FUTURE-RADAR, a comparison with practices in Europe is planned and the relationship between the funding landscape and the industry supply chain etc. will be considered.

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List of abbreviations

UNITED STATES

ABBREVIATION	DESCRIPTION
ARPA-E	Advanced Research Projects Agency-Energy
CAV	Connected and Automated Vehicle
DARPA	Defense Advanced Research Projects Agency
DGA	Division of Grants and Agreements
DOE	Department of Energy
DOT	Department of Transportation
EERE	Office of Energy Efficiency and Renewable Energy
EPA	Environmental Protection Agency
FHA	Federal Highway Administration
FOA	Funding Opportunity Announcements
FTA	Federal Transit Administration
FY	Fiscal Year
ITS	Intelligent Transportation Systems
MRL	Manufacturing Readiness Level
NHTSA	National Highway Traffic Safety Administration
NSB	National Science Board
NSF	National Science Foundation
NSTC	National Science and Technology Council
OTAQ	Office of Transportation and Air Quality
RITA	Research and Innovative Technology Administration
SBIR	Small Business Innovations Research
STTR	Small Business Technology Transfer
TRB	Transportation Research Board
TRL	Technology Readiness Level
USD	US Dollar
VTO	Vehicle Technologies Office

JAPAN

ABBREVIATION	DESCRIPTION
ADUS	Automated Driving for Universal Services
AI	Artificial Intelligence
AICE	Research Association of Automotive Internal Combustion Engines
CART	Committee on Advance Road Technology
CSTP	Japanese Council for Science and Technology Policy
ERTDF	Environment Research and Technology Development Fund
FCEV	Fuel Cell Electric Vehicles
FCV	Fuel Cell Vehicles
ImPACT	Impulsing Paradigm Change through Disruptive Technologies Program
JPY	Japanese Yen (official currency of Japan)
JSAE	Japan Society of Automotive Engineering
JSPS	Japan Society for the Promotion of Science
JST	Japan Science and Technology Agency
IoT	Internet of Things
LNG	Liquefied Natural Gas
METI	Ministry of Economy, Trade and Industry
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MLITT	The Ministry of Land, Infrastructure, Transport and Tourism
NALTEC	National Agency for Automobile and Land Transport Technology
NEDO	New Energy and Industrial Technology Development Organisation
NTSEL	National Traffic Safety and Environment Laboratory
SIP	Strategic Innovation Promotion Program

CHINA

ABBREVIATION	DESCRIPTION
BEV	Battery Electric Vehicles
CAS	Chinese Academy of Sciences
CATARC	China Automotive Technology and Research Centre
FOF	Funds-Of-Funds
MIIT	Ministry of Industry and Information Technology
MOF	Ministry of Finance
MOST	Ministry of Science and Technology

MOT	Ministry of Transport
NDRC	National Development and Reform Commission
NEV	New-Energy Vehicles
NKP	National Key R&D Programmes
NSFC	Natural Science Foundation of China
NTCAS	National Technical Committee of Auto Standardization
PI	Principal Investigator
RMB	Renminbi (official currency of the People's Republic of China)
SAEC	Society of Automotive Engineers of China
SKL	State Key Laboratories
SME	Small and Medium-Sized Enterprise

BRAZIL

ABBREVIATION	DESCRIPTION
ABC	Brazilian Cooperation Agency
ABDI	Brazilian Industrial Development Agency
ABVE	Brazilian Association of Electric Vehicles
AEA	Brazilian Association of Automotive Engineering
ANEEL	National Electricity Regulatory Agency
ANFAVEA	National Association of Car Producers
ANPEI	National Association of Research and Development of Innovative Companies
APEX	Brazilian Agency for the Promotion of Exports and Investments
BNDES	National Development Bank of Brazil
BRL	Brazilian Real (official currency of Brazil)
CNI	National Confederation of Industry
CNPq	National Science and Technology Council
CNT	National Confederation of Transport
CONCECTI	National Council of State Secretaries for Science, Technology and Innovation Affairs
CONPET	National Program for the Rational use of Oil and Natural Gas
CONFAP	National Council of State Research Foundations
DNIT	National Department of Land Infrastructure
EMBRAPII	Brazilian Association of Research and Industrial Innovation
ENCTI	National Strategy of Science, Technology and Innovation
EPE	Energy Research Company

EPL	Planning and Logistics Company
FAP	State Research Foundation
FINEP	Brazilian Agency of Innovation and Research
IFMG	Federal Institute of Minas Gerais
IPR	Road Research Institute
MCTIC	Ministry of Science, Technology, Innovation and Communications
MDIC	Ministry of Development, Industry and Commerce
MEI	Small and Medium Enterprises
MME	Ministry of Mines and Energy
MP	Ministry of Planning
MT	Ministry of Transport
PNLT	National Plan of Transport and Logistics
PROCONVE	Brazilian regulatory program for vehicle emissions control
PSTM	Sectoral Plan of Transport and Urban Mobility for Climate Change
SBPC	Brazilian Society for Technological Development

1 Introduction

The Horizon 2020 project FUTURE-RADAR (Grant Agreement Number 723970) is the support action for ERTRAC[1] (the European Technology Platform for Road Transport) and EGVIA[2] (the Association of the European Green Vehicles Initiative) which aim to create and implement the needed research and innovation strategies for a sustainable and competitive European road transport system.

Specific tasks of ERTRAC include:

- Providing a strategic vision for road transport research and innovation in Europe.
- Defining strategies and roadmaps to achieve this vision through the definition and update of a Strategic Research Agenda and implementation research roadmaps.
- Stimulating effective public and private investment in road transport research and innovation.
- Contributing to improving coordination between the European, national, regional public and private R&D activities on road transport.
- Enhancing the networking and clustering of Europe's research and innovation capacities.
- Fostering European commitment to Research and technological development, ensuring that Europe remains an attractive region for researchers, and enhancing the global competitiveness of the transport industries.
- Supporting the implementation of Horizon 2020

EGVI is a contractual Public-Private Partnership (PPP) dedicated to delivering green vehicles and mobility system solutions which match the major societal, environmental and economic challenges ahead. With a focus on the energy efficiency of vehicles and alternative powertrains, the EGVI PPP aims at accelerating research, development and demonstration of technologies allowing the efficient use of clean energies in road transport.

Linking representatives of all stakeholder groups, the activities of FUTURE-RADAR include project monitoring, strategic research agendas, international assessments and recommendations for innovation deployment and comprehensive dissemination and awareness activities, while working to facilitate the exchange between cities in Europa, Asia and Latin America on urban electric mobility solutions.

This Deliverable 2.5 is one of the two reports addressed in FUTURE-RADAR Task 2.2. This task covers three activities:

1. The first activity is the assessment of the national funding mechanisms for automotive R&D in four non-European countries (USA, Japan, China and Brazil). It also includes the development of best practice criteria for the identification of best practices. This is the assessment included in this report, Deliverable 2.5.
2. Secondly, a similar assessment of funding mechanisms for automotive RTD at an EU level and in six EU Member States (Austria, Czech Republic, France, Germany, Italy and the United Kingdom)

[1] ERTRAC members include public and private research providers and their researchers, automotive suppliers, the ITS industry, the road sector, in particular the infrastructure, service providers, vehicle manufacturers, and the energy/fuel supply sector
[2] EGVIA members represent industry and research and include automotive OEMs, automotive suppliers, the smart systems industry and smart grid industry.

will be carried out. This will be reported in Deliverable D2.4, “Recommendations for the deployment of innovative road transport solutions in Europe”, which is planned for Month 36 (December 2019).
3. Thirdly, on the basis of the above work, the funding mechanisms in the EU are compared to those outside the EU, combining the findings from activity 1 and 2. This will form the basis of recommendations to the European Commission on key policies to support and strengthen the automotive industry and research. These will also be reported in D2.4.

This deliverable report relates to the first phases of activities performed during the period M1-18 in Task 2.2 which has been written by Ricardo and involves the contributions from the partners: VDI/VDE-IT, Valeo and WI.

1.1 Objectives

In this report the road transport innovation funding landscape in the USA, China, Japan and Brazil, and identify the is described. Based on this description, examples of research funding programmes in the four countries are benchmarked to a pre-defined best practice of research funding.

To achieve this the structures of the national funding organisations in each of the four countries will be described with regard to road transport research, and information on their respective funding programmes will be analysed, including:

- National spending and funding on road transport and automotive related RTD
- Research priorities for road transport and automotive related RTD
- Information on the calls and types of projects financed
- Where details about the selection, evaluation and the dissemination of the projects can be found.
- Recent international cooperation in the field of road transport and automotive related research

Analysis of these areas will lead to identification of lessons learned from the funding mechanisms in the four countries and allow recommendations for future European Commission and EU member-state funding programmes to be generated.

1.2 Method

The method used in this report is the following:

- Firstly. a picture will be created of the research landscape with the public organisations involved on national level (e.g. responsible ministries and implementing agencies) and the private stakeholders involved in setting research priorities
- Secondly, national funding programmes will be described regarding their priorities, calls and eligible participants
- Thirdly, from the examples of national funding programmes, best practice examples will be selected based on criteria defined in this report

- Fourthly, with the best practice examples, a set of recommendations will be developed based on these experiences.

Within the project consortium it was agreed to limit the assessment to grant funding on national level (even if some countries have funding mechanisms on regional level available) and to exclude privately funded research.

This report is based on comprehensive investigations performed by researchers in the Czech Republic, Germany and the United Kingdom. Knowledge from other external experts in the USA, Japan, China and Brazil was combined with results from desk research that predominantly utilised Japanese, American, Chinese and Brazilian websites. The data collection was carried out from March to July 2018.

1.3 Background

The review of the funding landscape in the four countries is comparable to the research done in the EU FP7 project EAGAR (2008-2010). This project looked mainly at automotive research. For the FUTURE-RADAR project the method of the EAGAR project was partly adapted. FUTURE RADAR will move a step further and include a wider selection of road transport modes and interaction with other modes of transport. Another addition to the EAGAR project is that this research also looks at international collaboration in road transport RTD. More and more initiatives are developed between countries in North America, Europe and Asia.

The FUTURE-RADAR project also continues where the H2020 project FORSTER-ROAD ended. The FOSTER-ROAD project has been investigating the challenges of (grant-funded) RTD project results into successful innovation. The project launched an “Innovation Survey” to collect opinion and insight into the potential success factors and barriers on the pathway from research to innovation and commercial exploitation.

The research showed that correlating EC-funded projects with product innovations can be difficult for many reasons, such as the development “gap”, many RTD projects contributing to a single innovation, lost in the knowledge transition between R&D to advanced technology development and requirements for further financing. In summary, innovation success requires positive collaboration, time to innovate and a ready market for the product to be introduced.

The FUTURE-RADAR project and this study continues with this research by assessing national, European and international framework conditions and deployment strategies, in order to strengthen European competitiveness.

1.4 Overview of data sources used

This report investigates the framework conditions for four non-European countries (USA, China, Japan and Brazil) in the field of road transport RTD and innovation.

The type of data that was collected was the following:

- Published national policy documents, such as action plans for science and technology, roadmaps for transport research etc.
- Reports from international organisations, on research funding in some of the given countries.
- Websites of funding organisations and their hierarchies for automotive and/or road transport research
- Documents and websites on national public funding programmes with the most recent calls, e.g. between 2016 and 2018
- Where available, details of open calls, such as eligible applicants, grant funding rates and budgets, selection processes etc.
- Information about international cooperation initiatives in each of the four countries.

Documents were gathered from websites of national ministries and funding agencies, reports on RTD funding and in interviews with local experts. The complete list of data sources used, and experts consulted for all four country sections is included in the literature list.

1.5 Assessment of best practice

The third activity within this report is the selection of best practice examples based on criteria defined in this report. It would have been possible to carry out the assessment for four specific entity types, 1) Funding organisations, 2) Funding programmes, 3) Funding calls and 4) Funded projects. In this report, the choice was made for the assessment of 3) Funding calls.

The reason for choosing Funding calls was that their assessment requires information about funding practices (e.g. how funding applications work in the relevant country) combined with information about chosen automotive research topics, to be collected. This activity can, therefore, potentially bring the most useful information within the FUTURE-RADAR CSA, as the project is addressing future research needs. Furthermore, the assessment would create a picture of how funding organisations work but less about the funding topics that are financed. The alternative assessment of single projects, could give detailed information about projects but comparison of projects in different countries would have been very difficult with the chosen set of criteria.

1.6 Acknowledgements

This study is a combined effort from experts from Ricardo UK, Ricardo Prague and Wuppertal Institute.

The authors would like to thank various people for their contribution to this study. First of all, the following colleagues from Ricardo for providing general advice, recommendations to the report and detailed information on RTD funding in the USA, Japan and China:

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- Ricardo USA: Marc Wiseman
- Ricardo Japan: Joel Thomas, Shisei Kai
- Ricardo China: Shimin Yang, Daisy Gu

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In addition, we would like to thank Magdala Satt Arioli (Urban Mobility and Climate Consultant and PhD Candidate at Universidade Federal do Rio Grande do Sul) and Takehiko Nagai (Director General of the NEDO Representative Office in Europe), for providing valuable information on funding in Brazil and Japan respectively.

Assistance was also provided by our FUTURE-RADAR project colleagues who helped us in getting started with the analysis, mainly Gereon Meyer from VDI/VDE-IT, Oliver Lah from Wuppertal Institute and Jean-Luc di Paola-Galloni from Valeo.

[3] This study is now followed by another FPI "Improving EU Access to National and Regional Financial Incentives for Innovation in China".

2 Road transports research landscapes

For each of the four country chapters, an identical structure is used for presenting the information found. This structure has six sections as shown in the picture below. Section 1 includes an overview of strategic plans (such as national policy documents or technology roadmaps) related to road transport RTD. Section 2 includes the governance system of RTD and illustrates the hierarchy of the funding landscape. Section 3 describes the main funding organisations and other public and private stakeholders that influence RTD in the road transport sector. Section 4 provides as much detail as possible related to the grant programmes and open calls for projects. Section 5 will give an overview of the international collaboration (e.g. bilateral) ongoing with other countries. Section 6 will summarize the main findings per country and identify at least three good practice examples per country. These will be benchmarked against a pre-defined best practice in chapter 3.

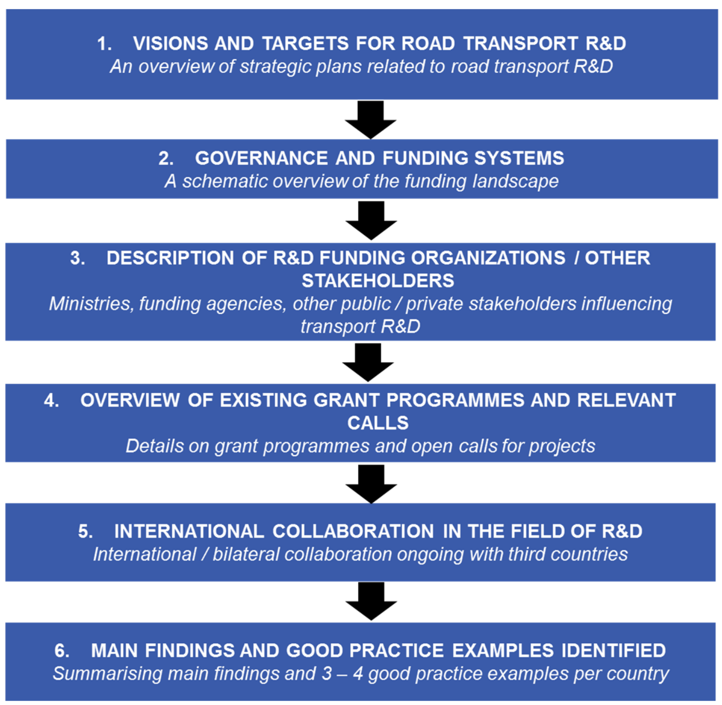


Figure: Deliverable 2.5 structure

2.1 United States

Transport research in the United States is supported by a number of federal, state, local and private-sector sponsors. The structure of the various funding programmes differs dependent upon the type of research. The structure of the various funding programmes differs dependent upon the type of research, e.g. based on their technology readiness level (TRL). These programmes thus contribute to research, development and technology transfer. As already mentioned in section 1.2, the research is limited to federal funding programmes, excluding state, local and private sector programmes.

The main funding organisations in the United States that fund transport related research on a federal level are the National Science Foundation (NSF), the Department of Energy (DOE) and the Department of Transportation (DOT). The NSF has specific programmes for basic research, while DOE and DOT mostly fund applied scientific and engineering research.

Transport research funds from these organisations are distributed through competitive processes which involve a formal national call for proposals, peer reviews by expert panels and, sometimes, the participation of decision-makers and politicians (European Commission, 2018).

2.1.1 Visions and targets for road transport RTD

This section includes an overview of any policy and strategic plans related to road transport RTD

There are a number of federal documents that lay out the strategy for RTD in the transport and energy sector. The most important ones described below are:

- Strategic Plan of the US Department of Transportation (DOT) for Fiscal Years 2018–2022
- Research, Development, and Technology (RD&T) Strategic Plan – U.S. DOT Plan presents U.S. DOT's research priorities for the next five years (FY 2017-2021)
- U.S. Department of Transportation, Intelligent Transportation Systems (ITS) Strategic Plan 2015 – 2019
- U.S. DOT's Beyond Traffic–Trends and Choices 2045
- U.S. Department of Energy - Office of Energy Efficiency and Renewable Energy - 2016–2020 STRATEGIC PLAN and Implementing Framework

Strategic Plan of the US DOT – 2018-2022

This Strategic Plan establishes the US DOT's goals and objectives for the Fiscal Years (FY) 2018 to 2022, with an outlook to the year 2030. The Strategic Plan presents the long-term objectives an agency hopes to accomplish at the beginning of each new term of an Administration by describing general and long-term goals the agency aims to achieve, what actions the agency will take to realize those goals, and how the agency will most effectively use its resources to deal with challenges and risks that may hinder achieving results. The document for the Fiscal Years 2018–2022 listed the following research areas as DOT priorities in funding considerations: Safety, Investments in Infrastructure, Innovation and Accountability (US DOT, 2017a).

Research, Development, and Technology (RD&T) Strategic Plan

This U.S. DOT Department of Research, Development, and Technology (RD&T) Strategic Plan presents research priorities for years (Fiscal Years (FY) 2017–2021 and describes the activities taken by the Department to address those priorities. In doing so, the document provides a five-year action plan that responds to the trends affecting the current and future performance of the US transportation system (US DOT, 2016a).

DOT's Beyond Traffic–Trends and Choices 2045

This document is a comprehensive assessment of current and future conditions of transport infrastructure in the USA. Beyond Traffic presents and analyses the long-term and emerging trends that will shape the US transportation system. As the US transportation system is on the brink of a major transformation, due to new technologies and business models, the document proposes corresponding transformation in transportation policy (US DOT, 2016b). Especially important will be to promote the adoption of new technologies and to incentivize innovation.

US DOT's Intelligent Transportation Systems (ITS) Strategic Plan 2015-2019

The Intelligent Transportation Systems Strategic Plan covering the years 2015 to 2019 presents a wide array of technical, policy, institutional and organizational concepts. It provides a comprehensive perspective that is based on an inclusive, collaborative, interactive and iterative process, with a wide mix of stakeholder engagement opportunities that ensured that the Strategic Plan reflects the aspirations of the multi-faceted ITS community across the nation.

This new Plan identifies a vision, "Transform the Way Society Moves", and the ITS Joint Program Offices associated mission of advancing research that cuts across all surface modes; outlines technology lifecycle stages and strategic themes articulating outcomes and performance goals that define six program categories; describes "Realizing Connected Vehicle Implementation" and "Advancing Automation" as the primary technological drivers of current and future ITS work across many sectors; and presents enterprise data, interoperability, ITS deployment support and emerging ITS capabilities as additional program categories that are supplemental and interdependent activities critical to achieving the program's vision. The plan further identifies research questions aligned to every program category in each stage of the technology lifecycle, in addition to cross-cutting organizational and operational disciplines that relate to the program categories (US DOT, 2015).

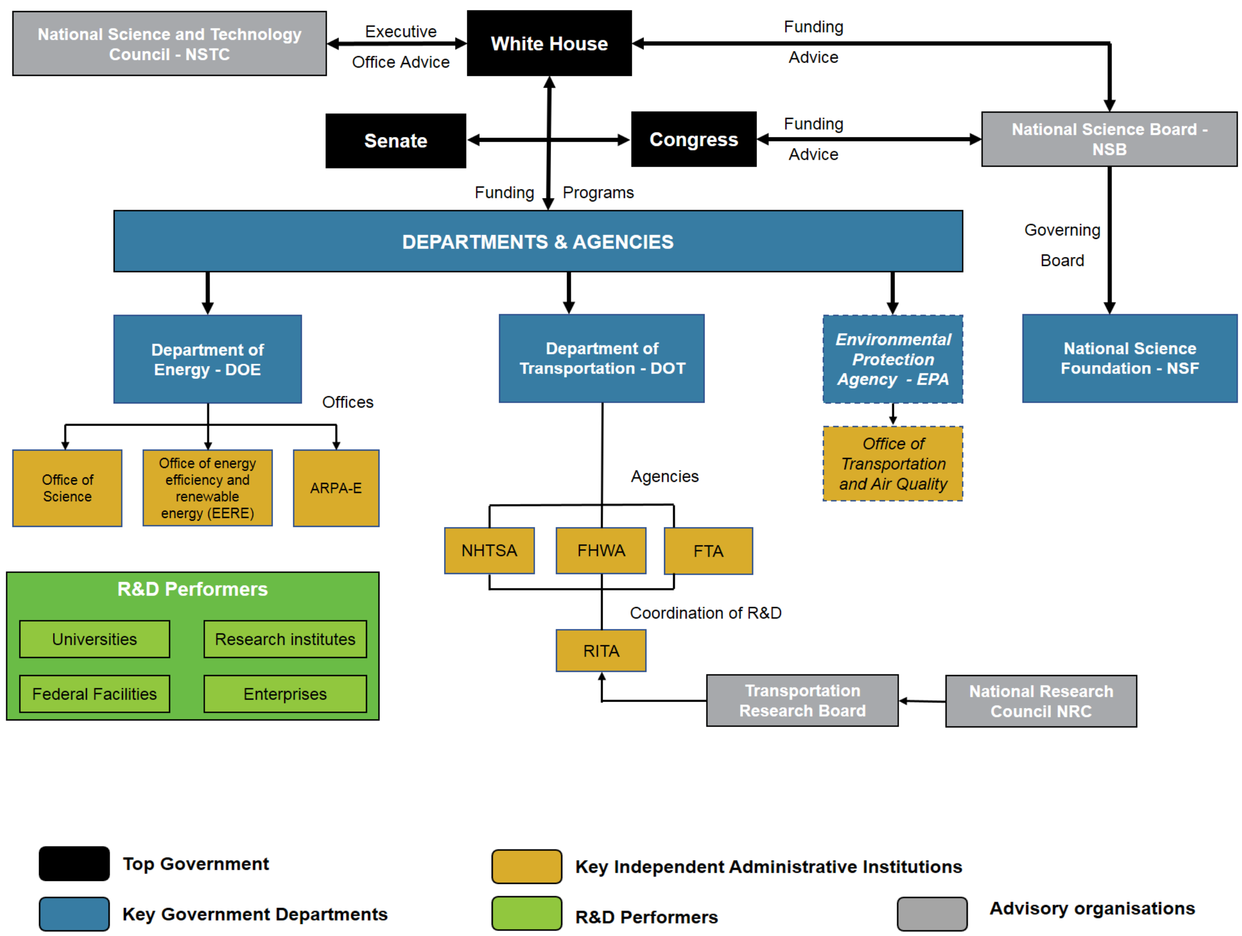
Department of Energy 2016–2020 Strategic Plan and Implementing Framework

The 2016–2020 Strategic Plan and Implementing Framework from the Office of Energy Efficiency and Renewable Energy (EERE) is the blueprint for launching the nation's leadership in the global clean energy economy. The Strategic Plan highlights include (US DOE, 2015):

- 7 strategic goal sections aligned along EERE's core technology sectors and crosscutting areas
- EERE's investment approach and core questions to prioritize work and deliver value
- Success indicators to ensure EERE stays on track or adjusts its strategies as needed.

2.1.2 Governance and funding system

The funding structure and governance in the United States is rather diversified but with a trend towards a centralised approach. Funding and topics are administered through the federal departments, which also negotiate the fiscal budget and RTD programs with the White House and Congress. The White House itself runs the National Science and Technology Council, as an executive office that defines the priorities for federal research and development. Those priorities are being implemented by the various departments running RTD programs. The governance system of federal funding in the USA is illustrated below. In the following sections the four main funding organisations for transport RTD (highlighted in blue) are described.



A schematic representation of the US RTD governance structure (based on EAGAR (2010) and recent developments)

2.1.3 Overview of the funding organisations and key stakeholders

The main funding organisations in the United States that finance or have financed transport related research are the National Science Foundation (NSF), the Department of Energy (DOE), the Department of Transport (DOT) and to a lesser extend the Environmental Protection Agency (EPA)[4].

2.1.3.1 National Science Foundation (NSF)

The National Science Foundation (NSF) is an independent federal agency created by Congress in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the

[4] The EPA has currently limited research funding available but is still mentioned due to its activities towards reducing air pollution from mobile sources.

national defence...". The NSF plays a vital role in the support of basic research and of the people to create knowledge that transforms the future. This type of support:

- Is a primary driver of the U.S. economy.
- Enhances the nation's security.
- Advances knowledge to sustain global leadership.

With an annual budget of $7.8 billion (FY 2018 - € 6.7 billion[5]), the NSF are the funding source for approximately 27 percent of all federally supported basic research conducted by America's colleges and universities. In many fields, such as mathematics, computer science and the social sciences, the NSF is the major source of federal backing (NSF, 2018a).

The NSF fulfils its mission chiefly by issuing limited-term grants - currently about 12,000 new awards per year, with an average duration of three years - to fund specific research proposals that have been judged the most promising by a rigorous and objective merit-review system.

As described in its strategic plan, the NSF is the only federal agency whose mission includes support for all fields of fundamental science and engineering, except for medical sciences. The NSF is tasked with keeping the United States at the leading edge of discovery in a wide range of scientific areas. So, in addition to funding research in the traditional academic areas, the agency also supports "high risk, high pay-off" ideas, novel collaborations and numerous projects that may seem like science fiction today, but which the public will take for granted tomorrow.

Unlike many other federal agencies, NSF does not hire researchers or directly operate its own laboratories or similar facilities. Instead, NSF supports scientists, engineers and educators directly through their own home institutions (typically universities and colleges).

The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

In the Directorate for Engineering research is funded that may be applied in the automotive and road transport. This research is funded within the following divisions[6]:

- Division of Electrical, Communications and Cyber Systems (ECCS)
    - Electronics, Photonics and Magnetic Devices (EPMD)
    - Energy, Power, Control, and Networks (EPCN)
    - Smart and connected communities (S&CC)
- Division of Civil, Mechanical and Manufacturing Innovation (CMMI)
    - Civil Infrastructure Systems (CIS)
    - Materials Engineering and Processing (MEP)
- Division of Chemical, Bioengineering, Environmental and Transport Systems (CBET)
    - Energy for Sustainability
- Division of Information & Intelligent Systems

[5] Exchange rate 31st of July, € 1 = 1.17 $ (www.oanda.com)
[6] Source: http://www.nsf.gov/ - Programs: Directorate for Engineering (ENG)

- Smart and Autonomous Systems (S&AS)

Research budgets

From the total NSF budget, a significant amount is allocated to the Directorate of Engineering. The annual research budget for the Directorate was 931 million. USD (€ 795 million) in FY2017. Within the directorate, more than 13,000 proposals were evaluated, and 2455 awards were approved (a success rate of 19%). The respective budgets per division were the following (NSF, 2017)[7]:

- Electrical, Communications and Cyber Systems (ECCS) - 114 million USD (€ 97 million)
- Civil, Mechanical and Manufacturing Innovation (CMMI) – 216 million USD (€ 185 million)
- Chemical, Bioengineering, Environmental and Transport Systems (CBET) – 184 million USD (€ 157 million)

Proposal applications and merit review process

Proposals may be submitted in response to the various funding opportunities that are announced on the NSF website. These funding opportunities fall into three categories - *program descriptions, program announcements and program solicitations* - and are the mechanisms NSF uses to generate funding requests. Scientists and engineers may also send in unsolicited proposals for research and education projects, in any existing or emerging field.

The Proposal and Award Policies and Procedures Guide (PAPPG) provides guidance on proposal preparation and submission and award management. At present, NSF receives more than 40,000 proposals per year (of which approximately 11,000 get funding) (NSF, 2018a).

To ensure that proposals are evaluated in a fair, competitive, transparent and in-depth manner, NSF uses a rigorous system of *merit review*. Nearly every proposal is evaluated by a minimum of three independent reviewers consisting of scientists, engineers and educators who do not work at NSF or for the institution that employs the proposing researchers. NSF selects the reviewers from among the national pool of experts in each field and their evaluations are confidential. On average, approximately 40,000 experts, knowledgeable about the current state of their field, serve as reviewers each year.

NSF's merit review process[8] ensures that many voices are heard and that only the best projects make it to the funding stage. The decision process is usually as follows (NSF, 2018b):

- The NSF program officer reviews the proposal and analyses the input received from the external reviewers.
- After scientific, technical and programmatic review and consideration of appropriate factors, the program officer makes an "award" or "decline" recommendation to the division director.
- Final programmatic approval for a proposal is generally completed at NSF's division level.

[7] These numbers are based on FY 2016 data, during this year the total research budget for the Directorate of Engineering of 916 million USD.
[8] This study only briefly describes the merit review process. More details can be found on the NSF website: https://www.nsf.gov/bfa/dias/policy/merit_review/#phaseone

- A principal investigator (PI) whose proposal for NSF support has been declined will receive information and an explanation of the reason(s) for declination, along with copies of the reviews considered in making the decision. If that explanation does not satisfy the PI, he/she may request additional information from the cognizant NSF program officer or division director.

If the program officer makes an award recommendation and the division director concurs, the recommendation is submitted to NSF's Division of Grants and Agreements (DGA) for award processing. A DGA officer reviews the recommendation from the program division/office for business, financial and policy implications, and the processing and issuance of a grant or cooperative agreement. DGA generally makes awards to academic institutions within 30 days after the program division/office makes its recommendation.

2.1.3.2 National Science Board (NSB)

The National Science Board has two important roles. First, it establishes the policies of NSF within the framework of applicable national policies set forth by the President and the Congress. In this capacity, the Board identifies issues that are critical to NSF's future, approves NSF's strategic budget directions and the annual budget submission to the Office of Management and Budget, and approves new major programs and awards. The second role of the Board is to serve as an independent body of advisors to both the President and the Congress on policy matters related to science and engineering and education in science and engineering. In addition to major reports, the NSB also publishes occasional policy papers or statements on issues of importance to U.S. science and engineering[9].

2.1.3.3 Department of Energy (DOE)

Under the Department of Energy, most of the energy-related research including vehicle technologies within the U.S. is being administered. Where the NSF is mainly supporting fundamental research (with a lower TRL, approx. 1 to 3), the DoE is supporting applied research that would be around TRL 4-6.

Research activities in the field of transport technology are split among a number of offices and agencies, all being part of DOE:

- The Office of Science
- The Office of Energy Efficiency and Renewable Energy (EERE)
- The Advanced Research Projects Agency-Energy (ARPA-E) - promoting and funding research and development of advanced energy technologies
- Under the DOE there are 17 national laboratories. Most of them are doing fundamental research. Research in the field of transport is mostly done in[10]:
    - Argonne National Laboratory
    - Oak Ridge National Laboratory

DOE – The Office of Science

The Office of Science, part of DOE, is the single largest supporter of basic research in the physical sciences in the United States, providing more than 40 percent of total funding. It oversees – and is the principal federal funding agency of research programs in the field of energy physics and nuclear physics.

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[9] More details about the National Science Board can be found on the website: https://www.nsf.gov/nsb/about/index.jsp

[10] Websites: Argonne National Laboratory - http://www.anl.gov/, Oak Ridge National Laboratory - https://www.ornl.gov/

The Office of Science manages fundamental research programs in basic energy sciences, biological and environmental sciences, and computational science. In addition, the Office of Science is the Federal Government's largest single funder of materials and chemical sciences, and it supports unique and vital parts of U.S. research in climate change, geophysics, genomics, life sciences, and science education.

The Office of Science portfolio has two principal thrusts: direct support of scientific research and direct support of the development, construction, and operation of unique, open-access scientific user facilities that are made available for use by external researchers.

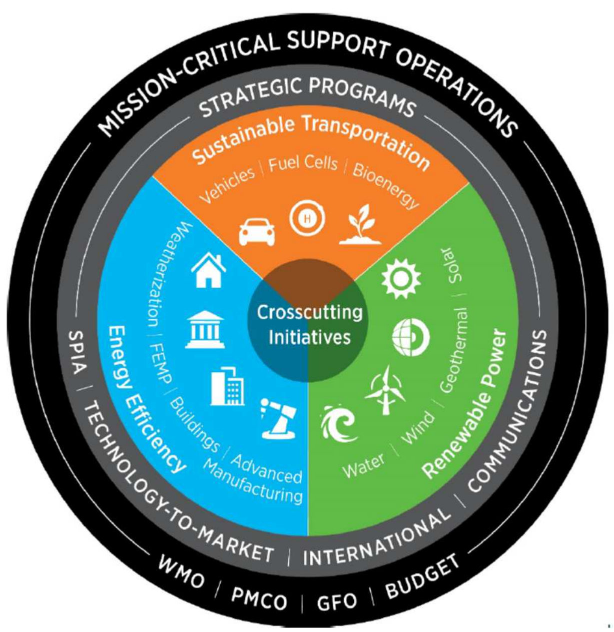
The Office of Science manages this research portfolio through six interdisciplinary scientific program offices: Advanced Scientific Computing Research, Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, High Energy Physics and Nuclear Physics. The Office of Science also has responsibility for 10 of the 17 United States Department of Energy National Laboratories.

The Office of Science issues two types of funding announcements:

- Funding Opportunity Announcements (FOAs), which may be open to one or more institution types (please read the eligibility requirements in a given FOA for details); and
- DOE National Laboratory Announcements, which are open only to DOE Laboratories.

DOE – The Energy Efficiency and Renewable Energy (EERE) program office

The Office of Energy Efficiency and Renewable Energy (EERE) was formed after the 1973 energy crisis, EERE's mission is to help support the development of clean, renewable and efficiency energy technologies to America and support a global clean energy economy. The Office of EERE is led by the Assistant Secretary of Energy Efficiency and Renewable Energy, who oversees three technology sectors: 1) sustainable transport, 2) Renewable Power and 3) Energy Efficiency (US DOE, 2016).



Structure of the Energy Efficiency and Renewable Energy (EERE) program office

The EERE program office is responsible for the vehicle technologies program fostering the research on electrical vehicles. The office has a special funding site, where it is possible to search for actual and upcoming funding opportunities: https://eere-exchange.energy.gov/.

In the field of sustainable transportation, the EERE leads U.S. researchers and other partners in making transportation cleaner and more efficient through solutions that put electric drive vehicles on the road and replace oil with clean domestic fuels. Through its Vehicle, Bioenergy and Fuel Cell Technologies Offices, EERE advances the development of next-generation technologies to improve plug-in electric and other alternative-fuel vehicles, advanced combustion engine and vehicle efficiency, and produce low-carbon domestic transportation fuels.

The links to each of the offices websites are the following:

- Vehicle Technologies Office - https://www.energy.gov/eere/vehicles/vehicle-technologies-office
- Biotechnologies Office - https://www.energy.gov/eere/bioenergy
- Fuel Cell Technologies Office - https://www.energy.gov/eere/fuelcells/fuel-cell-technologies-office

DOE – Advanced Research Projects Agency-Energy (ARPA-E)

ARPA-E, or Advanced Research Projects Agency-Energy is a special government agency that is part of DOE tasked with promoting and funding research and development of advanced energy technologies. In 2007, Congress passed The America COMPETES Act, which officially authorized ARPA-E's creation. ARPA-E is modelled after the successful Defence Advanced Research Projects Agency (DARPA) -the agency credited with such innovations as GPS, the stealth fighter and computer networking.

ARPA-E's initial $400 million budget (€ 342 million) was a part of the 2009 American Recovery and Reinvestment Act. During the following years ARPA-E received the following amounts of funding[11]:

Fiscal year	Budget (in $)	Budget (in €)
2011	180 million	154 million
2012	275 million	235 million
2013	251 million	215 million
2014	280 million	239 million
2015	280 million	239 million
2016	294 million	251 million
2017	306 million	262 million
2018 (budgeted)	353 million	302 million

[11] Source: https://arpa-e.energy.gov/?q=arpa-e-site-page/arpa-e-budget

Budgets are determined each year, the budget from 2019 onwards is not known yet. The 2019 budget could remain in the same range as the 2018 budget, although there remains uncertainty about the long-term existence of the programme[12].

ARPA-E funds high-potential, high-impact energy technologies that are too early for private-sector investment. ARPA-E awardees are unique because they are developing entirely new ways to generate, store or use energy. According to an independent assessment by the Information Technology and Innovation Foundation (ITIF) ARPA-E projects have the potential to radically improve U.S. economic prosperity, national security, and environmental wellbeing. ARPA-E focuses on transformational energy projects that can be meaningfully advanced with a small amount of funding over a defined period, typically two to four years. ARPA-E projects are generally categorised to be at TRL 2 to 4 (ITIF, 2017).

Currently two ARPA-E programmes are running in the field of transport, NEXTCAR[13] and REFUEL[14].

NEXTCAR

The $34 million NEXTCAR programme aims to create new control technologies that reduce the energy consumption of future vehicles by using connectivity and vehicle automation; Under the NEXTCAR programme 11 sub-projects have been financed.

The projects that make up NEXTCAR, short for "*NEXT-Generation Energy Technologies for Connected and Automated On-Road Vehicles*," are enabling technologies that use connectivity and automation to co-optimize vehicle dynamic controls and powertrain operation, thereby reducing energy consumption of the vehicle. Vehicle dynamic and powertrain control technologies, implemented on a single vehicle basis, across a cohort of cooperating vehicles, or across the entire vehicle fleet, could significantly improve individual vehicle and, ultimately, fleet energy efficiency.

REFUEL

The $33 million REFUEL programme aims to develop technologies that use renewable energy to convert air and water into liquid fuels (REFUEL); 16 projects have been financed.

Projects in the Renewable Energy to Fuels Through Utilization of Energy-Dense Liquids (REFUEL) program seek to develop scalable technologies for converting electrical energy from renewable sources into energy-dense carbon-neutral liquid fuels (CNLFs) and back into electricity or hydrogen on demand. REFUEL projects will accelerate the shift to domestically produced transportation fuels, improving American economic and energy security and reducing energy emissions.

[12] https://www.pv-magazine.com/2018/05/29/us-senate-proposes-business-as-usual-energy-budget/
[13] Source: https://arpa-e.energy.gov/?q=arpa-e-programs/nextcar
[14] Source: https://arpa-e.energy.gov/?q=arpa-e-programs/refuel

OPEN 2018

Approximately every three years, ARPA-E issues OPEN Funding Opportunity Announcements (FOAs) as a means to address the full range of energy-related technologies and fund those potentially disruptive technology concepts not currently supported through an ARPA-E focused FOA. In its own words, ARPA-E supports transformational energy research that can be meaningfully advanced with a small investment over a defined period of time. Examples of projects funded under OPEN 2018 are electricity generation by both renewable and non-renewable means; electricity transmission, storage and distribution; energy efficiency for buildings, manufacturing and commerce, and personal use; and all aspects of transportation, including the production and distribution of both renewable and non-renewable fuels, electrification, and transportation energy efficiency[15].

Future programs

DoE recently announced new upcoming funding opportunities related to the themes of energy storage[16] and advanced vehicle technologies, such as batteries and materials[17]. Details are described in Section 3.1.4. on funding calls.

2.1.3.4 Department of Transportation (DOT)

The United States Department of Transportation is a federal agency that oversees interstate travel. All U.S. states have similar organizations and provide enforcement through DOT officers within their respective jurisdictions.

The Department of Transportation hosts the Federal Highway Administration (FHA), the Federal Transit Administration (FTA) and National Highway Traffic Safety Administration (NHTSA) under which major transport-related research is being conducted. The research and technology programs within the DOT are coordinated by the Research and Innovative Technology Administration (RITA).

The U.S. DOT has defined four critical transportation topics in its RD&T Strategic Plan that will be supported by DOT over the next five years (US DOT, 2016a):

- Promoting Safety relates to safety issues affecting all modes and the development and deployment of countermeasures designed to address these issues. U.S. DOT's goal is to improve public health and safety by reducing transportation-related fatalities and injuries.
- Improving Mobility refers to demographic, economic, geographic, cultural and technological trends affecting travel demand, personal and commercial mobility across all transportation modes, and the effects of those trends on quality of life and access to economic and educational opportunities. U.S. DOT's goal is to improve the mobility of people and goods, reduce congestion, and increase access to opportunities for all.

[15] More information about the OPEN 2018 FOA can be found on: https://arpa-e.energy.gov/?q=open-program/open-2018
[16] Department of Energy Announces Funding to Support Long-Duration Energy Storage https://arpa-e.energy.gov/?q=news-item/department-energy-announces-funding-support-long-duration-energy-storage
[17] Secretary of Energy Rick Perry Announces $68.5 Million for Advanced Vehicle Technologies Research https://www.energy.gov/articles/secretary-energy-rick-perry-announces-685-million-advanced-vehicle-technologies-research

- Improving Infrastructure covers issues relating to the condition, costs, funding and delivery of the transportation infrastructure, as well as the methods and technologies to increase its durability and resilience. U.S. DOT's goal is to improve the durability and extend the life of the transportation infrastructure, preserve the existing transportation system, and ensure that the U.S. proactively maintains the critical transportation infrastructure in a state of good repair.
- Preserving the environment covers the effects of transportation activities on the environment as a whole (including water, noise and air pollution, and habitat degradation) and discusses approaches to avoid or mitigate those effects. U.S. DOT's goal is to advance environmentally sustainable policies and investments that reduce carbon and other harmful emissions from transportation sources.

In addition, DOT initiated two other special initiatives, Intelligent Transport Systems and the Smart Cities Challenge.

Intelligent Transportation Systems – Joint Programme Office

The DOT's ITS program focuses on intelligent vehicles, intelligent infrastructure and the creation of an intelligent transportation system through integration with and between these two components. The Federal ITS program supports the overall advancement of ITS through investments in major research initiatives, exploratory studies and a deployment support program including technology transfer and training[18].

Smart Cities Challenge

In December 2015, DOT launched the Smart City Challenge; funding one city with USD 40 million (€ 34 million) to support it in evolving to become the country's first Smart City by fully integrating innovative technologies, such as self-driving cars, connected vehicles and smart sensors, into their transportation network.

According to information on DOT's Smart City website[19] Seventy-eight cities participated in this initiative, with 82% of the participants including significant vehicle automation concepts as part of their Smart City vision. Many applicants identified opportunities for leveraging automated vehicles to connect disadvantaged communities, while significant interest was also shown in electric vehicles, as well as low speed automated vehicles supporting first mile / last mile connections, automated / semi-automated transit vehicles, automated truck demonstration and truck platooning.

In response to the $40 million committed by the DOT, cities leveraged an additional $500 million (€ 427 million) in private and public funding to help make their Smart City visions real. In October 2016, the DoT announced an additional $65 million (€ 56 million) in grants to support community-driven advanced technology transportation projects in cities across America, including 4 of the finalists in the Smart City Challenge.

By challenging American cities to use emerging transportation technologies to address their most pressing problems, the Smart City Challenge aimed to spread innovation through a mixture of competition, collaboration, and experimentation. But the Smart City Challenge was about more than just technology.

[18] Relevant information can be found at: https://www.its.dot.gov/
[19] https://www.transportation.gov/smartcity

DoT called on mayors to define their most pressing transportation problems and envision new solutions that could change the face of transportation in US cities by meeting the needs of residents of all ages and abilities; and bridging the digital divide so that everyone, not just the tech-savvy, can be connected to everything their city has to offer.

2.1.3.5 Environmental Protection Agency (EPA)

The EPA was established in 1970 to consolidate in one agency a variety of federal research, monitoring, standard-setting and enforcement activities to ensure environmental protection. The main office concerned with air quality and transport emissions is the EPA Office of Transportation and Air Quality. Its mission is to reconcile the transportation sector with the environment, by advancing clean fuels and technology, and working to promote more liveable communities. OTAQ is responsible for carrying out laws to control air pollution from motor vehicles, engines and their fuels. Mobile sources include: cars and light trucks, large trucks and buses, farm and construction equipment, lawn and garden equipment, marine engines, aircraft and locomotives. Activities include: characterizing emissions from mobile sources and related fuels; developing programs for their control, including assessment of the status of control technology and in-use vehicle emissions; carrying out a regulatory compliance program, in coordination with the Office of Enforcement and Compliance Assurance, to ensure adherence of mobile sources to standards; fostering the development of State Motor Vehicle Emissions Inspection and Maintenance Programs; and implementing programs for the integration of clean-fuelled vehicles into the market [20].

2.1.3.6 Other important stakeholders

Transportation Research Board (TRB)

The Transportation Research Board (TRB) is a division of the National Research Council of the United States, which serves as an independent adviser to the President of the United States, Congress and federal agencies on scientific and technical questions of national importance.

TRB manages transportation research by producing publications and online resources. It convenes experts that help to develop solutions to problems and issues facing transportation professionals. TRB also provides advice through its policy studies that tackle complex and often controversial issues of national significance.

National Science and Technology Council (NSTC)

This is an Advisory Council for the President, proposing priorities for federal research and development programs and allocated budget. The Council prepares research and development strategies that are coordinated across federal agencies to form investment packages aimed at accomplishing multiple national goals[21].

National Highway Traffic Safety Administration (NHTSA)

The National Highway Traffic Safety Administration (NHTSA) is an agency of the Executive Branch of the U.S. government, part of the Department of Transportation. It describes its mission as "Save lives, prevent

[20] https://www.epa.gov/air-pollution-transportation
[21] NSTC website: https://www.whitehouse.gov/ostp/nstc/.

injuries, reduce vehicle-related crashes". NHTSA and the U.S. Department of Transportation are involved in the Federal Automated Vehicle Policy that set a proactive approach to providing safety assurance and facilitating innovation[22].

2.1.4 Overview of existing grant programmes and relevant calls

Funding programmes can be found in the website www.grants.gov, where there is search engine for all types of federal grants in the USA. In this section, funding opportunities from the NSF, DoE and DoT are described briefly.

2.1.4.1 NSF funding calls

The NSF mainly supports fundamental research in all sectors except medical research. These are related to topics such as battery development and these can be categorised as TRL 1-3.

The main funding opportunities and topics in the field of transport RTD are found within the Directorate for Engineering. Within the Division of Information and Intelligent Systems there is a program on **Smart and Autonomous Systems (S&AS).** The S&AS program focuses on Intelligent Physical Systems (IPS) that are capable of robust, long-term autonomy requiring minimal or no human operator intervention in the face of uncertain, unanticipated and dynamically changing situations. IPS are those which combine perception, cognition, communication and actuation to operate in the physical world. Examples include robotic platforms, self-driving vehicles, underwater exploration vehicles and smart grids.

Programs within the Division of Civil, Mechanical and Manufacturing Innovation (CMMI) that are to some extent mobility related are:

- Civil Infrastructure Systems (CIS)
- Materials Engineering and Processing (not battery related)

Energy for Sustainability Program

The goal of the Energy for Sustainability Program, within the Division of Chemical, Bioengineering, Environmental and Transport Systems (CBET), is to support fundamental engineering research that will enable innovative processes for the sustainable production of electricity, fuels and for energy storage.

Proposed research should be inspired by the need for economic and impactful conversion processes. Highly integrated multidisciplinary projects are encouraged.

The main topic of interest related to the transport sector is "*Electrochemical Energy Systems*". This call addresses radically new battery systems or breakthroughs based on existing systems can move the U.S. more rapidly toward a more sustainable transportation future. The focus of this topic is on high-energy density and high-power density batteries suitable for transportation and renewable energy storage

[22] More information: https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety#issue-road-self-driving

applications. Advanced systems, such as lithium-air, sodium-ion, as well as lithium-ion electrochemical energy storage, are appropriate.

Within the Division of Electrical, Communications and Cyber Systems (ECCS), the following programmes are transport related:

- Electronics, Photonics and Magnetic Devices (EPMD)
- Energy, Power, Control and Networks (EPCN)
- Smart and connected communities (S&CC)

Of the aforementioned programmes, most relevance is the EPCN Program that supports innovative research in modelling, optimization, learning, adaptation, and control of networked multi-agent systems, higher-level decision making, and dynamic resource allocation, as well as risk management in the presence of uncertainty, sub-system failures, and stochastic disturbances. EPCN also emphasizes electric power systems, including generation, transmission, storage, and integration of renewable energy sources into the grid; power electronics and drives; battery management systems; hybrid and electric vehicles; and understanding of the interplay of power systems with associated regulatory and economic structures and with consumer behaviour. Major topics addressed are the following:

- Control Systems
- Energy and Power Systems
- Power Electronics Systems (incl. hybrid and electric vehicles)
- Learning and Adaptive Systems

NSF funding call procedures have a fixed duration, split into three phases:

- Phase I – Proposal preparation and submission – 90 days
- Phase II – Proposal review and processing – 6 months
- Phase III – Award processing – 30 days

This means that the entire procedure takes about 10 months. Since August 15, 2018, all core programs in the Directorate for Engineering (ENG) will accept proposals at any time throughout the year. There will no longer be any restriction on when an unsolicited proposal can be submitted for consideration to the core programs[23]. This also includes proposals under the EPCN Program.

2.1.4.2 DOE funding calls

The Department of Energy is an important contributor to vehicle research funding. Examples are programmes managed by the Office of Energy Efficiency and Renewable Energy (EERE).

Two recent funding examples related to vehicle technologies are the following FOAs (Funding Opportunity Announcement):

[23] Frequently Asked Questions (FAQs), Removal of Deadlines for Core Programs in the Directorate for Engineering https://www.nsf.gov/pubs/2018/nsf18083/nsf18083.jsp

- FY18 **Advanced Vehicle Technologies Research** (DE-FOA-0001919)
- FY18 **Hydrogen and Fuel Cell R&D** FOA (DE-FOA-0001874)

The *Advanced Vehicle Technologies Research* call was issued on behalf of the Vehicle Technologies Office (VTO). The objective of this call is, to invest in early-stage research to enable future private-sector development and commercialization of affordable, energy-efficient transportation technologies that can strengthen US energy security, in order to o support U.S. economic growth and offer consumers and businesses additional transportation choices. This call is managed by the Department of Energy (DOE)'s Vehicle Technologies Office. This FOA seeks research projects to address priorities in the following areas: batteries and electrification; materials; technology integration and energy efficient mobility systems; energy-efficient commercial off-road vehicle technologies; co-optimized advanced engine and fuel technologies to improve fuel economy (Office of EERE, 2018).

The *Hydrogen and Fuel Cell R&D FOA* provides up to $39 million (€ 33 million) in Federal funding to meet the FCTO's goals of enabling cost-competitiveness and the adoption of fuel cells, renewable hydrogen production, and low-cost hydrogen storage for both transportation and stationary applications.

Similar grant funding calls were open in FY 2017, one example is the following FOA:

- Medium/Heavy-Duty, On-Road Natural Gas Engine Research and Development (DE-FOA-0001813)

The 2017 call was open during the 4th quarter of 2017, with a deadline for applications early January 2018. This FOA supports a broad portfolio of advanced highway transportation technologies that reduce petroleum consumption and improve energy efficiency while meeting or exceeding performance and cost expectations.

The objective is to address barriers to adoption of natural gas vehicles through early-stage research on medium- and heavy-duty on-road engine technologies. The programmatic goal is to enable natural gas engines that can cost-effectively achieve diesel-like efficiency while meeting current and future emissions standards.

The application process

The duration of application process is specific per FOA, but when looking at the 2018 calls, similar durations per phase can be observed:

- Submission of a concept paper is 4 weeks after FOA is published
- After concept paper notification (around two or three weeks), there are 4 to 5 weeks for submission for full proposals
- Selection of proposals takes two to three months
- Contract award negotiations and the period up to project start is another three months.

This leads to a total duration of approximately 9 months.

2.1.4.3 Other Funding Opportunities related to the DOE

The Small Business Innovations Research (SBIR) and Small Business Technology Transfer (STTR) programs are research and development initiatives across the federal government specifically targeting small businesses. Businesses that win SBIR or STTR awards keep the rights to any technology developed and are encouraged to commercialize it. VTO, through broader Department of Energy efforts, supports SBIR/STTR to increase commercialization of technology developed through DOE-supported research and development, stimulate innovation in the private sector, and improve the return on investment from federally funded research.

The Small Business Vouchers program through the Department of Energy's national laboratories provides U.S. small businesses with access to the expertise and facilities of its national laboratories.

EERE's SBIR/STTR program is aligned with the federal Small Business Administration SBIR program and EERE's mission to lead DOE efforts to develop and deliver market-driven solutions for energy-saving homes, buildings, and manufacturing; sustainable transportation; and renewable electricity generation.

In addition to DOE funding opportunities, there are a variety of state, local, and federal incentives, including tax credits, listed on the Alternative Fuels Data Center that support the use of alternative fuel vehicles and infrastructure[24].

2.1.4.4 DOT funding calls

The DOT is currently focusing on investments in infrastructure. Through the so-called BUILD grants, investments in infrastructure are financed.

BUILD grants

BUILD Transportation grants were launched early 2018 and replace the pre-existing Transportation Investment Generating Economic Recovery (TIGER) grant program. As the Administration looks to enhance America's infrastructure, FY 2018 BUILD Transportation grants are for investments in surface transportation infrastructure and are to be awarded on a competitive basis for projects that will have a significant local or regional impact. BUILD funding can support roads, bridges, transit, rail, ports or intermodal transportation.[25]

Other, research-related funding, is administrated through the Volpe National Transportation Systems Center, the main centre of transportation and logistics expertise under the DOT[26].

U.S. DOT's Small Business Innovation Research Program

U.S. DOT's SBIR program awards contracts to domestic small businesses to pursue research on and develop innovative solutions to the nation's transportation challenges. The U.S. DOT SBIR program favours research that has the potential for commercialization through products and applications sold to the

[24] Details can be found on https://www.afdc.energy.gov/
[25] https://www.transportation.gov/BUILDgrants
[26] https://www.volpe.dot.gov/

private sector transportation industry, state departments of transportation, U.S. DOT or other federal agencies.

Small businesses that participate in the U.S. DOT's SBIR program have developed numerous new and innovative technologies that have benefitted the department and the public, while providing a basis for growth for small businesses. Over the past five years, the U.S. DOT SBIR program has invested $50 million (€ 43 million) in qualified small businesses. Proposals can be submitted when the U.S. DOT has an open solicitation. For 2018, a solicitation was open until March 2018 (Volpe Centre, US DOT, 2018). Information about past solicitations and awardees can be found on the Volpe Center website[27].

The U.S. DOT SBIR Program awards contracts in two phases and recognizes a follow-on Phase III.

- Phase I contracts seek to establish the technical merit, feasibility, and commercial potential of the proposal. Phase I awards normally do not exceed $150,000 total costs for 6 months.
- Phase II contracts are only available to small businesses that have successfully completed Phase I. Phase II seeks to develop and commercialize the Phase I technologies. Contracts awards normally do not exceed $1,000,000 total costs for 2 years.
- Phase III is for small businesses to pursue commercialization objectives resulting from the Phase I and Phase II activities. The SBIR program does not fund Phase III. Where applicable, Phase III may involve follow-on non-SBIR funded R&D or production contracts for products, processes, or services intended for use by the U.S. Government.

2.1.4.5 DOT – Smart Cities challenge

A mentioned earlier in the report, the DOT launched the Smart Cities Challenge at the end of 2015. 78 cities participated in this initiative and presented their ideas. The main topics addressed were:

- Providing first-mile and last mile service for transit users to connect underserved communities to jobs
- Facilitating the movement of goods into and within a city
- Coordinating data collection and analysis across systems and sectors
- Reducing inefficiency in parking systems and payment
- Limiting the impacts of climate change and reducing carbon emissions
- Optimizing traffic flow on congested freeways and arterial streets

From the group of 78 cities, the U.S. DOT named seven finalists: Austin, Columbus, Denver, Kansas City, Pittsburgh, Portland, and San Francisco. Each received $100,000 for public outreach, the production of pitch videos, and intensive technical assistance from Federal experts and private partners to further concept development. Through this process, the finalists refined their vision for what a smart city could be.

In 2016, the city of Columbus was chosen as winner. According to the DoT, the City of Columbus proposed a comprehensive, integrated plan addressing challenges in residential, commercial, freight, and downtown districts using a number of new technologies, including connected infrastructure, electric vehicle charging infrastructure, an integrated data platform, autonomous vehicles, and more. Columbus plans to work closely with residents, community and business leaders, and technical experts to implement their plan.

[27] https://www.volpe.dot.gov/work-with-us/small-business-innovation-research/past-solicitations-and-awards

They have committed to collaborate with Austin, Denver, Kansas City, Pittsburgh, Portland, and San Francisco to share best practices to help other cities across America replicate their successes. Public roll-out of the various Smart Columbus pilot projects started in 2017.

With additional funding, support was provided for four of the Smart City Challenge finalists to implement ideas developed as part of their applications. Grants were provided to the following projects (US DOT, 2017b):

- Pittsburgh - nearly $11 million to deploy smart traffic signal technology – proven to reduce delays at street lights by up to forty percent – along major travel corridors.
- San Francisco - nearly $11 million to implement connected vehicle technologies to allow the signal system to detect red light-violating vehicles and adjust timing, and personal wireless devices to prioritize pedestrian travel and safety at intersections. This includes a pilot of a shared, electric, autonomous shuttle.
- Denver - $6 million to upgrade its traffic management centre, build a connected vehicle network, and install automated pedestrian detection at difficult crosswalks.
- Portland - the transit agency, TriMet, will receive funds to integrate shared use mobility options into its existing trip planning app., allowing users to plan efficient trips even without nearby transit access.

2.1.4.6 EPA funding calls

A good example of an existing grant programme under the EPA is the Clean Diesel Funding Assistance Program. EPA anticipates awarding approximately $40 million in competitive grant funding for the Diesel Emissions Reductions Act (DERA) Clean Diesel Funding Assistance Program. The Program is soliciting proposals nationwide for projects that achieve significant reductions in diesel emissions in terms of tons of pollution produced and exposure, particularly from fleets operating in areas designated by the Administrator as poor air quality areas. The programme mainly funds investments in the replacement of old diesel engines for new ones (by clean diesel or other engine types such as CNG). There was a request for proposals open until June 12, 2018.[28] The same programme was running during the 2014 to 2017 financial years. There are no recent research funding opportunities from the EPA. Types of research funded in the past was mainly related to air pollution and climate change research, but no topics related to transport.

2.1.5 International collaboration in the field of RTD

The US has ongoing international collaboration in the field if transport RTD with other countries and regions, the EU (especially cooperation in the framework of H2020), Japan and China.

[28] More details can be found on the website: https://www.epa.gov/cleandiesel/clean-diesel-national-grants

2.1.5.1 Cooperation with the EU

Based on the work of the Joint Consultative Group (JCG), established under the EU-US Science & Technology Agreement, cooperation on research and innovation with the United States is addressing some priority RTD areas including transport[29].

The main purpose of the EU-US collaboration in surface transport research is to address global societal challenges and to pursue international standardisation requirements. Mutual benefit, joint priority setting, co-funding and critical mass through programme level cooperation are the underlying features. This EU-US cooperation has been growing steadily in recent years. In 2013, the US and EU signed an Implementing Arrangement (February 2013), covering Cooperative Activities in the Field of Research, Development, Technology, and Innovation Applied to all Modes of Transport.

With regards to the transportation research, the areas of cooperation are currently the following ones:

- development of highway infrastructures,
- road safety,
- automation
- urban logistics
- ITS (Intelligent Transportation System)

Cooperation is visible at programme level, e.g. at the level of the Horizon 2020 programme. Another element is EU-US "twinning" cooperation, e.g. collaboration between DG MOVE and DG RTD and US Department of Transport.

A milestone in EU-US transport cooperation was reached by the launch in 2013 and 2015 of Interoperability Centres for smart grids and e-vehicles by the Joint Research Centre and the US Department of Energy.

In the years to come US scientists will find specific calls inviting in US cooperation in the areas of:

- Automated driving and road automation in general[30]
- Air quality and low-emission freight transport systems
- Multi-modal inter-urban transport

In the current Horizon 2020 work programme on transport (2018-2020) international cooperation with the USA is specifically encouraged in a number of calls. It concerns the following calls for 2019:

- LC-MG-1-9-2019: Upgrading transport infrastructure in order to monitor noise and emissions
- MG-2-9-2019: Integrated multimodal, low-emission freight transport systems and logistics
- DT-ART-03-2019: Human centred design for the new driver role in highly automated vehicles
- DT-ART-04-2019: Developing and testing shared, connected and cooperative automated vehicle fleets in urban areas for the mobility of all

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[29] https://ec.europa.eu/research/iscp/pdf/policy/us%20clean_roadmap_2017.pdf
[30] Road transport automation and cooperation with the US is specifically mentioned in the H2020 Transport Work Programme

For earlier calls (2018), cooperation with the US was encouraged in these calls:

- LC-MG-1-1-2018: InCo flagship on reduction of transport impact on air quality
- LC-MG-1-2-2018: Sustainable multi-modal inter-urban transport, regional mobility and spatial planning
- LC-MG-1-3-2018: Harnessing and understanding the impacts of changes in urban mobility on policy making by city-led innovation for sustainable urban mobility
- DT-ART-01-2018: Testing, validation and certification procedures for highly automated driving functions under various traffic scenarios based on pilot test data
- DT-ART-02-2018: Support for networking activities and impact assessment for road automation

In all calls, it is specifically mentioned that proposals should foresee twinning with entities participating in projects funded by US DOT to exchange knowledge and experience and exploit synergies.

Specific support is provided for the organisation of the annual EU-US Transport research symposia. It concerns the preparation of support to the EU-US Transport Research Symposia, to be organised annually in 2018-2020 (second quarter of each year). In 2018 and 2020, the EU-US symposia will be held in Brussels, while in 2019 the symposium will take place in Washington, D.C.

2.1.5.2 Other cooperation initiatives

Other cooperation is in energy technology research, EU-US cooperation on energy technology research and innovation continues to be promoted under the EU-US Energy Council and its Technology Working Group. One specific example of international cooperation in the field of automotive research is the following:

Clemson University International Center for Automotive Research, South Carolina

An exemplary automotive-sector public-private cooperation in research and education[31]. The university centre conducts extensive collaboration activities with industry including facility sharing, joint curriculum development of a specific purpose master's programme, joint research and development with businesses and commercialisation of R&D in an exemplary public-private cooperation as well as community engagement to foster the next generation of automotive sector workers.

This university centre boasts a large amount of research partners from all around the world including BMW, Michelin, FCA or Bosch from the EU, as well as Toyota, Honda or NEC from Japan. Some of them even have large facilities on site which holds true mainly for one the founding partners – BMW.

Part of this university centre is the **International Transportation Innovation Center (ITIC)**

The ITIC is a non-profit organization headquartered in Greenville, South Carolina, USA which is focused on the development of an international network of open and closed testbeds to support connected, automated and sustainable mobility in smart city environments. ITIC is currently involved in the development of two open testbeds with one of them being in Munich, Germany in collaboration with a public private consortium.

[31] More info on: https://www.ub-cooperation.eu/pdf/cases/I_Case_Study_Clemson.pdf and http://cuicar.com

2.1.5.3 Cooperation between the USA, Japan and China

Cooperation is not only initiated by government agencies, but also by OEMs. For example, in 2015, Toyota created the Toyota Research Institute in the US, with a budget of $1 billion for autonomous driving research. To support this Institute, Toyota has hired professors and researchers from Stanford University, MIT, and the entire staff of the autonomous vehicle company Jaybridge Robotics.

More details are included in the country chapters on Japan and China.

2.1.6 Main findings and grant funding practices identified

Based on the review of US funding mechanisms in the field of transport RTD we can conclude the following:

- The main funding organisations in the United States that fund transport related research on a federal level are the National Science Foundation (NSF), the Department of Energy (DOE) and the Department of Transportation (DOT).
- In addition, a number of other stakeholders, like the National Science and Technology Council (NSTC), Transportation Research Board (TRB) and the National Highway Traffic Safety Administration (NHTSA) provide independent advice and assist in setting national research priorities.
- The NSF has specific programmes for basic research, such as fundamental engineering research that will enable energy storage and sustainable production of fuels and electricity.
- The Department of Energy and the Department of Transport support applied research. Funded topics are clearly split:
    - Advanced vehicle technologies (such as batteries) and engine research are funded by DOE
    - Intelligent Transport Systems and infrastructure research are funded by DOT

  Both departments have specific offices and programmes that support tailored topics such as automated driving, smart cities etc.
- Commercialisation of project results is viewed as important in the US as is shown by the large number of initiatives from research organisations in this field (e.g. NSF, DOE, DOT).
- A special role is played by ARPA-E, the Advanced Research Projects Agency-Energy of DOE, that is tasked with promoting and funding research and development of advanced energy and transport technologies. ARPA-E is modelled after the successful DARPA, the agency credited for innovations like GPS and computer networking.
- As a relatively new agency (first projects were funded in 2009) ARPA-E aims to support projects that are too early for private sector investments and advance to such a level that they can become commercially viable over a limited amount of years. ARPA-E has established both tailor-made programmes on topics from connected and automated vehicles to renewable transport fuels as well as open calls to fund potentially disruptive technologies in the energy and transportation sector. By combining these two ways of funding RTD, ARPA-E is seen as an agency that can more effectively generate new ideas to innovation that other, more established, agencies.

With regards to budgets, we can conclude the following from the programmes and calls that were analysed in detail. For specific calls / research programmes aimed at specific technologies, such as CAV, ITS or battery research budgets of about 10 – 30 million USD is available. These budgets are based on calls (e.g. Funding Opportunity Announcements) with a relatively narrow scope and specifically defined research topics. Overall funding programmes for transport related RTD can have budgets around 50 – 100 million USD per year. The whole ARPA-E annual budget for energy & transport research was around 300 – 350 million USD per year (years 2016 o 2018).

Some information was gathered on the duration of funding application process from publication of the FOA until the award notification. Funding calls of DOE (including ARPA-E) and DOT have a duration of approx. 6 months, the procedure at NSF takes longer, around 9 – 10 months. The DOE and DOT calls analysed are all two phase procedures, starting with the submission of a concept paper, a pre-selection and then the submission of the full proposal.

Grant funding practices identified

Best practice examples are discussed in Section 3.3. As interesting funding examples for further assessment and benchmarking to the best practice example are the following four funding programmes:

- the APRA-E programme NEXTCAR, addressing connected and automated vehicles as well as reducing energy consumption in future vehicles
- the Energy, Power, Control and Networks (EPCN) programme of the NSF
- the Advanced Vehicle Technologies Research funding opportunity of EERE, financing research in the field of vehicle materials and batteries
- The DOT Small Business Innovation Research Programme, addressing RTD for Intelligent Transport Systems, financing RTD initiatives by SMEs.

2.2 Japan

2.2.1 Visions and targets for road transport RTD

The Japanese government recognises that the transport sector is undergoing enormous changes, as is the Japanese society itself. These changes are related to technological development, environmental challenges and the aging of the population in Japan.

During the coming years, Japan needs to redirect its economy, whilst retaining its position as a leading RTD nation and not falling behind other Asian countries (especially China). It remains the third largest research-producing nation, in terms of share of global scientific production, and is near the top in trade and industry RTD expenditures (Giannopoulos, 2018).

Background to research policy

The Japanese government published a number of policy documents that highlight the main challenges and developments in RTD and the ways how to address them. The basic documents for directing national research and innovation are the so-called Science and Technology Basic Plans (ST&I Basic Plans). Other important research policy documents are:

- The Basic Plan on Transport Policy (2015)
- The New Industrial Structure Vision (2017)
- White Paper on Land, Infrastructure, Transport and Tourism in Japan (2016)
- White Paper on Manufacturing Industries (2016)
- Japan's Energy White Paper (2017)

Science and Technology Basic Plans

To structure the direction of science, technology and innovation, the Japanese Council for Science and Technology Policy (CSTP) initiated a Basic Planning process that is a multi-year, government-wide planning activity coordinated at the Cabinet Level. Key documents for this process are the Science and Technology Basic Plans (ST&I Basic Plans), which have a duration of four years and are the Japanese government's principal steering document for RTD policy. The fifth and latest ST&I Basic Plan was published in 2015. This latest Science and Technology Basic Plan is strongly promoted as a major policy document for the economy, society and the public, addressing the following trends and developments (Giannopoulos, 2018):

- Creation of a Super Smart Society – shape Japan's future – create new value, services and businesses
- Strengthen RTD&I achieve knowledge implementation
- Guide in transformational change in a broad range of industrial structures such as manufacturing, logistics, sales, transportation, health and medical care, finance and public services.

The 5th ST&I Basic Plan mentions "Intelligent Transport Systems" specifically as one of eleven systems to reach a Super Smart Society (Council for Science, Technology and Innovation, 2015).

The Basic Plan on Transport Policy (2015), developed by the Ministry of Land, Infrastructure, Transport and Tourism, highlights the expected developments in the transport sector. The ministry identifies the need to realize user-friendly transport that contributes to the welfare of the citizens and the need to create a new foundation for sustainable, secure and safe transport. The latter need is aimed at further low carbonization & energy conservation.

Another national policy document giving insight in the national RTD priority areas in the field of transport is the New Industrial Structure Vision of the Ministry of Economy, Trade and Industry (METI). This document outlines future steps and strategies toward realizing Society 5.0[32].

The Japanese government[33] defines Society 5.0 as a society where various social challenges can be resolved by incorporating the innovations of the fourth industrial revolution (e.g. IoT, big data, artificial intelligence (AI), robot, and the sharing economy) into every industry and social life. By doing so the society of the future will be one in which new values and services are created continuously, making people's lives more conformable and sustainable. This is Society 5.0, also called a "super-smart society". Japan is planning to take the lead to realize this ahead of the rest of the world.

The New Industrial Structure Vision leverages Japan's strengths to realize an active Society 5.0. These strengths include Japan's capacity to gather and use data, its pioneering use of technology to create innovative products, and its drive to offer solutions to developing social issues. METI has identified how each of these strengths can be used to solve problems in the fields of Mobility, Supply Chains, Healthcare and Lifestyle. The figure below shows the opportunities and strengths in the mobility sector. According to the METI, breakthrough projects in each field are expected to drive solutions for the future and generate further economic growth.

AREAS OF STRENGTH/ OPPORTUNITIES	DATE USE	INNOVATIVE PRODUCTS	SOCIAL ISSUES
Mobility 	Data on driving control collected from vehicle-mounted sensors and auto manufactures	World's largest market share in passenger vehicles: 30%	People with difficulty travelling (including approximately 40 million without a driver's licence and 2.36 million living 1km+ from public transit)
			26.7% citizens are 65+
			Labour shortage in the logistics industry: ~ 40,000 workers

Another future challenge recognized by METI is the shortage of commercial drivers which has grown more acute as the population ages. Furthermore, an increase in elderly drivers of passenger vehicles has caused more traffic accidents and a subsequent rise in fatalities. This creates a strong focus in RTD on automated mobility solutions for people and goods nationwide. The summary of a planning roadmap,

[32] Also mentioned in the 5th ST&I Basic Plan
[33] The Government of Japan: https://www.japan.go.jp/abenomics/_userdata/abenomics/pdf/society_5.0.pdf

shown below, highlights the issues of automated driving and (truck) platooning for the short- to long-term future.

	Short Term (~ 2018)	Medium Term (~ 2020)	Long Term (2020 ~)
HUMAN MOBILITY (automated driving)		Deploy automated transportation services in select areas	Expand coverage areas and develop the autonomous vehicle (AV) market
MOBILITY OF GOODS (platooning)		Introduce platooning (AVs led by human operators) on expressways	Commercialize expressway platooning
MOBILITY OF GOODS (drones)	Operate drones beyond visual line of sight (BVLOS) to deliver goods in uninhabited areas		Full-scale operation of BVLOS drone delivery services in inhabited rural and urban areas

The Ministry of Land, Infrastructure, Transport and Tourism (MLITT) issued a White Paper in 2017 where it states the importance of promoting innovation through the use of ICT. The White Paper mentions the main policy priorities in the field of RTD (also related to transport) that respond to a number of observed weaknesses.

One of the key weaknesses observed is related to the intensification of international competition. Companies in Japan and around the world are tending to divert much of their RTD expenditure into short-term research. The attention for medium- to long-term RTD investment, that takes more than three to five years until commercialization, shows a decreasing trend in private sector RTD investment (MLITT, 2017).

The role of the government is, therefore, of key importance in the support of medium- to long-term RTD. At the same time there is a need to establish an innovation system leading from business conceptualization through RTD to market acquisition and development. The White Paper also notes that the number of venture company start-ups in Japan, that would assist with the RTD commercialisation, is stagnating in Japan (at least when compared to other countries). This is a difficult situation for the creation of innovation by SMEs and venture companies.

In addition, the MLITT has published a new Technology Basic Plan (the 4th MLITT Technology Basic Plan[34]) in March 2017, extending to 2021, as a guideline for technology policy, including technological development, in the administration of Japan's land, infrastructure, transport and tourism. The new plan has three pillars

1. the use of the Internet of Things, Artificial Intelligence, and big data, with people as the focus;
2. responses to socioeconomic problems; and
3. the advancement of technology policy that will realize desirable cycles.

[34] Not to be confused with the Science and Technology Basic Plan from the CSTP

It seeks to realize a sustainable society by promoting a revolution in productivity and a reform of working styles through the creation of new value.

The plan seeks to advance technological research and development effectively and efficiently, promoting collaboration between industry, academia and government, with each becoming a major actor and realizing their optimum effort.

2.2.1.1 Japanese RTD priorities

Based on national policy documents, several priorities in the field of RTD can be identified. Among the first of them are Intelligent Transport Systems (ITS), ITS is expected to play a major role to reduce traffic congestion and is expected to reduce traffic congestion in 2020 to half compared to that in 2010. According to the STRIA report (European Commission, 2017), Japan's efforts to push connectivity and automation systems from different factors. The biggest driver is the country's ageing society. Apart from that, the country's scarcity of resources, the aim to reduce traffic fatalities, and the avoidance of congestion are further drivers.

Other topics that are among the RTD priorities for the coming years are the following:

- Truck platooning and platooning of personal cars (with the involvement of Japanese OEMs)
- Next Generation of Transportation Systems (multimodal transport) – public transport, passenger cars and pedestrians.
- Hydrogen and fuel cells – establishing a "hydrogen society" where fuel cells power homes and office buildings, as well as Fuel Cell Electric Vehicles (FCEV).

Truck Platooning

Between 2010 and 2015 Japan's Energy ITS project has been developing and testing platooning of fully automated trucks. The project was funded by METI through its agency NEDO with about USD 12 million per year for five years. The project was co-ordinated and managed by the Japan Automobile Research Institute (JARI) and involved a multitude of different universities and only indirectly truck manufacturers. The primary goal was to attain energy savings through the reduction of aerodynamic drag by operating trucks in an electronically coupled platoon at shorter-than-normal gaps. The reduction in aerodynamic drag for following vehicles, and build-up of pressure behind the lead vehicle yields impressive fuel efficiencies, with various tests reporting convoy savings of between 5% and 10%, with most fleet operators attributing some 30 to 40% of their operating costs to fuel expenditure. Further objectives were the improvement of highway traffic flow and safety. The Japan market is expected to witness a notable number of factory-equipped truck platooning systems by 2022, owing to the slow uptake of connected truck technology. After the end of the governments funded project, some Japanese OEMs continue with their own project, one of them Hino Motors[35].

The Japanese transport ministry, along with the government's IT strategy office and industry ministry, is aiming to start truck platooning pilot programs on public roads in 2018, with the goal of going mainstream

[35] https://driverless.wonderhowto.com/news/hino-motors-leads-way-japans-planned-2020-rollout-commercial-truck-platooning-0176299/

in 2020. Specifically, a dedicated lane on the Shin-Tomei Expressway was proposed by the group, which is a busy route that operates between Tokyo and Nagoya.

The vehicles being tested will support SAE Level 2-3 self-driving technology, requiring a human driver in each truck to monitor the vehicular system. They will also be prepared to handle any situations that may cause disengagements, i.e., the mitigation of malfunctions in driverless systems through human intervention (taking control of the wheel).

Hydrogen and fuel cells

Another very important topic within the Japanese transport sector is the development of fuel cells. For that purpose, the Japanese government set up the Strategic Roadmap for Hydrogen and Fuel Cells, subsidizing the construction of hydrogen stations and reviewing regulations to transition re-source-scarce Japan to alternative energy sources. The roadmap was part of the vision of a "hydrogen society" where fuel cells power homes and office buildings, as well as cars. The government estimated that the nation’s hydrogen market could expand to JPY 1 trillion by 2030. The goal is 1,000 stations and 50,000 FCEVs deployed by 2020, and 5,000 stations and 1 million FCEVs by 2030. (European Commission, 2017).

This document was followed by the Basic Hydrogen Strategy, published in December 2017 (Ministerial Council on Renewable Energy, Hydrogen and Related Issues, 2017). This Strategy states future visions that Japan should achieve with an eye on 2050 and also serves as an action plan to accomplish the visions by 2030. The strategy sets a goal that Japan should reduce hydrogen costs to the same level of conventional energy (e.g., gasoline and LNG) and to achieve the goal, provides integrated policies across ministries ranging from hydrogen production to utilization under the common goals.

The core issue of hydrogen use in the mobility sector is the expansion of FCVs and hydrogen stations. Japan aims to increase the number of FCVs in Japan to 40,000 units by 2020, to 200,000 units by 2025, and to 800,000 units by 2030. According to the plan the number of hydrogen stations in Japan should also be expanded to 160 by 2020 and to 320 by 2025 and make hydrogen stations independent by the second half of the 2020s.

To this end, Japan will promote regulatory reform, technological development, and joint strategic hydrogen station development by the public and private sectors. To secure the optimum locations for hydrogen stations, Japan will attempt to develop renewable-based hydrogen stations in conjunction with commercial hydrogen station development.

The use of hydrogen fuel will not only be limited to passenger cars, Japan aims to increase the number of FC buses to around 100 by 2020 and around 10,000 by 2030 and the number of FC forklifts to around 500 by 2020 to around 10,000 by 2030.

There are also plans to develop and commercialise FC trucks. As trucks (for business and personal uses) account for 36% of the transport sector’s total CO_2 emissions and record high CO_2 emissions per transportation volume, there is great potential to reduce CO_2 emissions for this category.

Maximum driving distances must be extended, and powertrain weight limited to eliminate CO_2 emissions. To this end, batteries for electric trucks and hydrogen tanks for FC trucks must be increased. Given the mass of batteries and hydrogen tanks, FC trucks have advantages over electric trucks for transportation ranges over 100 km.

Commercial trucks number more than 3.2 million units in Japan, with greater potential to consume hydrogen than buses (230,000 units). Large FC trucks including distribution vehicles for convenience stores have been analysed in Japan and other countries. The Strategy states that Japan will promote their technological development in a bid to diffuse FC trucks.

Concerning the utilization of hydrogen, METI focused on the difference in time periods required for solving technical challenges and for securing economic efficiency, and decided to advance efforts by categorizing them into three phases, as follows[36]:

- Phase 1: Expanding the scope of applications for fuel cell technology, e.g., fuel cells for households and fuel cell vehicles (which have been brought into use recently), and aiming to achieve dramatic energy conservation as well as acquiring a new global market (started in 2015);
- Phase 2: In terms of the supply side measures, establishing a system for supplying hydrogen using unconventional energy resources imported from other countries, while, for the demand side, aiming to enhance energy security measures, keeping an eye on full-fledged introduction of hydrogen power generation (time frame: putting the technology into practice by the late 2020s);
- Phase 3: Targeting the establishment of a carbon-dioxide-free hydrogen supply system using renewable and other energy (time frame: putting the technology into practice around 2040).

Another stream of efforts is put on biofuels. In its 2010-plan the government of Japan stated that it wants to introduce 500 million litres (crude oil equivalent) by 2017 and has mandated the oil industry to meet the goal. In turn, the industry is expected to introduce into the market 1.940 billion litres of bio-Ethyl Tert-Butyl Ether (ETBE) in 2017, which is equal to 500 million litres (crude oil equivalent) of biofuels, nearly all of which will be imported. These targets are confirmed in the 2017 National Biofuel Policy from 2018 to 2022.

When considering biofuels, there are two significant issues that Japan takes into account: food versus fuel and carbon emissions. Japan has a low self-sufficiency rate for food, it imports the majority of the food its citizens consume. As a result, Japanese people are highly sensitive to issues of rising food prices, leading to a broad debate within Japan about the use of food crops to produce biofuels. For this reason Japan is focusing research efforts on cellulosic ethanol technology, which does not compete with food.

Private RTD Initiatives of Japanese manufacturers

In addition to the RTD support provided by government, large industrial companies in Japan, including OEMs, have identified their own research priorities.

Toyota is putting their vision of smart mobility “Ha:mo", a next-generation urban transport system that has been tested in Toyoda City, Grenoble and Tokyo. Ha:mo, short for “Harmonious Mobility Network”, aims for optimally combining personal mobility vehicles such as automobiles with public transportation. The system features new mobility options such as the "Toyota i-Road" personal mobility concept car, "COMS" ultra-compact single-occupant electric vehicle and "Winglet" an ultra-compact personal transport assistance robot. In addition, there is a platooning project developed by Toyota. The company develops

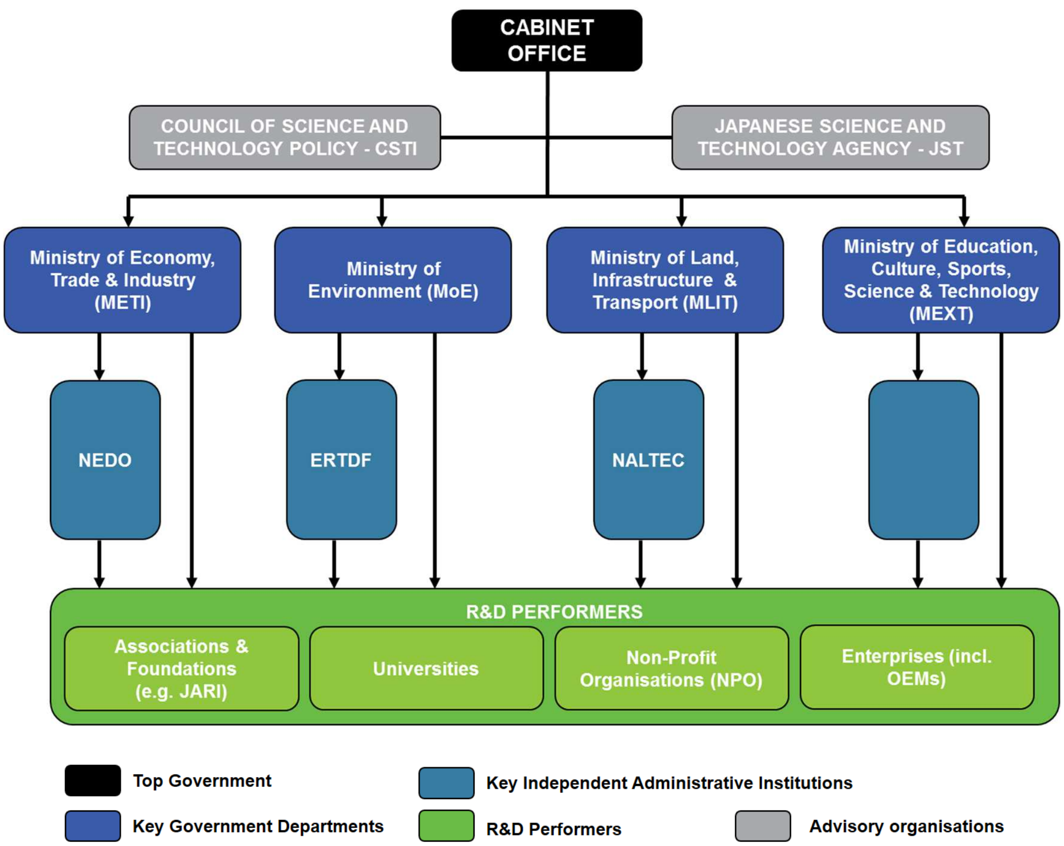
[36] Source: http://www.meti.go.jp/english/press/2014/0624_04.html

and tests a platoon of three Lexus LS-460 passenger cars that follow each other closely to reduce fuel consumption.

Fujitsu uses real-time display of information to generate a predictive determination of what there is to come and what there is to be done. By doing so, they want to realize a modal shift, improving the user/passenger experience and facilitating the management for urban transportation. To do so, Fujitsu Laboratories and MIT have partnered up to develop an on-demand transportation technology that dynamically assigns the same vehicle to different modes of transport depending on demand. Thus, they can balance vehicle oversupply or shortages. The partnership shall respond to various needs of transport users while increase profits for operators. The main driver is Japan's aging population and efforts to increase sustainability.

2.2.2 Governance and funding system

Research governance in Japan is a hybrid that combines centralised top-down control with supplementary "bottom-up" input from associations, research centres, major industrial sectors, corporations and academia. Strategic RTD&I policy is set at the highest levels of government based upon input from academia and corporations. A schematic representation of the Japanese TD policy is shown below.



The Japanese public RTD funding structure (based on EAGAR (2010) and recent developments)

The top body for formulating and monitoring the implementation of the Japanese RTD&I policies is the Council of Science and Technology Innovation (CTSI) whose Chair is the Prime Minister and members of the seven most relevant Ministers. One of the most important tasks of the Council is to oversee the implementation of the 5-year Science and Technology Basic Plans.

Under the leadership of the Cabinet Office and the Minister of STI Policy, the Council for Science, Technology and Innovation serves as the headquarters for the promotion of STI policy; it overlooks all of the nation's science and technology, formulates comprehensive and basic policies, and conducts their overall coordination (MLITT, 2017).

The roles of the CSTI are as follows (MLITT, 2017):

- Investigate and discuss basic policies concerning science and technology - "The Science and Technology Basic Plan" (every five years), "Comprehensive Strategy on Science, Technology and Innovation" (annually)
- Investigate and discuss science and technology budgets and the allocation of human resources - "Comprehensive Strategy on Science, Technology and Innovation" (annually)
- Assess nationally important research and development - Evaluation and follow-up of large-scale R&D, "General Guidelines for Evaluating Government Funded R&D"
- Decide other key issues surrounding the promotion of science and technology - Decision-making regarding cross-ministerial programs as
    - the "Strategic Innovation Promotion Program" (SIP) and
    - the "Impulsing Paradigm Change through Disruptive Technologies Program" (ImPACT)

Among the most active ministries for RTD&I is the Ministry of Education, Sports, Science and Technology (MEXT). The MEXT is actively involved in supervising universities and coordinating independent research institutes. The research part of the ministry is covered under the Science and Technology Policy Bureau, the Research Promotion Bureau and the Research and Development Bureau.

The Science and Technology Policy Bureau plans, formulates and implements science, technology and innovation policies which aim to realize sustainable growth in the advancement of society. Moreover, the bureau has established the Council for Science and Technology.

The MEXT mainly supports fundamental research carried out at universities. The Research and Development Bureau promotes among others RTD in the field of energy and environment. E.g. MEXT promotes research and development on innovative technologies, such as next-generation semiconductors and storage batteries, aimed at reducing greenhouse gas emissions.

In the field of automotive research, the most relevant ministry is the Ministry of Economy, Trade and Industry (METI). A significant part of funded Japanese automotive RTD is distributed through METI & NEDO (New Energy and Industrial Technology Development Organisation). NEDO was established in 1980 to promote the development and introduction of new energy technologies

The Ministry of Land, Infrastructure, Transport and Tourism (MLITT) is the government body of national transportation that also has its own research grant programme with several related bodies and committees.

The Ministry of the Environment is the government body for national environmental policy. The Ministry includes the Environment Research and Technology Development Fund (ERTDF) – cover transportation related research such as climate change and environmental sustainability

2.2.3 Overview of the funding organisations and other key stakeholders

Other involved public organisations with road transport RTD are:

- Japan Society for the Promotion of Science (JSPS)
  - Vast array of programs that are essential to promoting scientific research including Grants in Aid for Scientific Research)
- Japan Science and Technology Agency (JST) – core institutions for RTD in all fields including transport
  - Centre of Innovation Program (COI)
- National Agency for Automobile and Land Transport Technology (NALTEC) was established through the integration of two Independent Administrative Agencies, the National Agency of Vehicle Inspection and the National Traffic Safety and Environment Laboratory (NTSEL). The NALTEC is carrying out its own research work:
  - Automotive research (automated driving systems and fuel cell vehicles)
  - International Harmonization Promotion (representing Japan at international meetings, e.g. the World Forum for Harmonization of Vehicle Regulations - UN-ECE/WP29)

In addition, a key role in RTD is also played by:

- Universities and University Research Institutes
- Private Corporations (primarily the large Japanese OEMs)
- Independent think-tanks and consulting companies (such as the independent Japan Automobile Research Institute JARI)[37]

It was concluded in the EAGAR study (European Commission, 2010) that automotive RTD was mainly carried out and funded by Japanese OEMs. Until recently, Japanese automakers were doing their RTD independently. According to Daisho (2015), there is a large difference between RTD styles in Japan and in Europe. Japanese automakers tend to conduct RTD independently while European automakers collaborate in so-called pre-competitive areas. To cover this lack of cooperation between Japanese OEMs, the Research Association of Automotive Internal Combustion Engines (AICE) was founded in April 2014. Formed by eight Japanese automotive manufacturers, AICE is a research collaboration consortium operated by organizations throughout Japan.

[37] More information about this independent institute can be found at: http://www.jari.or.jp/tabid/200/Default.aspx

The AICE is seen as a leading precompetitive research collaboration[38] centre to do research on the next generation automobiles. The rationale for establishing such a centre was the recognition that to remain at the forefront of international competition, Japanese manufacturers, universities and research institutions should not only compete but also cooperate.

2.2.4 Overview of existing grant programmes and relevant calls

This section gives an overview of existing grant programmes and calls in Japan, related to transport research. Of importance for the transport sector are:

- Cross-Ministerial Strategic Innovation Promotion Program (SIP) – within this programme eleven key RTD themes are identified and funding is provided from basic research to application and commercialisation.
- Programmes of NEDO - New Energy and Industrial Technology Development Organisation
    - Energy ITS[39] Programme – 5-year programme, funded at about ¥ 1 billion (approx. US$ 12 million) per year, started in 2008 with the explicit goal of reducing CO_2 emissions through use of ITS strategies
    - Additional programme calls for battery research / fuel cell research, calls for proposals for these calls are open since 2013
- The Ministry of Economy, Trade and Industry (METI) supports RTD for industrial technologies and energy. Autonomous driving, batteries for electric vehicles and hydrogen are their most important topics. The support is organised in a relatively complex way as each division of the ministry promotes different programs independently (Nagai, 2018)[40].

Other programmes with some link to transport RTD are:

- Ministry of Land, Infrastructure, Transport and Tourism, has its own research grant programme with several related bodies and Committees, e.g. the CART (Committee on Advance Road Technology), which is related to road transport research
- The program "IMpulsing PAradigm Change through disruptive Technologies (ImPACT)" invests another JPY 55 billion (between 2014 and 2018) for the program "IMpulsing PAradigm Change through disruptive Technologies (ImPACT)" that promotes high-risk, high-impact RTD. In the 5th version of the Science & Technology Basic Plan (2016-2020) the ImPACT project shall be continued to act as a model case for extending similar schemes to the RTD projects that may not have a high probability of yield (high-risk research) but that can be expected to have a significant impact if successful. No direct transport related funding is provided within this programme. But it is not excluded that some of the research topics may have transport applications in the future (e.g. Internet of Things, charging, materials research).

[38] The term "precompetitive research collaboration" refers to researchers cooperating at a national level to conduct joint research that reduces inefficiencies and develops next-generation fundamental technology as quickly and efficiently as possible (Daisho, 2014)

[39] ITS – Intelligent Transport System

[40] Information from Takehiko Nagai, NEDO Europe office.

2.2.4.1 The New Energy and Industrial Technology Development Organization (NEDO)

NEDO was established against the backdrop of two oil crises as a semi-governmental organization in 1980 to promote the development and introduction of new energy technologies. Research and development of industrial technology was later added, and today NEDO is active in a wide variety of areas as one of the largest public research and development management organizations in Japan.

NEDO plays an important part in Japan's economic and industrial policies, as one of the largest public research and development management organizations. It has two basic missions:

I) addressing energy and global environmental problems, and
II) enhancing industrial technology.

Regarding the first mission of addressing energy and global environmental problems, NEDO supports technology development to achieve higher efficiency and lower cost, with a primary goal of developing new technologies and ensuring that project results are introduced to the market. For that purpose, NEDO is supporting commercialisation of project results through support for SMEs and venture business creation.

As for the second mission of enhancing industrial technology, NEDO has achieved a wide range of results by playing an important role as a catalyst for collaboration between industry, academia and government, by promoting exchanges of knowledge and ideas between private sector companies, universities and public research institutions.

New activities were undertaken in recent years (FY2016 and FY 2017) in such fields as the Internet of Things (IoT), big data, artificial intelligence (AI), and robot sensors, with the aim of achieving technological breakthroughs. As part of this, NEDO established the Internet of Things Promotion Department and reorganized the Robot and Machinery System Technology Department as the Robot and Artificial Intelligence Technology Department.

For the FY2017, the following research priorities were identified (budget of nearly €1 billion, NEDO (2018a)[41]):

- New energy (326 million EUR)
- Energy conservation (78 million EUR)
- Rechargeable batteries and energy systems (26 million EUR)
- Clean coal technology (119 million EUR)
- Environment and resource conservation (20 million EUR)
- Electronics, information, and telecommunications (96 million EUR)
- Materials and nanotechnology (97 million EUR)
- Robot technology (85 million EUR)
- New manufacturing technology (25 million EUR)

Transport related research was covered under the priorities of New Energy (Fuel cells and hydrogen), Energy Conservation and Rechargeable Batteries and Energy Systems.

[41] Source, Profile of NEDO, 2017: http://www.nedo.go.jp/content/100864279.pdf

Then there is a special budget for "Support for International Expansion", 130 million EUR in 2017, that includes some transport related research activities. NEDO introduces advanced Japanese technologies to countries and regions around the world having diverse needs and infrastructures. These international projects have been realised all over the world, major examples are:

- Russia - Demonstration Project on a Self-Controlled Advanced Traffic Signal System
- Indonesia - Demonstration Project for the Spread of Compressed Natural Gas Vehicles and Refuelling Infrastructure Including Support of Development of Sustainable Environment
- Malaysia - International Demonstration Project for Introducing Electric Vehicle Buses with Fast-Charging System
- USA (California) – Demonstration Project for Electric Vehicle Driving Behaviour in California

2.2.4.1.1 NEDO – project examples

NEDO is directly financing multi-annual projects that address major transport research topics. A very important topic for NEDO is battery research. NEDO initiated the development of a new innovative battery in FY2016 whose performance exceeds that of lithium-ion batteries (NEDO, 2018b).

Rechargeable Batteries and Energy Systems

NEDO is promoting the development of basic technology for practical application in innovative batteries, with energy density of 500 Wh/kg by 2030. Project name: *Research and Development Initiative for Scientific Innovation of New Generation Batteries 2* (RISING 2), project running from 2016 to 2020. Main contractor: University of Kyoto

Aiming at realizing a competitive electric vehicle with a cruising distance between recharges of 500 kilometres (a distance similar to that of gasoline vehicles between refills) by 2030, NEDO has, through a close partnership between industry, academia and government, carried out the development of basic technology for promoting the practical application of innovative batteries with an energy density of 500 Wh/kg. In this research, advanced analytical technology was utilized with the aim to develop the world's highest quality and most advanced batteries by 2030.

Another important research topic for NEDO is Fuel Cells & Hydrogen. For over 30 years, NEDO has been making efforts to develop fuel and hydrogen technologies. The polymer electrolyte fuel cell (PEFC)-based ENE-FARM system was commercialized in 2009, and a solid oxide fuel cell (SOFC)-based version followed in 2011. More than 190,000 units have been installed to date. Fuel cell vehicles (FCVs) were launched in the market in December 2014.

Examples of fuel cell and hydrogen projects financed by NEDO are the following (NEDO, 2018b):

- Research and Development Project on Hydrogen Utilization Technologies (2013-2017)
- Technology Development for Promotion of Practical Applications of Solid Oxide Fuel Cells (2013-2017)
- Pilot Research and Development Project on Hydrogen Utilization (2014-2017)
- Technology Development Project for Construction of a Hydrogen Society (2014-2020)
- Technology Development for Promotion of Practical Polymer Electrolyte Fuel Cell Applications (2015-2019)

As NEDO aims to create markets for hydrogen energy, it is also focusing on developing technologies necessary for power generation using hydrogen, establishing a large-scale hydrogen supply chain and zero emission systems integrating renewable energy and hydrogen.

Hydrogen and fuel cells remain an important policy and research topic for Japan, as already addressed in the Basic Hydrogen Strategy (section 2.2.1.1). Therefore, FCVs are expected to become widely available in the near future. In order to expand spreading of fuel cells, NEDO is working to develop SOFC systems for commercial use with the aim of launching such systems in the market in 2017. Basic technologies to upgrade fuel cells for FCVs, including durability evaluation and reaction analysis of PEFCs, are also being developed. In addition, NEDO is also financing the development of technologies to construct and operate hydrogen refuelling stations at lower cost and a review of relevant regulations. This research programme, addressed as one of the good practice examples in section 3, aims to accelerate market access for hydrogen technology in the transport sector.

2.2.4.1.2 NEDO – Project management cycle

NEDO carries out a variety of activities from technology development to dissemination of results. Such activities include information gathering around the world, and strategy formulation, implementation, and evaluation of projects in various fields. Such an "extended project cycle" runs from identification of technology trends through project selection and realisation to final review:

- Analysis of technology trends and formulation of strategies for technology fields - NEDO actively analyses information on technology fields both inside and outside of Japan. The
- information is then used to formulate technology strategies, set milestones and develop project plans
- Technology development to support progress in fields with a promising future – NEDO sets goals for technology development by studying technology trends – looking five to ten years in the future
- Technology development and demonstration testing – NEDO promotes technology development projects as well as large-scale demonstration projects which are difficult for private companies to carry out by themselves.
- Review and follow-up monitoring – After a project is completed, an evaluation is conducted by a third party and the project's results are thoroughly assessed. In addition, NEDO conducts follow-up monitoring of results to examine the economic and social effects of the project. Information collected during monitoring is also used to improve future project management.

Approach to conducting evaluations:

In addition to planning and implementing technology development projects, NEDO conducts evaluations during project implementation. Using a plan-do-check-act (PDCA) cycle which incorporates evaluation results in the planning process, NEDO endeavours to improve its management to carry out appropriate technology development which achieves excellent development results.

NEDO carries out a pre-project evaluation during the planning stage, a midterm evaluation about three years after the start of project implementation, and a post-project evaluation after project completion. Mid-term evaluation results are incorporated into tasks such as conducting a review of the technology development plan, and post-project evaluation results are useful for improving future planning and management of technology development projects.

In the FY2016, 12 mid-terms and 11 post-project evaluations were conducted.

For a period of five years after a project ends, follow-up monitoring of project participants is carried out using surveys and other information collection techniques. This monitoring is used to ascertain the utilization of NEDO project results and to analyse key issues for transferring them to practical application. After the results are introduced to the market in products or services, they are designated as “NEDO Inside Products” and NEDO provides an estimated sales performance forecast on its website. In addition, reports on the researchers involved and how they achieved practical application are published as “NEDO Project Success Stories.” In the FY2016, follow-up monitoring surveys were administered to a total of 974 companies, organizations and other entities five years after project end.

2.2.4.2 Details of calls for proposals - NEDO

NEDO is currently funding a large number of research initiatives through calls for proposals, some of it are own research, some of it related to financing sub-projects of other programmes.

In 2017 NEDO funded sub-projects related to the SIP program for Automated Driving System / Large Scale Trial Tests[42]. These subprojects, with a one-year duration, were in the category of Production technology, Machine systems, Robot – Artificial Intelligence. The research programme addresses applied research (TRL between 4 to 6). The budget for 2017 per topic was the following (incl. amounts in €):

- Dynamic maps (450 million JPY – 3.5 million €[43])
- Survey of overseas actions for international coordination of Dynamic Maps (10 million JPY – 77,000 €)
- Survey of specification related to traffic lane information (10 million JPY – 77,000 €)
- Utilization of probe information from vehicle dynamic map (20 million JPY – 154,000 €)
- Human Machine Interface (414 million JPY – 3.2 million €)

[42] http://www.nedo.go.jp/activities/ZZJP_100125.html (In Japanese)
[43] Exchange rate 31st of July, € 1 = 129.75 JPY (www.oanda.com)

- Information Security (up to 80 million JPY per topic – 617,000 €)
- Reduction of pedestrian accidents (58 million JPY – 447,000 €)
- Next generation city traffic (260 million JPY – 2 million €)

Calls for proposals were published online on the NEDO website and the names of the companies that got awarded can be found as well[44]. As illustration the example for the topic of Dynamic Maps is given:

- Objective of the call: It is related to specification and confirmation test for dynamic & high precision maps, related data update and transfer, and integration in the vehicle.
- Contractor should apply for one of the three tasks:
  a- to establish dynamic map prototype, equipment or functional center
  b- to organize and manage large scale test
  c- automatization and actualization of map information

For the FY 2018 NEDO again published a call for proposals, funding several topics related to the SIP program for Automated Driving System / Large Scale Trial Tests[45]. The sub-projects promoted are:

- RTD related to infrastructure conditions for next generation city traffic system conformity (year 2018, 50 million JPY – 385,000 €)
- Information provider business (until 20/3/2019, up to 50 million JPY)
- Survey and issue analysis of future needs of automated driving system (until 20/3/2019, less than 10 million JPY – 77,000 €)

In addition, NEDO funds research in the field of Fuel Cells and in the field of hydrogen technology (e.g. infrastructure). Details of two programme calls are addressed in section 3: .

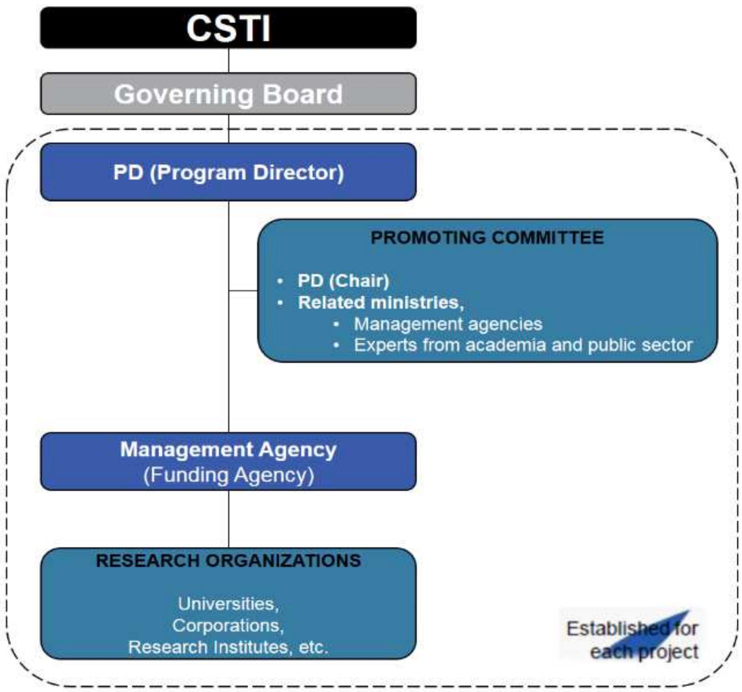
- The NEDO battery research programme – an RTD programme related to development of a new revolutionary battery cell.
- The NEDO programme on commercialising hydrogen research by improving different technologies for hydrogen usage.

2.2.4.3 The Strategic Innovation Promotion Program (SIP)

The SIP is one of the key programmes financing RTD in the field of energy (including combustion engines) and infrastructure. The programme is running from 2014 to 2018 with an annual budget of JPY 50 billion (385 million €). The programmes' main objectives are to realize science, technology and innovation through promoting RTD from overlooking from basic research to application and commercialisation by cross-ministerial cooperation.

[44] Call for application on the topic of "Dynamic Maps": http://www.nedo.go.jp/koubo/CD2_100073.html. Names of contractors that got awarded are published here: http://www.nedo.go.jp/koubo/CD3_100073.html
[45] http://www.nedo.go.jp/koubo/CD1_100111.html (Call text in Japanese)

The governance structure of the SIP programme is shown below. The Council for Science, Technology and Innovation (CSTI) selected the research themes and appointed program directors for each project and allocated budgets. Funding of the programme is provided by a number of different government agencies; the most important contributions are from the Japan Science and Technology Agency and NEDO (Council for Science, Technology and Innovation, 2017).



Currently, the SIP Programme identifies the following 11 RTD themes (Daisho, 2015):

Prioritised Societal Issues	Themes
ENERGY	Innovative combustion technology
	Next generation power electronics
	Structural materials for Innovation
	Energy Carriers
	Next generation technology for ocean resources exploration
NEXT GENERATION INFRASTRUCTURES	Automated driving system
	Infrastructure maintenance, renovation and management
	Enhancement of societal resiliency against natural disasters
	Cyber security for critical infrastructures
LOCAL RESOURCES	Technologies for creating next generation agriculture, forestry and fisheries
	Innovative design / Manufacturing technologies

The theme of “*Cyber security for critical infrastructures*” was added as an 11th RTD theme at the end of 2015. The allocated budget for these 11 themes in 2016 was 32 billion JPY[46] (247 million €).

In the field of road transport, of key importance are two programmes: 1) Innovative combustion technology and 2) Automated driving systems (Council for Science, Technology and Innovation, 2017).

1. **Innovative combustion technology** – The main objective is realising innovative combustion technology for maximum thermal efficiency of more than 50% to contribute to energy saving and CO_2 emission reduction, while developing world-leading researchers and building sustainable industry-academia collaboration in the field of combustion technology – financed with 2 billion ¥ (15 million €) per year from 2014 to 2018

   Within this theme, an industry-academia research collaboration project entitled “Research Project to Develop Technology of Clean Diesel Engine” was established thanks to matching funds from the Ministry of Economy, Trade and Industry (METI) and AICE. Waseda University oversees an annual research collaboration budget of 750 million JPY (5.8 million €) for the AICE clean diesel project and 200 to 400 million JPY (1.5 – 3 million €) for the SIP innovative combustion technology.

   Funding is provided by the Japan Science and Technology Agency

2. **Automated driving system** – the development of new transportation systems including technologies for avoiding accidents and alleviating congestion – budget for 2017 - ¥ 3.32 billion (average annual budget 2.45 billion JPY (19 million €) between 2014 and 2018).

   Funding is provided by a number of agencies: The Cabinet Office, National Policy Agency, Ministry of Internal Affairs and Communication, METI, MLITT and NEDO

This program is based on a public-private collaboration in which ITS-related ministries and five car manufacturers (Toyota, Nissan, Honda, Mazda and Subaru) participate to foster advancements of vehicle automation and connectivity.

The program aimed to achieve level 2 automation by the mid-2010s and aims to achieve level 3 by the early 2020s. Furthermore, it aims to contribute to the establishment of standardisation and harmonisation, as well as encouraging social acceptance, for the realisation and promotion of vehicle automation.

The scope of the project spans across different fields, including:

- development and verification of automated driving technologies;
- development of evaluation models and simulation technologies on vehicle behaviour and collision to effectively reduce traffic fatalities and congestion;
- international co-operation; and
- deployment for next generation urban transportation services

[46] Of the total abovementioned 50 billion JPY, 35 % (¥17.5billion) was allocated to medical fields.

Other programmes within the SIP that have some relation to transport RTD are the following:

- Infrastructure Maintenance, Renovation and Management – Realization of high quality infrastructure maintenance by cost-effective preventive measures, under the circumstances of serious accident risk increase and maintenance cost shortage because of aging. Creation of sustainable maintenance market, and promotion of expansion into overseas markets – budget for 2017 - ¥ 3.13 billion (24 million €). Funding is provided by MLITT, JST and NEDO.
- Cybersecurity for Critical Infrastructures – Development of technologies that monitor, analyse, and defend control and communication systems as well as confirm integrity and authenticity of system components to protect critical infrastructures against cyber threats – budget for 2017 - ¥ 2.62 billion (20 million €). Funding is provided by NEDO
- Innovative Design / Manufacturing Technologies – Main objective of this programme is to strengthen the global competitiveness of manufacturing in Japan – budget for 2017 ¥ 1.0 billion (7.7 million €). Funding is provided by NEDO.

2.2.4.4 Programme of the Ministry of Economy, Trade and Industry (METI)

One of the main tasks of the METI is to leverage stimulus policies to promote a private-sector productivity revolution. The METI support is focussed on three main topics[47]:

1. Investment to Promote Connected Industries, relevant topics are:
   - Standardize data formats and develop systems to support new business creation, leveraging data from autonomous vehicle tests and smart home appliances.
   - Support the development of next-generation AI chips and computing technology able to process increasingly complex data.
   - Support research and development programs in areas including robotics, biotech, drones and space technology.
   - Cooperate with the United States to develop human resources in cyber security through simulations targeting key infrastructure
2. Encourage SMEs and microbusinesses to achieve a productivity revolution
3. Measures to Promote Energy Policy Goals
   - Provide subsidies to support the introduction of hydrogen refuelling stations as part of wider efforts to develop a hydrogen-based transport system. Support pilot programs for new hydrogen fuel supply chains

2.2.4.5 RTD funded by METI

METI has its own RTD budget separately from NEDO. The main goal of METI is to leverage stimulus policies to promote a private-sector productivity revolution. METI's FY2018 initial draft budget amounts to approximately 1.3 trillion JPY (10 billion €) (METI, 2018). Its RTD programme includes three topics[48]:

- Promotion of connected industries
- Encourage SMEs and microbusinesses to achieve a productivity revolution
- Measures to promote energy policy goals

[47] http://www.meti.go.jp/english/aboutmeti/policy/fy2018/0119.html
[48] http://www.meti.go.jp/english/aboutmeti/policy/fy2018/0119.html

1. Investment to Promote Connected Industries
• Standardize data formats and develop systems to support new business creation, leveraging data from autonomous vehicle tests and smart home appliances. Promote intercompany data sharing. o FY2018 Initial Draft Budget: 6.7 billion JPY (52 million €) FY2017 Supplementary Draft Budget: 2.1 billion JPY (16 million €) • Strengthen standards-related information gathering and proposal functions and increase staff at international standards organizations to achieve international standards. o FY2018 Initial Draft Budget: 5 billion JPY (39 million €) • Support the development of next-generation AI chips and computing technology able to process increasingly complex data. • Support research and development programs in areas including robotics, biotech, drones and space technology. o FY2018 Initial Draft Budget: 61.4 billion JPY (473 million €) FY2017 Supplementary Draft Budget: 10.1 billion JPY (78 million €) • Cooperate with the United States to develop human resources in cybersecurity through simulations targeting key infrastructure. o FY2018 Initial Draft Budget: 4.2 billion JPY (32 million €)

2. Encourage SMEs and microbusinesses to achieve a productivity revolution
o Provide a package of programs including aid and technical support to Japanese SMEs to assist them in making investments to develop innovative services and prototypes as well as improve their manufacturing process, as part of broader policy efforts to promote the fourth industrial revolution. o FY2017 Supplementary Draft Budget: 100.0 billion JPY (8 billion €) • Publicize productivity-enhancing IT tools and support SMEs in introducing these tools to improve the efficiency of back-office operations and drive sales. o FY2017 Supplementary Draft Budget: 50.0 billion JPY (385 million €) • Provide consulting and other support to SMEs and microbusinesses to assist them in business succession planning, and recovery planning for those facing financial issues. o FY2018 Initial Draft Budget: 6.9 billion JPY (53 million €) o FY2017 Supplementary Draft Budget: 5 billion JPY (39 million €)

3. Measures to Promote Energy Policy Goals related to the transport sector
• Provide subsidies to support the introduction of hydrogen refueling stations as part of wider efforts to develop a hydrogen-based transport system. Support pilot programs for new hydrogen fuel supply chains. o FY2018 Initial Draft Budget: 299.9 billion JPY (2.3 billion €) FY2017 Supplementary Draft Budget: 7.0 billion JPY (54 million €)

- Continue to strengthen energy security. Specific measures to include the development of a network of emergency gas stations for use by local residents in the event of a major natural disaster, support for earthquake-proofing oil refineries, as well as strengthening the system for maintaining reserves of oil, LPG and other energy sources.
    - FY2018 Initial Draft Budget 265.3 billion JPY (2.0 billion €)
      FY2017 Supplementary Draft Budget Draft: 18.0 billion JPY (139 million €)

2.2.4.6 Summary table of RTD programmes in the field of road transport

The table below presents information about funding organisations and related programmes that at least partly address research in the road transport sector. Budget figures are for the financial year 2017 (*data provided by Ricardo Japan, 2018*). Most RTD programmes are financed through NEDO,

Organization (abbreviation)	Project name	Budget (Billion ¥)	Budget (Million €)	Note
New Energy and Industrial Technology Development Organization (NEDO)[49]	New Energy field	41.9	319.8	Solar, Wind, Bio,Tide/ Wave, Heat Regeneration,
New Energy and Industrial Technology Development Organization (NEDO)	Energy Conservation field	10.1	77.1	ITS (Platooning)
New Energy and Industrial Technology Development Organization (NEDO)	Storage battery / energy system field	3.3	25.2	Solid Batteries, Fuel cell, H_2 application
New Energy and Industrial Technology Development Organization (NEDO)	Electronic and information communication field	12.3	93.9	
New Energy and Industrial Technology Development Organization (NEDO)	Materials, Nanotechnology field	12.5	95.4	
New Energy and Industrial Technology Development Organization (NEDO)	Robot technology field	10.9	83.2	
New Energy and Industrial Technology Development Organization (NEDO)	International development support	16.6	126.7	International Cooperation
New Energy and Industrial Technology Development Organization (NEDO)	New Manufacturing Technology Field	4.2	32.1	

[49] http://www.nedo.go.jp/english/index.html

National Traffic Safety and Environment Laboratory (NTSEL)[50]	Safety, Autonomous	2.5	19.1	
National Agency for Automobile and Land Transport Technology (NALTEC)[51]	Safety, Autonomous	16.6	126.7	International cooperation (UN-ECE/WP29)
Strategic Innovation Promotion Program (SIP)[52]	Autonomous	3.4	26.0	Dynamic MAP/ Connected Vehicles/ Human Factors/ Impact Assessment/ Next Generation Transport/ Security
Japan Automotive Standards Internationalization Center (JASIC)[53]	ITS/AD-IG			
Japan Automobile Manufacturers Association, Inc (JAMA)[54]	Autonomous WG			
Japan Society of Automotive Engineering (JSAE)[55]	ITS Standardization Committee			
Japan Science and Technology Agency[56]	ImPACT - (Impulsing Paradigm Change through Disruptive Technologies Program)			

2.2.4.7 RTD funded by Japanese OEMS

As already noted in the 2010 EAGAR report, private investments contribute the majority of RTD spend in the automotive sector in Japan.

The private automotive RTD spend value is formed from the RTD spend of the eight largest Japanese car manufacturers by 2017, so does not include all automotive RTD; however, the RTD contributions of the three largest companies forms the vast majority of the RTD so the missing private RTD can be considered to be of minor significance.

50 https://www.ntsel.go.jp/e/index.html
51 NALTEC was established through the integration of two Independent Administrative Agencies, the National Agency of Vehicle Inspection and the National Traffic Safety and Environment Laboratory (NTSEL)
52 http://en.sip-adus.go.jp/
53 http://www.jasic.org/e/index_e.htm
54 http://www.jama-english.jp/
55 http://www.jsae.or.jp/en/
56 http://www.jst.go.jp/impact/en/index.html

This of course assumes that all the public spending programmes have been identified in this research, and this figure cannot be guaranteed either – some programmes may be missing, meaning that the public RTD spend would increase.

The following table shows the RTD spend of eight largest Japanese car manufacturers in FY2017[57].

Company	RTD Expenditures 2017 (Million JPY)	RTD Expenditures 2017 (Million EUR)
Toyota	1,037,500	7,996
Honda	685,300	5,282
Nissan	525,000	4,046
Suzuki	131,539	1,014
Mazda	126,900	978
Subaru	114,300	881
Mitsubishi	102,000[58]	786
Total	**2,722,539**	**20,983**

2.2.5 International collaboration in the field of RTD

Historically, Japan's self-reliant culture and science governance system impeded collaborations with the US and Europe. However, as Japan continues to face competition from a China committed to investing in science and technology, its national research governance systems have developed a more positive attitude to collaborations both regionally and with the US and Europe.

Japan encourages collaborations between universities and the private sector to catch up in critical scientific areas. While Japan remains a leader in several fields of the transport sector, such as hybrid vehicle technologies, they are lagging behind in many others including ITS, robotics and artificial intelligence (Giannopoulos, 2018).

Both public and private sector organisations are investing time and money in international collaboration:

- One of the main Japanese OEMs, Toyota, has recently invested quite heavily in collaboration efforts around the world. The bulk of the attention goes to US firms, research centres, universities, or individual researchers. In 2015, Toyota created the Toyota Research Institute in the US, with a budget of $1 billion for autonomous driving research. To support this Institute, Toyota has hired professors and researchers from Stanford University, MIT, and the entire staff of the autonomous vehicle company Jaybridge Robotics.
- Increasing cooperation is also taking place between Japanese universities and other similar institutions around the world. Examples are cooperation between Japanese and US universities

[57] In Japan from 01.04.2016 o 31.03.2017. Data based on Annual Reports of OEMs
[58] Total RTD expenditures in company are 201,330 million yen, 102,000 is automotive related (estimate)

- With the EU, the Japan Science and Technology Agency has signed, in 2011, the "Agreement between the European Union and the Government of Japan on Cooperation in Science and Technology". Under this agreement, co-funded research by the two sides (the EU and Japan) is taking place with several projects already assigned.

2.2.5.1 Examples of international cooperation programmes

Japanese participation is possible in most of the Calls for Proposals of the EC Horizon 2020 Programme. There are also 22 Call topics that specifically encourage cooperation with Japan in Horizon 2020 Work Programme 2018-2020. The main calls relevant for road transport area in 2019[59]:

- DT-ART-03-2019 Human centred design for the new driver role in highly automated vehicles (Deadline on 24 Apr 2019)
- DT-ART-04-2019 Developing and testing shared, connected and cooperative automated vehicle fleets in urban areas for the mobility of all (Deadline on 24 Apr 2019)
- MG-2-9-2019 Integrated multimodal, low emission freight transport systems and logistics (Inco Flagship) (From 16 Jan 2019 to 12 Sep 2019)

Cooperation was also supported in the 2018 calls: DT-ART-01-2018 and DT-ART-02-2018

Strategic International Collaborative Research Program

The „Strategic International Collaborative Research Program" (SICORP) of the Japan Science and Technology Agency supports both bilateral and multilateral programmes with selected countries including China, USA and the EU. But from those only the e-ASIA programme incorporates Intelligent infrastructure for Transportation research topic. This programme promotes multilateral collaboration with ASEAN (but also other) countries. A recent example of road transport projects is the IITSL: Intelligent Integrated Transport for Smart Life project between Japan, Thailand and Philippines. [60]

NEDO Japanese-German Co-Funding Programme

The Co-Funding Program aims to promote innovation in technological development through collaborative efforts in RTD projects with the German partners. The partnership should complement each other and demonstrate an added value to the project.

Intelligent Transportation Systems – EU, Japan and USA

An early example of international cooperation between the EU, Japan and the United States for the development of standards and technologies in the Intelligent Transportation Systems (ITS) domain, dates to 2010 when a Trilateral research agreement was signed between the EU, Japan and the United States to work together on the issues of ITS standards, architecture, safety, sustainability, automation, deployment and human factors. The agreement enabled all parties to stay updated with research and policy in these areas, support active research exchanges and cooperation, exchange data and information between them and with other countries on these topics. Through this trilateral research agreement, a MoC

[59] Source: http://ec.europa.eu/research/participants/data/ref/h2020/other/hi/h2020_localsupp_japan_en.pdf
[60] Source: http://www.the-easia.org/jrp/index.html

was also signed with the Eur. Telecommunications Standards Institute (ETSI) on the development of the harmonised basic safety message and cooperative awareness message, central to Vehicle to Vehicle (V2V) communications and safety applications.

2.2.6 Main findings and grant funding practices identified

The main technological challenges for Japan and the RTD topics to be addressed are highlighted in a number of high-level policy documents. Key document for Japanese RTD is the Science and Technology Basic Plan of the Japanese Council for Science and Technology Policy.

Research topics are defined by respective ministries and government agencies, but with bottom-up input from academia and major industrial sectors.

When looking at research priorities in Japan, one can notice the integration of long-term objectives for society and industry into research programmes. Three examples can be mentioned:

- The aging of Japanese society has led to research initiatives in the field of automated driving that should increase road safety even with higher shares of older drivers, and research initiatives in the field of truck platooning reduces the need for truck drivers.
- The strong wish to remain competitive and one step ahead of the automotive sector in other major economies (EU, USA, China), has led to the battery research programme of NEDO. This programme aims to develop a revolutionary battery for electric vehicles by 2025 to be ready by 2030 for full commercialisation (meaning to be assembled in in new cars by this time).
- The Japanese government sees an important role for hydrogen, becoming an increasingly important fuel for the energy sector. The main reasons are energy security and CO_2 emission reductions. Due to this development, and the technical possibilities for the use of hydrogen in transport, Japan also would like to remain the world leader in hydrogen-based transport.

Other findings from the RTD landscape analysis in Japan are the following:

- The main programmes for transport RTD are funded by the Ministry of Economy, Trade and Industry and by NEDO.
- Since 2010 a new cross-ministerial programme was established (SIP), covering research in energy and infrastructure. Transport topics like innovative combustion technology and automated driving systems are included here.
- The SIP programme is especially highlighted due to its holistic approach that unites research, testing, demonstration and implementation in one single governmental programme (and bringing together a multitude of stakeholders.
- There is strong attention of organisations like NEDO for commercialisation of project results. Some projects are directly aimed at commercialisation of certain technologies, such as fuel cell vehicles or automated driving
- Following the project results of already finished projects. NEDO is doing follow-up monitoring of already finished projects until 5 years after project end.

Research budgets for the projects analysed in detail are the following:

- The SIP Programme in total has about 250 million € annual budget, for each of the 11 themes (such as automated driving), this means about 25 million € per year. This is divided between long-term (multi-annual research) and calls for small-sub projects that are tendered each year (about 50:50 split).
- The NEDO programmes analysed have budgets of up to €100 million, depending on the duration and the topic. The research programme "Technologies for hydrogen usage" invests about € 140 million over a 5-year period (2013-2017), while the Energy Storage" research budget is about € 100 million over a three-year period.

For further analysis and benchmarking against best practice, three project examples were chosen:

- the Programme Innovation of Automated Driving for Universal Services (ADUS), defined as one of ten key themes in the Strategic Innovation Promotion Program (SIP). It is implemented from 2014 to 2018 to influence RTD until 2030.
- The NEDO battery research programme – an RTD programme related to development of a new revolutionary batter cell.
- The NEDO programme on commercialising hydrogen research by improving different technologies for hydrogen usage.

2.3 China

2.3.1 Visions and targets for road transport RTD

During the end of the 20th Century, China transitioned from a developing country to an emerging economy and an industrialized nation. China is now increasingly focusing on innovation that pushes outwards the technology frontier and builds upon current areas of acquired comparative advantage. Transport is one of these key focus areas, with electrification of vehicles and autonomous vehicles being in the forefront. The declared aim of successive Chinese governments has been to make China an innovative producing and originating nation, i.e. where innovations are invented and designed rather than imported from other countries (Giannopoulos, 2018).

This aim and its related policies, have resulted in the modernization of the domestic innovation system, through structural reforms, accelerated formation of international collaborations and large scale financial investment in education, research and technology ventures.

The policies for building innovation and entrepreneurship and for promoting international cooperation in RTD were initiated in the Medium and Long-term plan for Science and Technology Development (MLP), published in 2006 by The State Council of the People's Republic of China (Giannopoulos, 2018). This document was one in a collection of policy documents that addressed the promotion of research and innovation in the P.R. of China.

Other RTD policy documents that provided the direction of RTD funding are the following:

- Planning for the Development of the Energy-Saving and New Energy Automobile Industry (2012-2020)
- Opinions of the State Council on Accelerating Promotion and Application of New-Energy Automobiles
- National Plan for Scientific and Technological Innovation during the Period of the Thirteenth Five-year Plan and
- Special Plan for Scientific and Technological Innovation in Transportation during the Period of the Thirteenth Five-year Plan

Motives and objectives in the field of transport RTD

One of the main policy and research priorities for the automotive sector in China is the development and deployment of electric vehicles. China is leading the way in deploying EVs and associated infrastructure, which can be related to the urgency of environmental problems such as the air pollution that envelopes parts of China. Deployment of EVs is not only supported through massive investments in RTD, but also through regulatory measures in the form of sales targets. These targets, announced by the Ministry of Industry and Information Technology (MIIT), are a key part of a drive by China, the world's largest automotive market, to develop its own NEV[61] market, with a long-term aim to ban the production and sale of cars that use traditional fuels.

[61] NEV – new energy vehicles

In the field of EVs and hybrid cars, China has set a deadline imposing new sales targets for electric plug-in and hybrids vehicles by 2019[62]. Car makers will need to gather credits for new-energy vehicles (NEVs)[63] equivalent to 10 percent of annual sales by 2019. That level will rise to 12 percent for 2020. Under the rules, car makers will receive credits for new-energy vehicles, including plug-in hybrids and fully electric cars, that can be transferred or traded. Firms with annual sales volumes above 30,000 units will need to comply with the targets.

Another key RTD focus, also promoted by Chinese OEMs, is the development of autonomous driving. An important motivation for pushing the development of autonomous driving could be that, according to data from the 2015 World Economic Forum survey, Chinese people are more eager to ride a self-driving car than Americans (75% of Chinese against 50% of Americans). Expectations are that within the next 20 years, China will probably become the most important market for autonomous vehicles (is expected to be the largest market by 2040), meeting the needs of at least one quarter of global demand, with the automated taxis introducing this development. An important incentive for China's market development of autonomous vehicles can be considered as an economic advantage on world markets due to its low labour costs, as well as the existing manufacturing infrastructure that enables fast production (European Commission, 2017).

2.3.2 Governance and funding system

The number of national RD&I programmes in China has increased over the past three decades. Up to the end of 2014, the following core programs were existing (Giannopoulos, 2018):

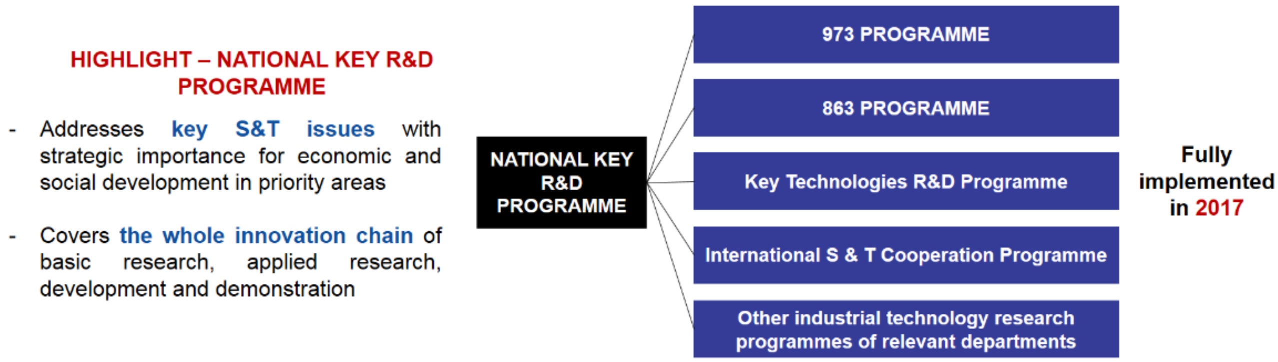
- National Key Technology TD&I Program (the Strategy Supporting Program after 2006)
- The National High-tech R&D Program (863 Program) and the National Basic Research Program of China (973 Program) which have invested in developing technologies to address economic, sectoral (e.g. agriculture) and social challenges,
- Innovation fund (or Innofund) for support of technology-based SMEs
- National Science and Technology Infrastructure Program (of the Chinese MOST)
- Flagship program for basic research – National Natural Sciences foundation of China (NSFC)
- Talent acquisition initiatives developed by the Chinese Academy of Sciences

2.3.2.1 Reform of the funding landscape

From 2014 onwards, China started with streamlining numerous state-funded scientific and technological programs[64]. The plan focused on research in fields vital to the country's development and people's well-being, such as agriculture, energy, the environment and health, as well as strategic fields key to industrial competitiveness, innovation and national security.

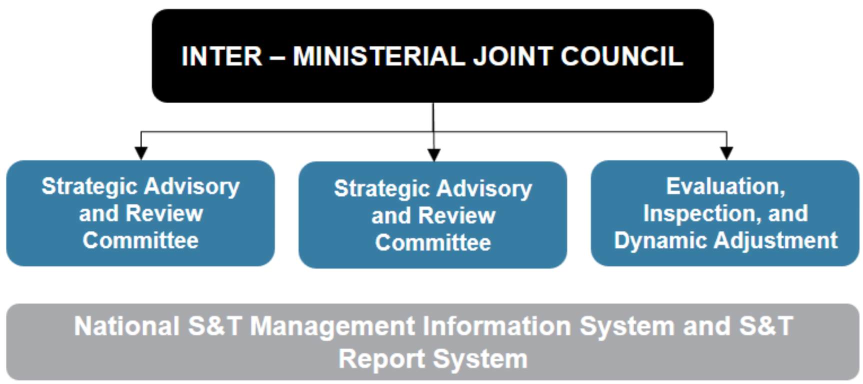
[62] https://www.reuters.com/article/us-autos-china-electric/china-sets-2019-deadline-for-automakers-to-meet-green-car-sales-targets-idUSKCN1C30ZL - China sets 2019 deadline for automakers to meet green-car sales targets
[63] New Energy Vehicles (NEVs) are defined as vehicles using non-traditional fuels (ethanol, biogas or biodiesel); and also refers to any technology of powering an engine that does not involve solely petroleum (e.g. electric vehicles, fuel cell vehicles, solar powered vehicles or various hybrids).
[64] Source: Xinhua News Agency, 2016

The plan merged several prominent state science and technology programs, including the program 863 and program 973, focused on key fields such as biotechnology, space, information, automation, energy, new materials, telecommunications and marine technology (shown in the picture below).



To address low efficiency resulting from redundant programs, over 100 programs were merged into five plans: 1) natural science, 2) major science & technology, 3) key RTD plans, 4) technical innovation and the 5) science & technology human resources. In addition to these national programmes, there are several regional funds, but these are out of the scope of this report.

The current overall institutional and management platform of the central funding system for RTD can be illustrated as follows (European Commission, 2018).



An Inter-Ministerial Joint Council was introduced to coordinate interagency priorities and budgeting, and to prevent overlaps across and within ministries. It is formed by a total of 31 government bodies, led by the Ministry of Science and Technology (MOST), and including the Ministry of Finance (MOF) and the National Development and Reform Commission (NDRC). It is mainly responsible for approving the overall development strategy of central government STI funding, as well as the layout, setting, major tasks, implementation schemes and management regulations for specific funding programmes.

The Inter-Ministerial Joint Council is also responsible for:

- Approving the composition of a Strategic Advisory and Comprehensive Review Committee;

- Approving the selection of project management professional agencies: agencies empowered for the daily management and operation of central STI funding programmes, on behalf of the ministries and other bodies in the Joint Council.
- Establishing a unified evaluation, inspection and dynamic adjustment mechanism: MOST and MOF will supervise, evaluate and inspect the results and performance of all national STI programmes to ensure that the expected outputs are met.

2.3.3 Overview of the funding organisations and other key stakeholders

The leading ministries in the field of Science and Technology (S&T) are the following (Giannopoulos, 2018):

The **Ministry of Science and Technology** (MOST) has played the lead role in the Chinese S&T systems for decades. (it was known as the State Science and Technology Commission before 1998). Its primary responsibilities are determining S&T development priorities, setting up national S&T strategies, managing S&T programmes, formulating guidelines of international cooperation and drafting S&T related regulations.

The **Ministry of Education** (MoE) plays an important role in talent cultivation. The MoE develops policies for education reform and implements and coordinates national education programmes in universities, such as the 211 and 985 programs. The MoE also plans, guides and funds RT&I activities in higher education institutions in China, it has direct affiliation with 75 universities. In addition, while MSOT establishes national labs, MoE is responsible for their operation.

The **Ministry of Transport** (MOT) of the People's Republic of China is an executive agency under the State Council responsible for road, water and air transportation. There are 10 functional divisions under the Ministry of Transport, with the aim of establishing a convenient, smooth, effective, safe and integrated transport system. Its main duties are:

- To formulate and implement development plans, policies and standards of industries of road, water and air transportation;
- To plan and coordinate works related to the integrated transport system;
- To promote connection of various modes of transportation;
- To optimize the layout of transportation.

Apart from the abovementioned ministries, other public organisations have a key role in the promotion of Science and Technology:

Chinese Academy of Sciences (CAS) – CAS is headquartered in Beijing and comprises 104 research institutes, 12 branch academies, two universities and 11 supporting organisations in 23 provincial-level areas through the country. It both funds and performs research.

National Natural Science Foundation of China – The NSFC was founded in 1985 and its key focus is providing funding for fundamental basic research according to the National S&T Guiding Principles.

The **National Development and Reform Commission** – The NRDC plays a significant role in the formulation of S&T policies and serves as the macroeconomic management agency under the State Council, with broad administrative and planning control over the Chinese economy.

China Association for Science and Technology – This is the largest national non-governmental organisation of scientific and technological workers in China.

State Key Laboratories (SKLs) – SKLs were created starting from 1984 to promote scientific basic research in a period of major structural economic reforms and development. They have now become essential bases and platforms for science, technology and innovation in China, promoting basic and applied research, gathering and nurturing innovative talents, and promoting scientific cooperation and exchanges, with the objective of realising breakthroughs in support to the country's development needs and priorities.

SKLs have expanded over the decades to target different entities (universities, research structures or enterprises), reflecting increasingly diversified national and international innovation trends as well as the country's evolving development priorities and needs. They now feature a complex structure comprised of six different categories of laboratories:

- (i) National Research Centres: the highest level of research structure in China, conducting top-level cross disciplinary research. Six National Research Centres are currently existing (link);
- (ii) University-Research SKLs, established within institutes of higher education and research structures for conducting pioneering and innovative research in areas of national priority, further supporting the country's technological and economic development;
- (iii) Provincial-Ministerial Joint SKLs: established by local governments within universities or research structures not administered by the central government, especially in less developed regions, focusing on regional specialties and regional needs and priorities. 26 of such labs currently exist;
- (iv) Military-Civil SKLs: established within military research structures and focusing on civil-military integration. 14 of such labs currently exist
- (v) Hong Kong and Macau Partner SKLs: established within universities in Hong Kong and Macao SARs, in cooperation with SKLs in the mainland. 18 of such laboratories currently exist; and
- (vi) Enterprise SKLs, established following the publication of the Outline of the National Medium- and Long-term Programme on Science and Technology Development (2006-2020), as a parallel and complementary leg of the University-Research SKLs. Enterprise SKLs conduct applied basic research and research on pre-competition generic technologies in areas of major interest and needs for the country's socio-economic development. They also significantly contribute to the formulation of international, national and industry standards

Stakeholders in the Chinese automotive sector

In the automotive sector, an additional group of stakeholders can be identified that play an important role in transport / automotive RTD:

China Automotive Technology and Research Center (CATARC) - CATARC is a research institute established in 1985 to meet China's need of managing the automotive industry. Belonging to the State-owned Assets Supervision and Administration Commission of the State Council (SASAC), CATARC assists the authorities to organize the research on industry policy and also provides consultation to the industrial organizations and enterprises.

Society of Automotive Engineers of China (SAE-China), a national academic organization. As a member of China Association for Science and Technology, it is a non-profit social organization. As an executive member of the International Federation of Automotive Engineering Societies, SAE-China is also one of the sponsors of the Asia Pacific Automotive Engineering Conference (APAC).[65]

In addition, Chinese OEMs undertake their own RTD. An important research topic for them is the development of automated driving. The following Chinese OEMs are active in this field:

- Great Wall Motor Co.
- Chongqing Changan Automobile Co
- Zhejiang Geely Holding Group Co
- Baidu Inc.
- BYD Auto Co.
- SAIC Motor Co.
- Changan Automobile Group Co.

Research activities of Chinese OEMs

Chinese OEMs are currently very active in the promotion and development of electric vehicles as well as self-driving cars. China is competing with USA and Europe, which currently have the leading role in the self-driving sector, it is preparing a regulatory framework that could provide China with precedence. Chinese OEMs are undertaking several research initiatives, independently or in cooperation with foreign OEMs (European Commission, 2017):

- The Great Wall Motor Co., has begun RTD actions in Yokohama (Japan) aiming also to reinforce and further develop its cooperation with OEMs from Japan, mainly industries relevant of auto-parts production. In parallel, the company also aims to create at least three more overseas research and development centres in India, North America and Europe, to be able to deliver products of high quality and expertise in several areas, such as environmental friendly and automated cars.
- Chongqing Changan Automobile Co has also opened research centers in the U.S., Japan, Britain and Italy.
- Zhejiang Geely Holding Group Co. has created a research centre together with its Volvo Car unit in Gothenburg, Sweden.
- Baidu Inc. has also announced the formation of a relevant team in Silicon Valley, which will be part of Baidu's newly-created Autonomous Driving Unit (ADU).
- The Japanese Nissan Motor Co., has signed a cooperation agreement with the China Automotive Technology and Research Center (CATARC) for the adaptation of safety features, like lane

[65] Source: http://en.sae-china.org/

keeping and collision avoidance, so it can adjust its work and production to China's driving habits and road conditions.

Support for automated vehicles from the government

The Chinese government estimates to have self-driving vehicles ready for highways within the next 3-5 years, as well as autonomous vehicles for urban driving until 2025. For that purpose, a roadmap was prepared by the National Technical Committee of Auto Standardization (NTCAS) that has the support of the Ministry of Industry and Information Technology and is expected to set up a common language for communication between vehicles and (V2V) but also between vehicles and infrastructure (V2I).

The roadmap on self-driving cars was published end of 2016, with the aim of having highly or fully autonomous vehicles on sale in the world's biggest automotive market as early as 2021[66].

The 450-page roadmap, issued by the official Society of Automotive Engineers of China (SAEC), lays out the blueprint for the development of virtually every aspect of the automotive industry until 2030. The roadmap creates a consensus within China's auto industry in moving towards producing and selling self-driving cars. This document creates a clear over-arching policy toward autonomous vehicles, accelerating their development and getting China on the forefront of their development worldwide.

The report lays out three distinct five-year periods to 2030 for the development of autonomous vehicles, with cars capable of driving themselves in all, or nearly all, situations first reaching the market between 2021 and 2025. Some form of automated or assisted driving should be in every car by 2026 to 2030.

Following-up on this development, the Chinese government released a national guideline on road tests for self-driving vehicles in April 2018, as part of a broader drive to accelerate the development of the technology and gain the advantage in commercializing such vehicles[67].

The guideline, which was jointly issued by the Ministry of Industry and Information Technology, the Ministry of Public Security and the Ministry of Transport, allows local authorities to evaluate local conditions and arrange road tests for autonomous vehicles. It states that the test vehicles should be passenger or commercial automobiles, not low-speed vehicles or motorcycles.

According to the regulation, which presumably took effect on May 1, 2018 test vehicles should be able to switch between self-driving and conventional driving in order to ensure the test driver can quickly take over in case of a malfunction. Moreover, test applicants must be independent legal entities registered in China, which have to first complete tests in designated closed zones before conducting road tests.

The nation's first guideline for road tests of autonomous vehicles were issued in December 2017 and unveiled a closed testing ground for autonomous cars in February 2018. In addition, on March 1st, 2018, local authorities in Shanghai issued the country's first road test licenses to two smart-car makers, SAIC Motor Corp Ltd and the electric vehicle start-up, Nio Auto.

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[66] *The roadmap itself is only available in Chinese. News article: https://www.reuters.com/article/us-china-autos-autonomous/china-issues-roadmap-for-rapid-development-of-self-driving-cars-idUSKCN12Q0OZ*

[67] Source: http://english.gov.cn/state_council/ministries/2018/04/13/content_281476110368454.htm

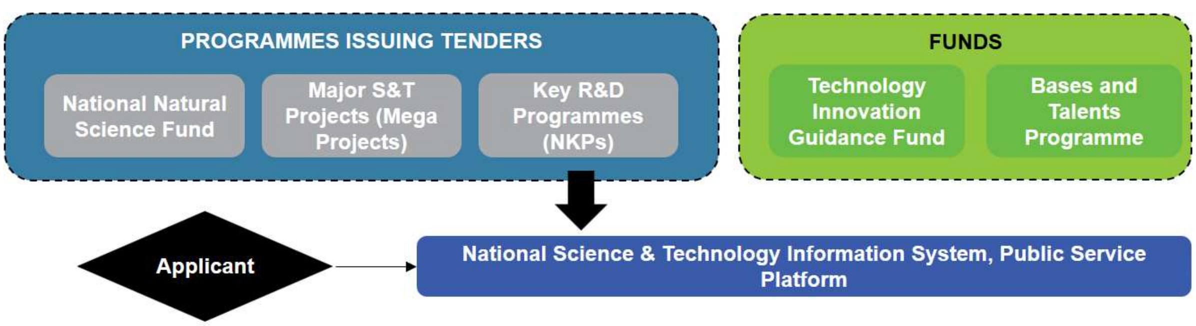
According to a recent KPMG survey, automotive executives see China as the top destination for innovation[68]. China is leading the development of new business models and innovations, including battery electric vehicles (BEVs) and car-sharing. It featured insights from a survey of 900 executives in the automobile and technology industry (including 135 from China), and around 2,100 consumers globally (including 251 from China).

A large number of automotive executives highlighted China as their top pick for launching new mobility services and data-driven business models. Around one-fifth of global executives identified China as the number one country to launch new products/cars and new mobility services, up from 16 percent and 15 percent in 2017, respectively. Meanwhile, 15 percent of respondents said China is the place to implement new data-driven business models, up from 13 percent last year. US and Germany are also key destinations for pilot launches.

2.3.4 Overview of existing grant programmes and relevant calls

As the Chinese RTD landscape appears complicated to actors outside China, the European Commission financed the work on a "Guide for EU stakeholders on Chinese national STI funding programmes" to increase the awareness about Chinese RTD funding for no-Chinese stakeholders. The information about Chinese funding programmes and relevant calls is to a large extent based on the findings of this study, as it is one of the few English language sources on Chinese RTD funding. [69].

The current national funding landscape in China, after its reform starting 2014, now exists of five main pillars (shown in the picture below). Each pillar includes a key section of the national research and development landscape (e.g. basic scientific research, applied research and market introduction of research results) (European Commission, 2018):



1. The **National Natural Science Fund** is focusing on basic research and applied research in natural sciences, particularly in: physics and mathematics; chemistry; life sciences; earth sciences; engineering and materials; information sciences; and management sciences. The Fund is administered by the Natural Science Foundation of China ("NSFC").

[68] https://home.kpmg.com/cn/en/home/news-media/press-releases/2018/02/auto-executives-see-china-as-top-destination-for-innovation.html

[69] The project team was in frequent contact with the author of the report, Alessio Petino from DEVELOPMENT Solutions Europe, Ltd, to find out about the latest development since the publication of the report (January 2018).

2. The **National S&T Major Projects ("Mega Projects")** include 16 programmes addressing major key products, technologies and engineering of strategic importance for the country's economy and industrial competitiveness. Characterised by a strong top-down design and a sharp distinction between "civilian" and "military" application, the Mega Projects' mission is to support and fulfil some of China's most ambitious RTD tasks over the mid- and long-term, e.g. development of the country's first domestically-designed passenger aircraft and third-generation nuclear reactor, commercialisation of 5G technologies and vaccines, earth observation etc. The current 16 Mega Projects will be replaced by 2020 by 16 other new "2030 Innovation Mega Projects" reflecting new trends and priorities in global science and technology development.
3. The **National Key R&D Programmes ("NKPs")** are a newly-created category of programmes. They are incorporating several previously-existing programmes such as the "863 Programme" for R&D, and the "Program 973" for basic research. It supports R&D in areas of social welfare and people's livelihood, such as agriculture, energy and resources, environment, health etc. They feature several objectives and deliverables to be achieved in a period ranging from three to five years, reflecting a top-down and industry-university-research cooperation design that integrates basic research, technology application, demonstration and commercialisation. It is currently the most active of the five pillars, with a total of 48 NKPs established, each funding every year tens of projects from diversified sources. There are currently 4 NKPs with a specific transport topic.
4. The **Technology Innovation Guidance Fund** is consisting of three major funds emerged from a structural re-organisation, re-classification and merging of previously-existing national funds from different government departments. These funds are in turn organised into several sub-funds or funds-of-funds, which invest in priority and strategic areas through venture capital funds, private equity and risk compensations. The aim is to stimulate the transfer and commercialisation of scientific technology results by supporting the growth and activities of innovative start-ups and SMEs. They are currently very active, with an average of 70 new investments concluded every month.
5. The **Bases and Talents Programme** is incorporating several previously-existing programmes from MOST (State Key Laboratories, National Engineering Technology Centres, Innovation Talents Promotion Programme) and NDRC (National Engineering Centres/Labs, National Enterprise Technology Centres etc.). It aims to promote the establishment of scientific bases, and the fostering of innovative talents and teams by supporting their research activities.

Each of the five pillars cover specific types of research and have their own funding requirements, which are described below.

2.3.4.1 National Natural Science Fund – Pillar I

The National Natural Science Fund is China's largest fund for supporting basic research and applied research in natural sciences, particularly in the fields of: physics and mathematics; chemistry; life sciences; earth sciences; engineering and materials; information sciences; and management sciences.

The Fund is administered by the Natural Science Foundation of China (NSFC), which is responsible for directing, coordinating and making effective use of the Fund while stimulating free exploration, identifying and fostering scientific talents and teams, and promoting science and technology development in line with the country's strategies and needs.

The NSFC's funding system is divided into 14 different programmes, grouped under three categories: (I) research promotion; (II) talents fostering; and (III) research environment. One of these programmes is exclusively directed to international joint research, the remaining target China-based actors, meaning that China-based affiliates of European institutes and European scientists working in China can apply too.

Unlike most of the other funding pillars, guidelines on new programmes and projects to be funded by the NSFC are published on the NSFC website on an annual basis, in December. The latest annual project guidelines introduce in detail what areas will be funded under each specific programme in 2018, as well as the corresponding requirements that applicants must possess.

The selection and evaluation process are standard, well-documented and relatively transparent. It applies to all categories of projects and can be summarised as follows:

The evaluation criteria of the proposals generally include:

- Scientific value; innovativeness; impact on society; feasibility of the proposal; and
- The Project Leaders research experience; composition and research conditions of the team; rationality of the requested funding.

The results of the NSFC applications are usually communicated by email in September of the same year. Top-ranked proposals generally receive the funding requested in the application process; lower-ranked ones might be cut.

2.3.4.2 National S&T Major Projects – Pillar II

National S&T Major Projects (or "Mega Projects") are considered to be the largest and most ambitious RTD tasks for China's mid- and long-term development. They were introduced by the Outline of the National Medium- and Long-term Programme on Science and Technology Development (2006-2020), the manifesto for science and technology development guiding the country towards becoming an effective "Innovative Country" by 2020. These Mega Projects were then integrated into the State Council's 2014 reform of the national STI funding system, a move that contributed to a higher the degree of standardisation and transparency of their tender cycles.

Mega Projects address key products, technologies or engineering tasks of strategic importance for the economy and competitiveness of China. These range from the development of China's first domestically-designed passenger aircraft and third-generation nuclear reactor, to the commercialisation of 5G technologies, internationally-recognised vaccines and semiconductors, to moon exploration and earth observation. The major aim is to solve bottlenecks for technology breakthroughs and to fill strategic blanks.

No (direct) transport related "mega-project" is financed by the programme. This programme is also the most difficult to access by non-Chinese entities according to experts that were consulted (Petino, 2018).

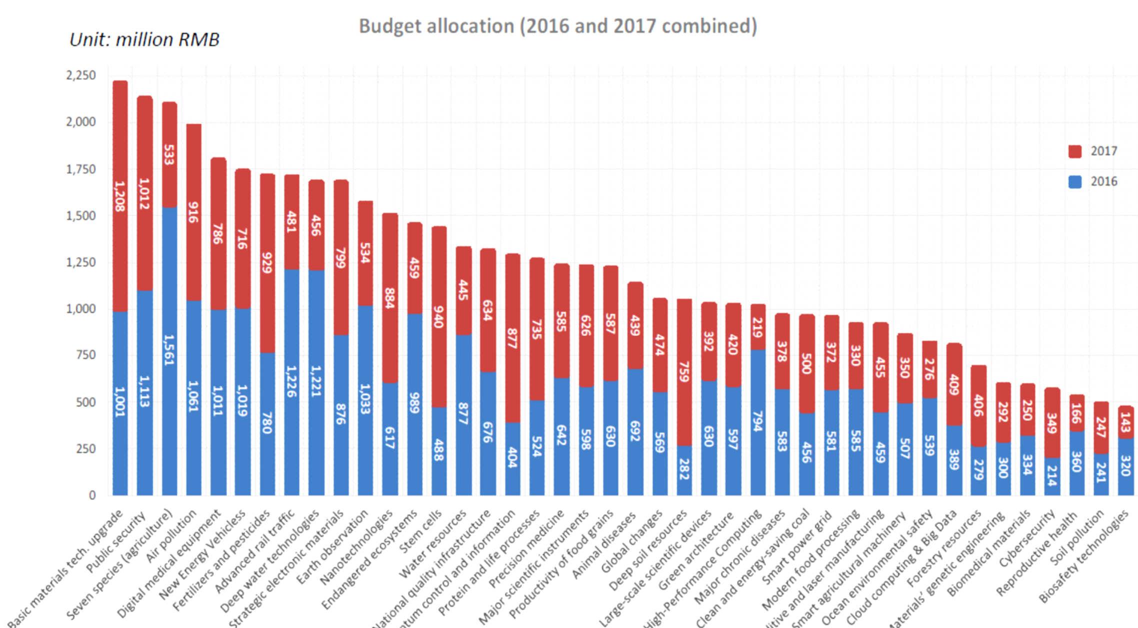
2.3.4.3 National Key R&D programmes – Pillar III

National Key R&D Programmes ("NKPs") are a new category of projects created after the 2014 reform of the national STI funding system. They have incorporated numerous previously-existing programmes:

- MOST's "863 Programme" for R&D,
- "Programme 973" for basic research,
- Key Technologies R&D Programme,
- International S&T Cooperation Programme; and
- NDRC and MIIT's Industrial Technology R&D Fund.

NKPs support RTD in multiple areas, such as agriculture, industry, energy, transportation, environment, and health, focusing especially on strategic, fundamental and prospective major scientific issues, key generic technologies as well as international S&T cooperation regarding core industrial competitiveness, indigenous innovation capabilities and national security. They feature several well-targeted and defined objectives, and deliverables to be achieved in a period ranging from three to five years, reflecting a top-down and industry-university-research cooperation design that integrates basic research, technology application, demonstration and commercialisation.

NKPs are currently among the most active and standardised of the five funding pillars. A total of 42 NKPs were initially established, followed by the launch of 6 new NKPs in the second half of 2017. Since their official launch, a total of 50.7 billion RMB (around 6.4 billion EUR[70]) was allocated by the central government for 42 NKPs in the 2016 and 2017 annual calls. The figure below shows the 42 NKPs with their annual budgets for 2016 and 2017 (European commission, 2018).



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[70] Exchange rate 31st of July, € 1 = 7.96 RMB (www.oanda.com)

The figure below shows the budget allocation for those NKPs that are related to engineering, transport, energy, IT, anything that may be slightly related to transport.

Budget Allocation of selected NKPs (2016 and 2017)

NATIONAL KEY R&D PROGRAMMES	2016 (Million RMB)	2017 (Million RMB)
Basic Materials Tech. Upgrade	1,001	1,208
Air Pollution	1,061	916
New Energy Vehicles	1,019	716
Advanced Rail Traffic	1,226	481
Strategic Electronic Materials	876	799
Earth Observation	1,033	534
Nanotechnologies	617	884
National Quality Infrastructure	676	634
High Performance Computing	794	219
Clean and Energy-Saving Coal	456	500
Smart Power Grid	581	372
Cloud Computing & Big Data	389	409
Cybersecurity	214	349

As shown in the table, the budget for transport related calls are the following:

- New Energy Vehicles: 1,019 million RMB (128 million €) for 2016 and 716 million RMB (90 million €) for 2017
- Advance Rail Traffic: 1,226 million RMB (154 million €) for 2016 and 481 million RMB (60 million €) for 2017.

A total of 2,288 projects were funded under the 2016 and 2017 annuals calls within the 42 NKPs. The majority was led by institutes of higher education and research structures (37.5% and 33%, respectively), followed by State-owned Enterprises (12%) and privately-held enterprises (9.5%). Almost eight thousand experts took part in the evaluation of proposals.

Tender applications

Tender guidelines for NKPs are published on the National Science and Technology Information System, Public Service Platform (commonly referred to as "National S&T Service Platform") on a yearly basis, usually in groups. The first cycle of 2016 annual calls were published between February and April 2016. The cycle of the 2017 annual calls was published in October 2016. 2018 annual calls were published in October 2017 and December 2017.

2.3.4.3.1 RTD calls related to the transport sector

The following ongoing calls of the Key R&D Programme are related transport RTD:

- New Energy Vehicles – from the calls for proposals published in 2016 and in 2017[71], the 2016 and 2017 projects and PIs awarded are published online (in Chinese):
  - The list of winners of the 2016 and 2017 calls are published online
  - Most award winners are Chinese companies, but in 2016 one project from the 2016 call was assigned to Qingdao TGOOD Electric, a Sino-German JV
- Advanced Rail Traffic – calls for proposal were launched in 2016, 2017 and the latest one in 2018:
  - The list of the winners of the 2018 call, including budget allocated is published online (in Chinese)
  - For the 2018 round, 4 projects were selected with a total budget of 187 million RMB. Two of them were granted to the company CRRC Corporation Limited, the national rolling stock manufacturer.

In 2018, two new NKPs will be launched on two new topics. So far draft tender documents have been published and the official tender is expected to be published soon, the topics are:

- Comprehensive transportation and smart transports[72]
- Key Technology and Demonstration of Internet of Things and Smart Cities[73]

Tender application process

The application process for NKPs is divided into two rounds of application, a pre-application and a full (official) application. The tender cycle usually lasts six months, and can be summarised as follows:

1. Call for comments – usually published two months before official tender guidelines
2. Official tender guidelines – Final tender guidelines are published without any pre-announcements on the National Service Platform
3. Pre-application – Application deadline is usually set four to five weeks after the publication of the tender guidelines (applications submitted online through the National Service Platform)
4. Screening of applications and preliminary evaluation – Applications are first screened. Those who do not meet formal requirements are automatically rejected. The remainder of applications is selected for the final round of application (three to four times higher than the amount of projects to be financed)
5. Second round of evaluation (including video interview[74]) – deadline for submission and interview is one to two months after the results of the first evaluation were published.
6. Project approval – List of final winners are published on the National Service Platform one or two months after the video interview

[71] Call text 2016: http://service.most.gov.cn/u/cms/static/201511/171134444cos.doc, call text 2017: http://service.most.gov.cn/u/cms/static/201610/14101453d5ex.pdf (in Chinese) – Ministry of Science and Technology, 2017
[72] Call text in Chinese: http://service.most.gov.cn/u/cms/static/201801/24091822d12t.pdf
[73] Call text in Chinese: http://service.most.gov.cn/u/cms/static/201802/14142126lc3k.pdf
[74] The interview lasts 45 minutes, of which 15 are dedicated to a presentation by the candidate PI (Principal Investigator), and the remaining to Q&A with the evaluation committee (entirely in Chinese language)

Details of single calls related to the transport sector are discussed below[75]. Each call text includes the overall goal of the NKP call and describes the research topics in detail.

2.3.4.3.2 New Energy Vehicle Call - 2017

From the officially published “Recommendations for 2017 Project Declaration Guideline for Pilot Program of New Energy Vehicles”, the overall goal of the NKP is defined as follows:

“To promote the transformation strategy towards “pure electric drive” technology of new energy vehicles (NEV); upgrade the power system technology platform of NEVs; and seize the new round of technological transformation opportunities for NEVs brought by new energy, new materials, information technology and other technologies to deploy and research & develop the next generation technologies in advance”

According to the NKP call, by 2020, a sound technology innovation system for NEVs should be established to support the large-scale industrialization development (Ministry of Science and Technology, 2017).

A total of 38 key research tasks are deployed in this pilot program according to six innovation chains (or technology directions):

1. power battery and battery management system,
2. motor drive and power electronics assembly,
3. electric vehicle intelligence technology,
4. fuel cell power system,
5. plug-in/extended-range hybrid power system and
6. pure electric power system.

The implementation period for the pilot program is 5 years (2016-2020). In 2016, this pilot program has launched and implemented 18 projects in 6 technology directions. In 2017, 19 projects were launched in the 6 technologies directions, and arrange for a total estimated budget of RMB 1.12 billion (141 million €) appropriated from national treasury. Any project led by an enterprise must be co-funded: the ratio of total supporting fund to the total capital appropriated from national treasury shall not be less than 1:1. This means that 50% of the funding needs to be covered by the private entity.

The numbers of projects selected in previous calls were:

- In the call of 2016 – 17 projects were selected
- In the call of 2017 – 20 projects were selected[76]

The complete list of research topics is included in the Annex.

2.3.4.3.3 Integrated Transportation and Intelligent Transportation – call 2018

The overall goal of this new NKP is to solve the problems in the comprehensive transportation system, such as weak operation supervision ability, low multi-mode cooperation efficiency, poor active prevention and control ability in transportation safety, insufficient integrated services etc. The NKP will focus on the

[75] Call texts are only available in Chinese on the website of the MOST, they have been translated for the purpose of this research.
[76] Two projects on the same topic were preselected, final selection made after the inception phase (1-year)

breakthrough of the basic science problems and major common key technologies of integrated transportation and carry out the typical application demonstration.

The objective is also to significantly enhance the cooperative operation and intelligent supervision capability of the integrated transportation and comprehensively improve the comprehensive and intelligent level and service quality of the integrated transportation in China.

By 2022, a new generation of integrated transportation and intelligent transportation technology system should be formed to provide effective and sustainable comprehensive transportation system support for the implementation of major national development strategies.

Adhering to the whole-chain innovation design and integrated organization implementation principle of “basic research, major common key technology, typical application demonstration”, a total of 15 key research tasks will be deployed in the key special program according to the 6 innovative chains (or technology directions) (Ministry of Science and Technology, 2018a):

1. intelligent traffic infrastructure,
2. intelligent synergy of carrying tools,
3. supervision and coordination of traffic operation,
4. collaborative operation of large transportation hub,
5. integration of multi-mode integrated transportation,
6. and safety risk prevention & control and emergency rescue of integrated transportation.

The implementation period for the special program is 5 years (2018-2022). The complete list of research topics is included in the Annex.

The call text for this NKP was published on August 3, 2018[77]. The maximum available budget for the 2018 call is 436 million RMB (€ 55 million) and the call text mentions that 16 to 32 projects will be funded under this NKP. It is expected, based on experience with other past NKPs, that more or less the same budget will be allocated at least for 2019 and 2020 (Petino, 2018).

With regards to financing, the budget allocated for projects belonging to the category of “generic key technologies” should respect a 1:2 ratio with funds provided by the consortium (67% of funding). The ratio increases to 1:3 (75% of funding) for projects belonging to “application and demonstration” category (this latter category of projects also encourages the inclusion of local government funds, although no indication on percentages is provided).

2.3.4.3.4 Key Technology and Demonstration of Internet of Things and Smart Cities – proposed call 2018

In order to implement the tasks proposed in the Outline of National Program for Long- and Medium-Term Scientific and Technological Development (2006-2020), the key special program of “Key Technology and Demonstration of Internet of Things and Smart Cities” was launched and implemented in the national key research and development plan. This NKP call has not been published yet.

[77] Website: http://www.most.gov.cn/mostinfo/xinxifenlei/fgzc/gfxwj/gfxwj2018/201808/W020180803515418282707.pdf

The overall goal of this new NKP is to focus on key technologies of “sensing - link - knowledge - application - integration” of smart cities based on the national cyber development strategy and demand of social and economic transformation, build the integrated service system of Internet of Things (IoT) and smart cities, and carry out the demonstration application of integrated innovation and integration services in the typical urban agglomerations, such as, Beijing-Tianjin-Hebei Economic Circle, Pearl River Delta, Yangtze River Economic Belt, Belt and Road Initiative etc., so as to support the demonstrative construction of more than 50 national new smart cities[78], improve the urban governance capabilities and public service levels and promote China to be a global leader in technology innovation and industrial application of smart cities. China will carry forward the scale-based development of IoT and smart cities and the sharing of “three integrations and five spans” to form a perfect industrial ecological chain, so that the technical research, standards and industrial application of China’s IoT and smart cities can reach the leading level in the world.

A total of 51 key research tasks will be deployed in the NKP according to the 5 innovative chains (or technology directions) (Ministry of Science and Technology, 2018b):

1. intelligent technology and intelligent terminals,
2. IoT ubiquitous access technology and integration system,
3. urban modelling technology and dynamic cognitive system,
4. urban comprehensive decision-making technology and intelligent service platform,
5. urban trust integration technology and support system.

The implementation period for the special program is 5 years (2018-2022). The complete list of research topics is included in the Annex.

2.3.4.3.5 General rules

As shown above, each of the NKPs is focusing on different topics, but in discussion with local experts, some general features of the NKPs could be identified:

- For each call under the NKPs, information is published on selected projects: title, project leader organisation, project leader, funding amount
- The topics in the NKPs are usually focusing on applied science, which means a TRL of 4-6
- Evaluation of running projects takes place after each year, after each key milestone
- Funding %, a participating private company has to co-finance at least 50% of the costs itself. Public organisations (universities, research institutes) get 100% funding. Co-funding percentages can differ per NKP.
- Rule of 1-2 projects, if two projects are submitted on same topic and get same score then both projects get into the initiation phase. After one year the best performing of the two projects is selected
- Foreign companies can cooperate, but not be leader of a consortium

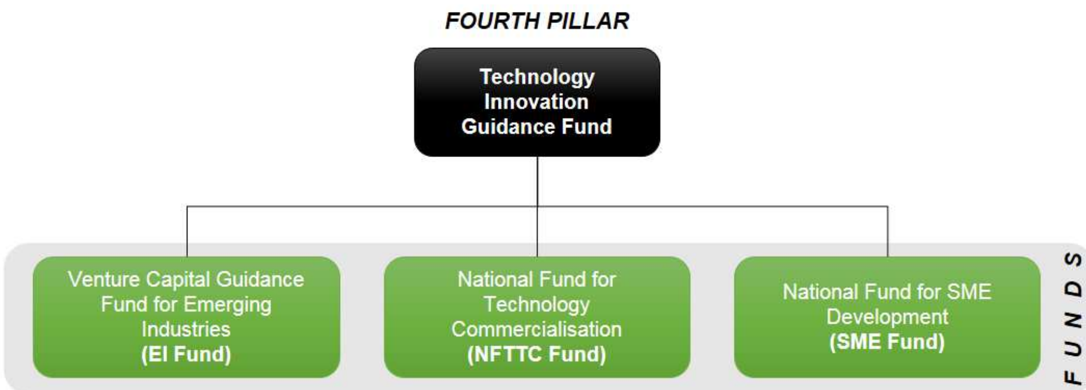
[78] A pre-selection of 40-50 smart cities has been made.

2.3.4.4 Technology Innovation Guidance Fund – Pillar IV

The Technology Innovation Guidance Fund is a new category of funds exclusively oriented to start-ups and small- and medium-sized enterprises (SMEs). The first ones have been established in 2016.

It consists of three main funds, which are in turn organised into several sub-funds or funds-of-funds (FOFs). These invest in innovative start-ups and SMEs in priority and strategic areas through venture capital (VC) funds, private equity, and risk compensations, and according to market mechanisms. The aim is to stimulate the transfer, capitalisation and commercialisation of scientific technology results.

Within this pillar it is possible to commercialise results of research projects from other pillars (such as the NKPs) and support the establishment of start-ups. The structure of the Technology Innovation Guidance Fund with its three separate funds is summarised as:



Source: European Commission, 2018

In the framework of the Technology Innovation Guidance Fund, the receivers of central government funds will not be the final end users of such funds (e.g. to implement RTD projects) but are special funds created ad hoc (FOFs, equity funds, VC funds etc) to re-invest in enterprises according to market mechanisms (in line with the priorities outlined by State policies). It follows a “two-level process”:

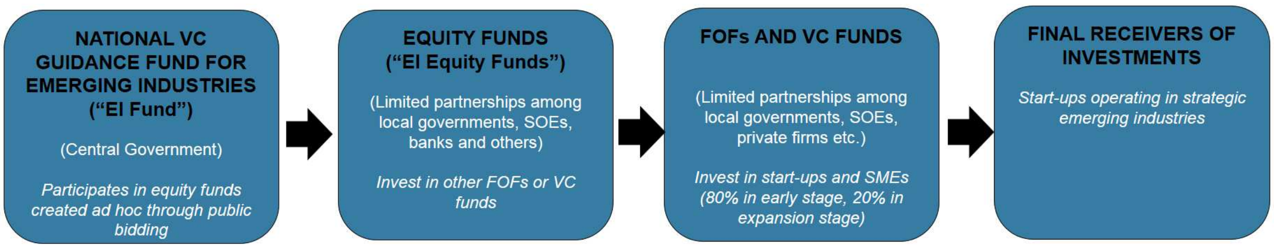
(1) Applicants (consisting of limited partnerships among local governments, enterprises and financial institutions, and led by an investment firm) apply to be selected as national-level FOFs or sub-funds through public bid. If selected, they will receive additional financial injections from the central government;
(2) Once selected, national-level FOFs and sub-funds will re-invest in enterprises

Within the fourth pillar, three basic funds can be identified:

(1) The Venture Capital Guidance Fund for Emerging Industries (EI Fund) -
(2) The National Fund for Technology Transfer and Commercialisation (NFTTC Fund)
(3) National Fund for SME Development (SME Fund)

The three major funds under the Technology Innovation Guidance Fund are mainly intended to stimulate the growth and vitality of technologically-advanced and resource-seeking innovative start-ups and SMEs.

1) The **EI Equity Fund** participates in equity funds, which are created ad hoc after being selected through public bidding. The EI equity funds' daily operations are delegated to professional managing firms. These invest mainly in other FOFs or venture capital funds (VC funds), which in turn re-invest in innovative enterprises operating in one of the strategic emerging industries listed in the 13th Five-Year Plan on National Strategic Emerging Industries[79]. 80% of the investments will be directed to enterprises in early or start-up stages; the remaining 20% to enterprises in their expansion stage. Investments follow market principles, without the government's direct intervention. This complex mechanism is summarised as:



Source: European Commission, 2018

2) The purpose of the **NFTTC Fund** is to support the transfer and commercialisation of scientific results (new technologies, products, techniques, materials etc.) achieved under national and local government funding. This is done through supporting the establishment of venture capital sub-funds (hereinafter referred to as "VC sub-funds"), credit risk compensations and performance awards.

Similar to the EI Fund, the NFTTC Fund features a combination of central government funds, local government funds and funds from enterprises, financial institutions and other social actors. It abides by the principles of "performing a guiding, indirect, not-for-profit and market-oriented role". It targets and supports the commercialisation of results and technologies included in the National Science and Technology Achievement Database[80]. It thus aims to strengthen the link with other government funding programmes, particularly by making sure that scientific results generated under these are translated into concrete commercial products.

3) The **SME Fund** was established in September 2015 by the State Council, with the purpose of supporting and boosting the mass innovation and entrepreneurship of SMEs. The SME Fund has a total size of 60 Billion RMB.

Through the establishment of FOFs ("SME FOFs") and direct investment, the SME Fund invests in priority sectors in highly-competitive manufacturing industries featuring high market failure risks and evident spill-over effects. The focus is especially on growth-oriented SMEs in seed and start-up stages, largely through private equity investments supporting moderate series B financing or beyond. Each SME FOF should give particular attention to (i) investing in the Jing-Jin-Ji, Yangtze Economic Belt or the One Belt, One Road regions; (ii) solving bottlenecks and weaknesses that hinder SMEs' core competitiveness; and (iii)

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[79] These include: ICT, advanced manufacturing, new materials, biology, **new energy vehicles**, new energy, energy-saving and environmental technologies, and digital innovation industries

[80] The Database was established in September 2014 and contains detailed information on S&T results in all regions and industries. S&T results generated under national funding projects will automatically be inserted in the database (except those involving state secrets), while those under local-level funding programmes will be included only after approval of relevant bodies. Website: http://www.nstad.cn/

increasing the supply-side quality and standards to cope with the increasing improvements and diversification of consumption standards.

2.3.4.4.1 Examples of established funds

As of January 2018, a total of fourteen VC sub-funds has been established, totalling an amount of 24.7 billion RMB (around 3.1 billion €), around 23% of which are provided by the central government. One of these funds focuses on new energy vehicles and relevant industries under the NFTTC Fund)

Name – New Energy Vehicle S&T Innovation (Hefei) Equity Investment Partnership LP
Funding – 500 million RMB (63 million €) **Shareholders:** 1. Hefei Guoxuan High-Tech Power Energy Co., Ltd.: 43% 2. National S&T Venture Capital Development Center (MOST): 30% 3. Other investors in Anhui: 27% Hefei Science & Technology Risk Investment Ltd; Anhui Wantou Industrial Investment Ltd; Hefei Gaoxin Construction Investment Group; Hefei Guoke New Energy Equity Investment Management LP **Managing firm** – Hefei Guoke New Energy Equity Investment Management LP. The largest investor (24%) behind this management firm is the Hefei Guoxuan High-Tech Power Energy Co Ltd, which is also the first shareholder of the sub-fund. At the time of writing, no information was available about its project portfolio.

Then there are three funds focused on investments in energy-saving & clean technologies (without specific focus on transport technologies):

- China Venture Capital Co. Ltd (Hunan) Venture Capital LP
- Shanghai Green Technologies Results VC Centre LP
- Anhui Ma'anshan Zhidian Technology Results Conversion No. 1 Fund LP

Within the National Fund for SME Development, there are 4 Funds of Funds established:

One of them, the SME Fund – Shenzhen Limited Partnership, has as priority focus new energy vehicles. Several projects covering all segments of the industry chain are already financed. Other focuses of the Fund are: IT chips; advanced manufacturing; internet; energy and environment; drugs and healthcare; new materials and chemical engineering.

Name – SME Development Fund – Shenzhen Limited Partnership
Funding – 6 billion RMB (754 million €) Shareholders: (1) Ministry of Finance: 25% (2) Shenzhen SMEs Service Department: 25% (3) Tehua Investment Holding Co., Ltd.: 13.3% (4) Other investors in Shenzhen: 36.7% Shenzhen Capital Group Co., Ltd Shenzhen Hongxin Investment Limited Partnership Shenzhen Huahui Group Co., Ltd Shenzhen Ronghao Investment Co., Ltd

Managing firm – Shenzhen Guozhong Venture Capital Co., Ltd.   The firm is largely controlled (49%) by the Shenzhen Capital Group Co., Ltd, a VC firm established by the Shenzhen municipal government which also has a 10% share of this SME Sub-fund. The other main investor (40%) is the private firm Pingxiang Changrong Investment Management LP.

Based on information from its website, it can be learned that[81] the SME Development Fund (Shenzhen) LLP is the first fully market operated government guided fund as well as the biggest Fund directed at supporting Small Medium Enterprises in China. The Ministry of Finance contributed a quarter of the total of the SME Development Fund (Shenzhen), with the rest three quarters coming from various corporations, financial institutions and regional governments amounting to a total of 6 Billion RMB. The SME Development Fund focuses mainly on seed, early and developing stage enterprises.

As to date, the Fund has approved 39 investments that amount to a total of over 1 billion RMB. With all investments covering industries such as information technology, high end equipment manufacturing, internet, renewable resources, new materials and pharmaceuticals. A special focus of the fund is electric vehicles, with respective investments in fields of electric motor, battery and chargers, which means a spread across the clean energy vehicles industry chain.

2.3.4.4.2 Criteria for investments

As stated in the EC study on Chinese R&D funding (European Commission, 2018) the processes through which such funds and sub-funds conduct investments remain relatively complex. Relevant documents only regulate the processes through which each of the three major funds under this funding pillar (EI Fund, NFTTC Fund, and SME Fund) identify, select and conclude investments in sub-funds (equity funds, VC funds, FOFs, etc). These are usually recommended by managing firms and approved by their board of partners (in which the central government should participate in view of its average 20% to 30% shares).

On the other hand, however, it is not clear how these sub-funds (equity funds, VC funds, FOFs) will, in turn, re-invest in enterprises – i.e. the final receivers and beneficiaries of this funding pillar. Relevant documents only outline what the areas and targets are in which investments should be channelled, and stress that all of them should operate according to market mechanisms, with no government intervention.

It should be noted that, in addition to the central government, financial institutions or corporate actors also participate in all the sub-funds (equity funds, VC funds, FOFs) under this funding pillar, suggesting that a certain return on investments is expected. Limited government intervention, centrality of managing firms, and the for-profit nature of these funds suggest that technologically advanced international actors with large prospects of growth are well-positioned to become targets of such investments, as long as they meet the necessary conditions outlined by the government (e.g. innovative enterprises in the strategic emerging industries listed in the 13th Five year Plan on National Strategic Emerging Industries; enterprises commercialising scientific results included in the National S&T Achievement Database etc).

2.3.5 International collaboration in the field of RTD

[81] http://gzvcm.com/index/index/english/2

China is motivated to be committed to international scientific and technology collaborations to advance its standing in various scientific and technological areas. China advances its technological and scientific capabilities, including encouraging its major EV companies to open facilities in the US, and developing cooperative relationships with the EU.

China's policy decision making bodies have pronounced international cooperation as their main policy with the aim of advancing the opening of China to the world and moving to high tech transportation products like EVs.

For example, several billions of dollars of direct and indirect Chinese government investments go to EV development and manufacturing and soon Chinese companies, such as BYD, will be selling EVs in the US and other world markets.

One flagship example of international collaboration in the academic sphere between the US and China is the US-China Clean Energy Research Centre (CERC). This government programme pairs researchers from both countries to accelerate development and deployment of critical technologies for clean energy in the United States and China.

Furthermore, US states like California, with a serious impetus to move away from carbon-based fuels recognise that collaborations with China are critical to understand how to manage EVs on a mass scale. California has actively sought partnerships with Chinese quasi governments organisations to learn from their experiences.

Government-to-government sponsored collaboration also exists between the EU and China. These include activities taking place under the EU-China Agreement for Scientific and Technological Cooperation. The EU and China agreed to continue to promote closer cooperation based on reciprocity and mutual benefit. They agreed to develop a package of joint flagship research initiatives, launched in 2017 with co-funding from the EU and China. Among the target areas is surface transport and aviation.

2.3.5.1 Cooperation with the EU:

There are a number of funding-related initiatives on-going in the EU and targeting China (Petino, 2018), some of them funded through the Horizon 2020 programme. The H2020 Work Programme on Transport mentions specific calls where the cooperation of Chinese entities is encouraged:

- There are joint EU-China STI Flagship initiatives with the Ministry of Science and Technology (MOST), open to Co-Funding from both EU and China. There is 1 topic in Surface Transport (LC-MG-1-1-2018: InCo flagship on reduction of transport impact on air quality)[82]:
- H2020 topics targeting cooperation with China in transport sector, mainly the following calls for proposals:
    - LC-GV-05-2019: InCo flagship on "Urban mobility and sustainable electrification in large urban areas in developing and emerging economies"

[82] http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/lc-mg-1-1-2018.html. 1st stage deadline: 30 January 2018; 2nd stage deadline: 19 September 2018.

- LC-MG-1-3-2018: Harnessing and understanding the impacts of changes in urban mobility on policy making by city-led innovation for sustainable urban mobility
- LC-MG-1-1-2018: InCo flagship on reduction of transport impact on air quality: A) Low-emission oriented driving, management and assistance (China, CELAC)
- MG-2-9-2019: Integrated multimodal, low-emission freight transport systems and logistics (Inco Flagship)

A number of bilateral calls have and are organized by the Ministry of Science and Technology (MOST):

- 2017: MOST bilateral calls with EU (Co-Funding mechanism), Germany and Greece[83]
- 2018: MOST bilateral calls with EU (Co-Funding mechanism), Germany and Sweden[84]
- New call published for 2018 under the EU-China Co-Funding Mechanism for Research and Innovation (March 2018), https://ec.europa.eu/research/iscp/index.cfm?pg=china

2.3.5.2 Bilateral cooperation

There are EU-China joint research structures, some of them are in the field of transport[85]. Examples are:

- The Sino-German Institute on Electromobility (IAPS) - Joint Research Institute for Advanced Power Sources for Electric Vehicles, http://www.internationales-buero.de/en/iaps.php, Established in 2010, IAPS carries out research and development of electrochemical energy technologies with a focus on electromobility.
- Another one is a joint research laboratory on rail transport between China and the UK http://paper.sciencenet.cn/htmlnews/2016/11/360267.shtm.

Another specific collaboration exists with the China Automotive Engineering Research Institute Co., Ltd (CAERI)[86]

- CAERI is first class state institute serving as an important base and technical support institution for product development, experimental research and quality test in auto industry.
- The main foreign science & technology cooperation areas of CAERI include automotive safety, vehicle vibration & noise, automotive energy saving & emission, electric vehicle, alternative fuel automotive, key vehicle parts development, etc. CAERI has carried out in-depth project cooperation with well-known scientific research institutions and enterprises in many countries, including Southwest Research Institute, Argonne National Laboratory, America Delphi, Germany FEV company, UK MIRA company, British Institute of Engineering Technology, Sweden DynaTech

[83] Link to the 2017 call: in Chinese: http://www.most.gov.cn/mostinfo/xinxifenlei/fgzc/gfxwj/gfxwj2017/201701/W020170119459870314770.pdf
[84] Link to the 2018 call: in Chinese: http://service.most.gov.cn/u/cms/static/201803/28093225rmr5.pdf
[85] The full list by EU member state is available here: https://euraxess.ec.europa.eu/worldwide/china/directory-europe-china-joint-research-structures
[86] Source: http://www.caeri.com.cn/english/chinabari/about.html

Automotive AB, Netherlands Organization for Applied Science Research, Australia Orbital, Japan Toyota Motor Corporation, Japan Automobile Research Institute, etc.

2.3.6 Main findings and grant funding practices identified

China recently reformed its RTD funding system, now including five main pillars.

1. The National Natural Science Fund is focusing on basic research and applied research in natural sciences
2. The National S&T Major Projects (“Mega Projects”) include 16 programmes addressing major key products, technologies and engineering of strategic importance for the country’s economy and industrial competitiveness.
3. The National Key R&D Programmes, supporting R&D in areas of social welfare and people’s livelihood, such as agriculture, energy and resources, environment, health etc. It is currently the most active of the five pillars, with a total of 48 NKPs, 4 of them with a specific transport topic.
4. The Technology Innovation Guidance Fund is consisting of three major funds. Their aim is to stimulate the transfer and commercialisation of scientific technology results by supporting the growth and activities of innovative start-ups and SMEs.
5. The Bases and Talents Programme, directed to universities, research structures, enterprises and individual talents and teams.

Transport related RTD is primarily financed by the NKPs. Since 2016, there is a specific NKP for advanced rail traffic and a specific NKP for new energy vehicles. In 2018, two new NKPs were announced and are soon to be published, an NKP on Comprehensive Transportation and Smart Transports and an NKP on Key Technology and Demonstration of Internet of Things and Smart Cities.

The budgets for transport related within the NKP calls are the following:

- New Energy Vehicles: 128 million € for 2016 and 90 million € for 2017
- Advance Rail Traffic: 154 million € for 2016 and 60 million € for 2017
- Comprehensive transportation and smart transports: 55 million € for 2018

Similar budgets are expected to be available for the coming years, up to 2020.

These NKPs have been included in the assessment of the best practices in chapter 3. Another good practice of RTD is the Technology Innovation Guidance Fund (Pillar IV). Some EU experts are looking with interest at this Fund (Petino, 2018). An interesting element of this Fund is that it enables to commercialise results of other pillars (funding fundamental research) and support the establishment of start-ups. Due to the limited information available, it was not possible to include this fund into the best practice analysis.

2.4 Brazil

Brazil is the 10th biggest car producer in the world (2016). Accordingly, Brazil's automotive industry represents 22% of its industrial GDP, 4% of the total GDP, and generates 1.3 million jobs.

Since the 1980s, Brazil has been implementing a series of policies, programmes and strategies that aim at promoting the strategies to improve the automotive industry and reduce the air pollution in the country. Brazil is also known for being the first country in implementing Bus Rapid Transit Systems[87], a cost-effective mobility solution that has been replicated in many cities around the world.

Brazil undertook measures to develop biofuels, as well as for the production of vehicles that are able to run on ethanol and biodiesel. As a result, Brazil is the second largest producer of biofuels in the world, after the USA, and 88% of all new light vehicles (LV) sold in Brazil run on a combination of ethanol and gasoline, with flex-fuel engines. Furthermore, in 2005 Brazil started the production of biodiesel with the goal of reducing the use of fossil fuels in heavy duty vehicles. These achievements could not have been accomplished without the Research and Development (RTD) policies and programmes implemented by the Brazilian government in the past 40 years to support the automotive and the biofuels industries.

2.4.1 Visions and targets for road transport RTD

The most important national programmes, regulations and policy documents that regulate and promote the development and expansion of (clean) road transport in Brazil at present are:

1. National Plan of Transport and Logistics (PNLT)
2. Rota 2030 (2018)
3. Sectoral Plan of Transport and Urban Mobility for Climate Change (PSTM)
4. National Program for the Rational use of Oil and Natural Gas – CONPET
5. Brazilian Ethanol Programme - PROALCOOL
6. National Program for Production and Use of Biodiesel
7. Brazilian regulatory program for vehicle emissions control - PROCONVE
8. National Strategy of Science, Technology and Innovation (ENCTI) 2016-2022
9. Science, Technology and Innovation Plan for Advanced Manufacturing – Pro Futuro (2017)

These are each explained further in the following sections.

1. **National Plan of Transport and Logistics (PNLT)**

The PNLT (2011) is the development plan for the implementation of the Brazilian transport infrastructure, which has a long-term vision in terms of solving transportation and logistics problems in the country. The plan seeks to define a new national transport and logistics system that can improve and modernize the quality of national transportation infrastructure, as well as redirect investment policies, programs and projects. The PNLT includes the following objectives:

- Improvement in logistic chains, optimising and rationalising the costs associated with this chain;

[87] The first example being the Curitiba Bus Rapid Transit (BRT) System, established in the 1970s and 1980s.

- Promotion of multimodality, with maximized use of the advantages of each mode of transportation, valuing the current structures and networks;
- Plan effective changes in the country's current freight transport matrix, better balancing the modal distribution (cargo and passenger logistics);
- Protect the environment, seeking to respect the areas of restriction and control of land use, whether in the production of goods or in the implementation of infrastructure;
- Advance scientific and technological evolution, with intensive use of the already available technology of information and communication in transportation services and offer new transport matrix;
- Prioritise biofuels in the transport sector.

Moreover, the PNLT determines the roles of the institutions related to transport and logistics in Brazil, such as the National Department of Transport and Infrastructure (DNIT), part of the Ministry of Transport.

2. Rota 2030

Brazil's national government together with the automotive industry are currently developing a 12-year plan for the development of the automotive industry, called Rota 2030, which will be the continuation of the 5-year programme Inovar-Auto (2012-2017). Inovar Auto, the previous automotive policy regime of Brazil, was an industrial policy that provided tax reduction benefits to assemblers that met or exceeded certain goals related to the percentage of national production and the energy efficiency of the produced vehicles. In order to profit from the tax incentives provided by the government, automotive companies had to fulfil two of the following three requirements (de Mello, Marx, and Motta 2016):

- A minimum percentage of investment in RTD;
- A minimum percentage of investment in engineering;
- Adherence to the national program of vehicle labelling related to fuel efficiency.

Manufacturers invested approximately EUR 20 billion between 2012 and 2018, from which EUR 3.5 billion were for RTD. 10 new plants were built in this period and the fuel efficiency of Brazilian cars increased by 12%.

Rota 2030 aims at setting new energy efficiency and safety targets. The pillars of Rota 2030 are:

- Restructuring auto parts industry;
- Investment in RTD, engineering and structuring;
- Energy efficiency, new technologies and biofuels[88];
- Incentives to manufacture electric vehicles and hybrid vehicles;
- Safety, vehicle technical inspection, fleet renovation;
- Low-volume production, embedded electronics and strategic systems.

[88] The discussion about electric vehicles should be included in the group of Energy efficiency, new technologies and biofuels. However, some groups have pushed to create an autonomous group to promote the development of this sector.

Working groups have been created to discuss each one of these topics and set the future targets and goals of the programme by the end of 2018[89]. The launch of this program was planned for June 2018, but it was postponed and is still in discussion between the Ministry of Treasury and the Ministry of Industry, Foreign Trade and Services[90].

3. Sectoral Plan of Transport and Urban Mobility for Climate Change (PSTM)

The general objective of the PSTM, approved in 2013, is to contribute to the GHG emissions mitigation in the transport sector, through initiatives that lead to the expansion of the transportation infrastructure and the increased use of modes such as public transport systems, contributing to the fulfilment of the commitments assumed by Brazil. In general, the strategy of the plan is to support measures that promote behavior changes on travel patterns, by increasing the participation of public transportation in the modal share, especially in major urban centers. It supports research, and provide guidance to national, regional and local level administration.

Examples of research activities undertaken within the programme are:

- Broaden the knowledge about CO_2 emissions from the transport and urban mobility subsectors, and their mitigation potential in the coming years;
- Contribute, in line with other government policies, to the decision-making regarding the expansion and transfer to more efficient modes of transport, and infrastructural and logistical solutions that lead to the reduction of emissions;
- Boost the investments in urban mobility, highlighting the socio-environmental co-benefits of the expansion of public passenger transport and non-motorized transportation.

4. National Program for the Rational use of Oil and Natural Gas – CONPET[91]

CONPET is a national program under the Ministry of Mines and Energy, established in 1991, and is performed with Petrobras' technical and administrative support. The main purpose and goal of CONPET are to: rationalize the consumption of petroleum and natural gas; reduce greenhouse gas emissions in the atmosphere; promote research and technological development; and provide technical support to increase energy efficiency in energy end-use.

The functions of CONPET cover six areas: institutional, transportation, industrial, residential / commercial, agricultural and power generation. Eliminate waste of diesel is a priority to CONPET. Through the projects *TRANSPORTAR*, *ECONOMIZAR* and *DESPOLUIR*, CONPET provides technical support for the implementation of measures related to fuel efficiency and use of good quality fuel in final use (handling and storage) and improving the qualification of drivers and mechanics.

During the period between 2006 and 2010, the program invested USD 25 million and saved a billion liters of diesel. Recent information regarding current activities were not published.

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89 http://www.autoindustria.com.br/2017/08/23/eletricos-e-hibridos-ganham-grupo-especifico-no-rota-2030/
90 https://www.poder360.com.br/economia/prestes-a-ser-lancado-texto-do-rota-2030-volta-para-analise-da-fazenda/
91 http://www.conpet.gov.br/portal/conpet/pt_br/pagina-inicial.shtml

5. Brazilian Ethanol Program - PROÁLCOOL

In November 1975, Brazil established the National Alcohol Program (PROALCOOL) to promote domestic ethanol production, mainly using sugar cane, and offset some of the negative impacts of large-scale use of imported gasoline. This policy along with the innovations in the engineering field led to the creation of the flex-fuel vehicle, which allows the use of blends of gasoline with ethanol. The first phase of this program required fuel suppliers to blend 10% anhydrous ethanol with gasoline. Subsequent revisions to the program have served to increase the blend requirements for anhydrous ethanol in commercial gasoline to 20-25% in the early 1990s and, most recently, to 27% beginning in March 2015. Between 2003 and 2012, flex-fuel vehicles grew from 0% to 57% of the total in-use LD passenger vehicle fleet[92]. At present, 88% of the LD vehicles sold in the Brazilian market are flex-fuel. This represents an emission reduction of 62 million t $CO2_{-eq}$[93].

In addition to ethanol, Brazil has also promoted the production of biodiesel as a substitute for petroleum-derived diesel fuels. Brazil's Federal Law No. 11,097/2005 established the legal requirement for blending biodiesel with petroleum-derived diesel. The initial blend ratio was set to 2% by volume beginning in 2008 and has subsequently been increased to 7%. In March 2016, new mandatory blend ratios were set for 2017 (8%), 2018 (9%) and 2019 and onward (10%). Moreover, Petrobras, the semi-public Brazilian corporation in the oil industry, is carrying out and financing technical and commercial feasibility studies for the production of advanced biofuels (from cellulose crops and residues).[94]

6. National Program for Production and Use of Biodiesel[95]

The National Program for Production and Use of Biodiesel is a federal government program that aims to implement the production and use of biodiesel in a sustainable manner, focusing on social inclusion and regional development, by generating employment and income. Main objectives of the Program are to:

- Implement a sustainable program, promoting social inclusion
- Ensure competitive prices, quality and supply
- Produce biodiesel from different oil sources and in different regions

In 2005, the law nº 11.097 made it obligatory to add a minimum percentage of biodiesel to the diesel sold to consumers anywhere in the country. The current blend is 10% biodiesel and 90% diesel.

7. Brazilian regulatory program for vehicle emissions control - PROCONVE

The Program to Control Air Pollution caused by Motorized Vehicles (PROCONVE by its Portuguese acronym) was launched in 1986 with a series of targets to be attained in 6 different periods by car and fuel producers. PROCONVE has been instrumental in improving the emission performance of new vehicles sold in the country and, since its introduction, has offset some of the impacts of the rapidly growing

[92] http://researcharchive.vuw.ac.nz/xmlui/bitstream/handle/10063/2418/thesis.pdf?sequence=1
[93] Source: ANFAVEA – Brazilian National Association of Motor Vehicle Manufacturers
[94] https://ec.europa.eu/transport/sites/transport/files/themes/urban/studies/doc/2016-01-21-alternative-fuels-and-infrastructure-in-seven-non-eu-markets.pdf
[95] http://www.mda.gov.br/sitemda/tags/programa-nacional-de-produção-e-uso-de-biodiesel-pnpb

Brazilian fleet. The phase 6 of PROCONVE L6 for light-duty vehicles was completed in 2015. The results of this program have been very satisfactory in terms of emissions reduction in Brazil.

Initial phases of PROCONVE (L1-L3) set stringent emission limits to promote the application of best available engine design strategies and treatment control devices. These include electronic fuel injection and engine controls and three-way catalytic converters. The widespread adoption of catalytic converters in this time period was enabled by the addition of ethanol and phase-out of tetraethyl lead as antiknock additives to gasoline fuels. Subsequent phases of PROCONVE have continued to set more stringent emission limits for LD vehicles, with a specific focus on addressing urban ozone pollution problems through better control of NO_X and HC emissions. Beginning in 1994, LD diesel vehicles were also explicitly included in PROCONVE regulation[96].

8. **National Strategy of Science, Technology and Innovation (ENCTI) 2016-2022[97]**

ENCTI 2016-2022, developed by the Ministry of Science, Technology, Innovation and Communications (MCTIC), is the medium-term strategic orientation document for the implementation of public policies in the area of ST & I. This document is drawn from a public consultation with stakeholders from various sectors. The document is composed of two sets of chapters:

I. Comprehensive contextualization of national sector policy and
II. Guide S & T initiatives for the next few years.

The allocation of the resources of the National System of Science, Technology and Innovation (SNCTI) occurs through several instruments that have formats and executors with characteristics appropriate to the results delineated by the planning of the sector. In general, the Development Agencies are the operators of these instruments, which can benefit researchers, ICTs, companies or arrangements that combine ICTs and companies.

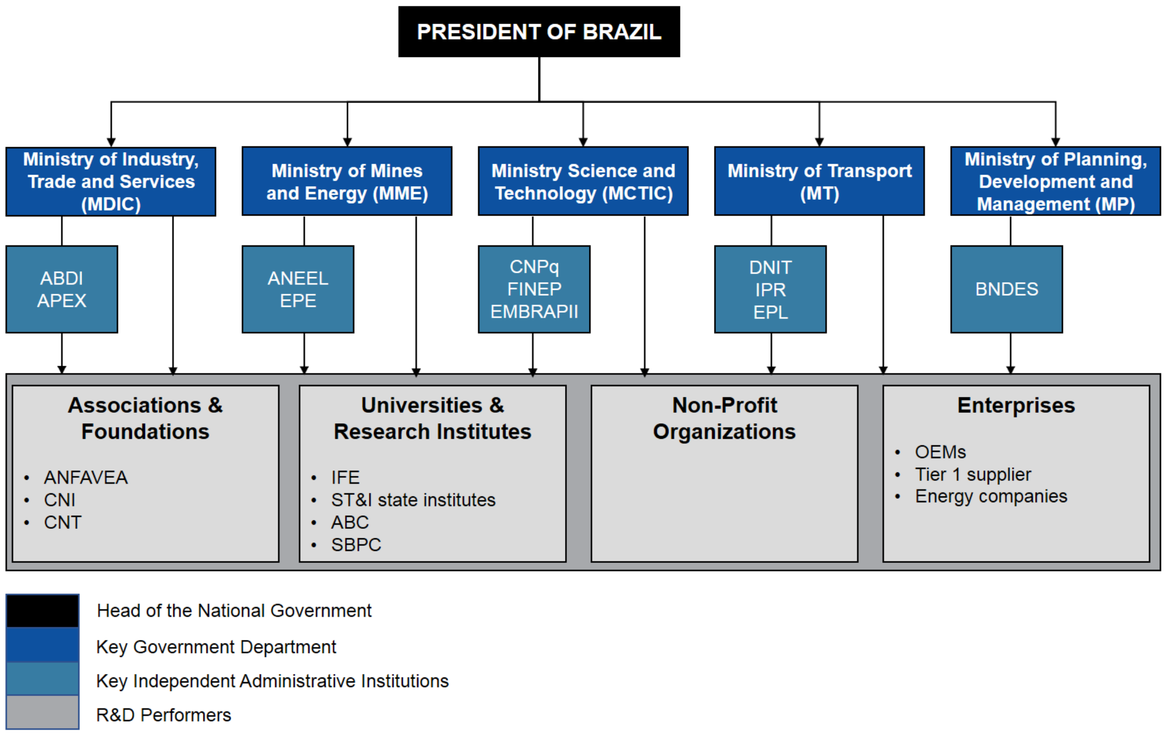
9. **Science, Technology and Innovation Plan for Advances Manufacturing – Pro-Futuro (2017)**

The Ministry of Science, Technology, Innovation and Communications (MCTIC) launched the Science, Technology and Innovation Plan for Advanced Manufacturing in Brazil in December 2017, named ProFuturo - Production of the Future, defines actions and priority sectors for the development of industry 4.0 in the country. Among the priority sectors that can benefit from advanced manufacturing included in the plan are the automotive industry, as well as transport and logistics[98]. The goal of the plan is to give companies support for science, technology and innovation in order to develop productive chains of promising economic sectors that meet social demands. The technology priority areas for Brazil in advanced manufacturing are automation, Big Data, Cloud Computing, Renewable Energy, Internet of Things, Nanotechnology, Cyber Security and Information and Communication Technologies (ICTs).

[96] https://www.theicct.org/sites/default/files/publications/Brazil-LDF-Regs_White-Paper_ICCT_14042017_vF.pdf
[97] http://www.finep.gov.br/images/a-finep/Politica/16_03_2018_Estrategia_Nacional_de_Ciencia_Tecnologia_e_Inovacao_2016_2022.pdf
[98] http://www.mctic.gov.br/mctic/export/sites/institucional/tecnologia/tecnologias_convergentes/arquivos/Cartilha-Plano-de-CTI_WEB.pdf

2.4.2 Governance and funding system

The scheme developed by Wuppertal Institute (2018) shows the key stakeholders of Brazilian RTD.



Overview of the Institutional Structure of the RTD Programmes of Road Transport in Brazil

2.4.3 Overview of the funding organisations and other key stakeholders

There are several organizations in Brazil that provide support for the industry, and which are in charge of managing the development of the automotive industry in the country. The most important ministries are:

Ministry of Science and Technology (MCTIC)

The Ministry of Science and Technology (MCTIC by its Portuguese acronym) is in charge of the coordination of the SNCTI. The MCTIC manages the National Fund for Scientific and Technological Development (FNDCT) and has the legal competence of formulating the national policies for the sector.

Part of the Ministry are the following funding agencies of the System:

- National Council of Scientific and Technological Development (CNPq), its role is to promote scientific and technological research and to foster technological development and innovation through partnerships with government agencies and the private sector.
- Financier of Studies and Projects (Finep) – linked to MCTIC, serves as the Executive Secretariat of the FNDCT and also presents itself as a central player in the financing of SNCTI.

Other Ministries also have a relevant role in the Science and Technology System, managing separate bodies to manage the ST & I theme or by operating in the sector and provide RTD Funds.

Ministry of Development, Industry and Commerce (MDIC)

The Ministry of Development, Industry and Commerce is responsible for industry, commerce and services development policies, copyright and technology transfer, metrology and international trading. Linked to the MDIC is the Brazilian National Development Bank (BNDES), promoting innovation.

Ministry of Mines and Energy (MME)

This ministry supports RTD activities in the sector of energy. It has a programme that publishes information on Biodiesel in Brazil and a programme for validating the use of hydrogen powered buses.

A major stakeholder of RTD is the National Electric Energy Agency (ANEEL). The volume of resources of the RTD of this agency has gradually increased (the agency and its programmes are highlighted below).

Research entities

The category of RTD performers consists mainly of all Entities of Science and Technology (ICT by its Portuguese acronym), which includes universities, research institutes, Federal Institutes of Education, Science and Technology (IFE), and ST & I State Institutes.

Within the framework of academic representation, the Brazilian Academy of Sciences (ABC) and the Brazilian Society for the Advancement of Science (SBPC) are main stakeholders in favour of scientific and technological development.

2.4.3.1 Other major stakeholders

National Confederation of Transport (CNT)[99]

The CNT (National Confederation of Transport) represents the transportation and logistics sector and its mission is to support the development and defend its interests. The organisation plays an important role in promoting multimodality and strengthening the transport and logistics system. Focusing on sustainability, its vision is to promote research and innovation that strengthens the transportation sector. CNT conducts research related to transport. The technical studies developed by CNT are a reference for transporters, society, press, academic area and government, at all levels. The studies encompass different models, contribute to improving the planning of transport companies and recommendations for direct investments in infrastructure. Some of the recent studies produced are:

- Road Accidents and Infrastructure;
- Urban Logistics - Trucks Restrictions;
- The Addition of Biodiesel and Quality Diesel in Brazil;
- The P7 Phase of PROCONVE and its Impact on the Transportation Sector;
- Survey: Mobility of Urban Population 2017.

[99] http://www.cnt.org.br/Paginas/conheca-a-cnt

Planning and Logistics Company (EPL)[100]

The Planning and Logistics Company (EPL) is a state-owned company created in 2012 whose purpose is to structure and contribute, through studies and research, to the process of integrated logistics planning in the country (by e.g. interconnecting highways, railways, ports, airports and waterways). EPL plans and structures projects, on request, to be executed by the respective bodies of each sector and may sign contracts and agreements with scientific and technological institutions for research and development activities, technological transfer and licensing of patents.

National Department of Transport Infrastructure (DNIT) [101][102]

The National Department of Transport Infrastructure (DNIT) is a federal authority linked to the Ministry of Transport, created in 2001. The objective of DNIT is to implement the infrastructure policy of the Federal Highway System, comprising its operation, maintenance, restoration or replacement, capacity adequacy and expansion through the construction of new roads and terminals. The resources for the execution of the works are the Union. In other words, the body is the manager and executor, under the jurisdiction of the Ministry of Transport, of waterways, railroads and federal highways, ports and intermodal facilities.

Among the responsibilities of the National Department of Transport and Infrastructure (DNIT) are:

- The promotion of research and experimental studies in the areas of road, rail, waterway and port engineering, including their impact on the environment;
- The carrying out of research and technological development programs, promoting technical cooperation with public and private entities, through the maintenance of exchanges with national and foreign research organizations and educational institutions;
- The provision to the Ministry of Transport of information and data to support the formulation of the general approval plans for the road infrastructure segments.

Institute of Road Research (IPR)

The mission of the IPR covers research, standardization, technology transfer and technical assistance to DNIT and the Ministry of Transport. The IPR's specific duties include the elaboration of standards and technical documents, training and qualification of personnel, audits and technical support to DNIT.

The main objectives of the Technological Development Cycle of IPR are:

- Identifying new products, services and materials;
- Developing studies and researches generating new technologies and road materials;
- Performing tests on materials;
- Carrying out concrete dosing projects of cement and asphalt mixtures;
- Advising on national road works;
- Organising seminars, courses and training.

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[100] http://www.epl.gov.br/institucional
[101] http://www.dnit.gov.br/acesso-a-informacao/insitucional
[102] http://ipr.dnit.gov.br/pesquisa/pesquisas-em-andamento

National Electricity Regulatory Agency - (Agência Nacional de Energia Elétrica - ANEEL)

The National Electricity Regulatory Agency (ANEEL), an authority linked to the Ministry of Mines and Energy, was created to regulate the Brazilian electricity sector, including generation (production), transmission, distribution and commercialization of electric energy. ANEEL is also involved in electric mobility in Brazil and supporting regulations for electric vehicles charging services.

Brazilian National Development Bank (BNDES)

The BNDES aims to stimulate capacity building and the development of innovative environments. It provides favourable conditions of support for investment plans in innovation within their entire set of financing lines and programs. Among the options, the BNDES Inovação line stands out, which supports operations of companies of all sizes and sectors.

The automotive sector has received considerable benefits from the creation of BNDES financing channels. However, as a result of the current stage of development of the automotive sector, the funding of incremental innovations in product and process engineering are more frequent than disruptive innovations. In the medium and long term, support for new hybrid and electric drive models, the development of batteries, integrated automation systems and the use of alternative fuels should become essential to the industry (Barros and Pedro 2012).

Brazilian Industrial Development Agency (ABDI)

The Brazilian Industrial Development Agency (ABDI) was created by the federal government in 2004 to promote the implementation of industrial policy, in line with science, technology, innovation and foreign trade policies. Connected to the Ministry of Industry, Foreign Trade and Services (MDIC), it acts as a link between the public and private sectors, contributing to the country's sustainable development through actions that increase the competitiveness of the industry.

Working as a systematic technical support entity for the articulation and management of the new industrial policy (Plan Brasil Maior) and the provision of short-term, strategic and technological studies for different sectors of the industry, ABDI contributes to the construction of sectoral action agendas and for the advances in the institutional, regulatory and innovation environment in Brazil.

The Agency also has flexibility, agility and capillarity to act as a forum for the promotion, monitoring and evaluation of the Greater Brazil Plan, bringing together public and private entities around programs, projects and actions of a strategic and operational nature.

Brazilian Research and Innovation Enterprise (Finep)

The main role of the Finep is to promote the economic and social development of Brazil through the public promotion of Science, Technology and Innovation in companies, universities, technological institutes and other public or private institutions. It supports various R & D programs and projects in the Brazilian transport sector through operating reimbursable (business credit) and non-reimbursable resources (for scientific and technological institutions and grant for companies).

National Council for Scientific and Technological Development (CNPq)[103]

As a research promotion body, linked to the Ministry of Science, Technology, Innovations and Communications (MCTIC), the CNPq participates in the formulation, execution, monitoring, evaluation and diffusion of the National Science and Technology Policy, especially promote and foster the development and maintenance of scientific and technological research and innovation, as well as the training of qualified human resources for research in all areas of knowledge.

Brazilian Agency for Industrial Research and Innovation (EMBRAPII)

EMBRAPII (Brazilian Association of Industrial Research and Innovation) is qualified as a Social Organization by the Federal Public Power since September 2013. EMBRAPII acts through cooperation with scientific and technological research institutions, public or private, focusing on the demands sharing the risk in the pre-competitive phase of innovation. By sharing project risks with companies, it aims to stimulate the industrial sector to innovate more and with greater technological intensity, in order to boost the competitive strength of companies both in the domestic market and in the international market.

2.4.4 Overview of existing grant programmes and relevant calls

2.4.4.1 ANEEL R & D Programme

Law 9.991 / 2000 determines that authorized companies of the electricity sector are obliged to annually apply a percentage of their Net Operating Revenue (ROL) in research and development (R & D). ANEEL provides guidelines and procedures for the elaboration, submission, evaluation of proposals and of RTD projects in the Electric Energy Sector.

The ANEEL R & D Programme seeks to promote a culture of innovation, stimulating research and development in the Brazilian electric sector. The main objectives to be achieved are security of electric power supply, modality of tariffs, reduction of the environmental impact of the sector and technological dependence of the country.

The following institutions participate in the programme regulated by ANEEL:

- Energy companies (distribution companies, transmission companies and energy generators), who act as project proponents;
- Research and development institutes, higher education institutions, consulting firms, technology-based companies and incubated companies, which may be executing R & D projects;
- Industries or other institutions with interest in providing resources for the execution of the project, which may be partners in the projects.

Because of its nature, ANEEL focuses mainly on energy and electricity projects not related to road transport. However, in the past years, considering the potential of electric vehicles in Brazil, ANEEL and several other electric power sector companies have assigned resources for conducting research on EVs. It includes evaluation of potential network impacts resulting from massive EV insertion, fast charging stations and development of electric buses.

[103] http://cnpq.br/competencias/

Most of the projects financed through the ANEEL R & D Programme are related to energy. 16 projects from 10 different electricity companies were approved until 2017 with a total budget of € 35 million. The average project size was € 2.2 million, the smallest project being € 200,000, the largest one € 14 million.

2.4.4.1.1 Programme examples – Plano Inova Energia

Between 2013 and 2016 ANEEL in partnership with BNDES and Finep provided resources of approximately € 700 million for the implementation of the Plano Inova Energia. The Joint Action Plan has as one of its four research areas the support to initiatives that promote the development of components in the production of electric and hybrid vehicles and he improvement of the energy efficiency of motor vehicles in the country. Specific RTD activities that are promoted are:

- Engines and traction systems (Powertrains): development of technologies for engines, components and complete electric traction systems for hybrid / electric motor vehicles, as well as technologies to improve energy efficiency in ethanol (or flex-fuel) and transmission;
- Batteries and accumulators of energy: development of batteries, supercapacitors, other technologies of accumulators and recuperators of energy for traction, fuel cells and materials for batteries, as well as management systems and their components, for use in hybrid / electric automotive vehicles, preferably to ethanol;
- Scale production: pioneer projects in pilot scale or superior development and implementation of production of hybrid / electric automotive vehicles, preferably ethanol.

2.4.4.1.2 Programme examples - Emotive

In 2013, the RTD programme of CPFL[104], under the framework of ANEEL, started a research project on electromobility. This project, called Emotive, is conducted in partnership with several research institutes, universities and private sector entities. Emotive aims at identifying the potential and challenges of the implementation of electromobility in Brazil. It takes place in the Campinas region, where electric vehicles for passengers and cargo have been purchased and tested. Its main purpose is to conduct the necessary research on different aspects of e-mobility to generate inputs for an adequate legislation in Brazil. The 5-year programme has a budget of approximately € 5 million and focuses on the following areas:

- Energy distribution network;
- Energy Planning;
- Rates and regulation;
- Life cycle of EVs and batteries;
- EVs as a source of distributed generation;
- Charging infrastructure;
- Electric mobility cluster;
- Economic feasibility study;
- New business models.

[104] CPFL Energia is the second largest non-state-owned group of electric energy generation and distribution in Brazil and the third biggest Brazilian electric utility company.

In the first phase of the research, it was possible to conclude that electric vehicles are an excellent option for people who want to reduce their expenses. The data collected by the project show that the cost of travelled kilometre by a combustion car is approximately BRL 0.30, while this cost of an electric vehicle is BRL 0.10[105], that is, one third of the cost of a conventional car.

Another conclusion of the first phase is that the expansion of electric vehicles would have small impact on the energy demand. CPFL Energia's initial projections indicate that the use of this technology would increase energy consumption by 0.6% to 1.6% in the National Interconnected System (SIN) by 2030, with a foreseen EV fleet of between 4 million and 10.1 million units[106].

The Emotive programme has shown that after 24,300 travelled kilometres, 105 tonnes of CO_2 have been avoided and approx. BRL 20,000 (€ 4,600) have been saved in energy costs.[107]

2.4.4.2 BNDES Innovation Line

The BNDES Innovation line grants loans of a minimum of BRL 10 million (2.3 million €) for investments in innovation for both public and private entities based in Brazil. The Innovation Line also funds RD&I that provides proven market opportunity, including the development of incremental product or process innovations in several industrial sectors including the automotive one. This programme funds the following areas:

- Potentially disruptive or incremental innovations in product, process and marketing;
- Investments in innovation environments and their support structures located in technological parks, incubators, accelerators etc.;
- Innovation infrastructure (laboratories and R & D centres), pilot plants and demonstration plants
- New business models, production and distribution of content on new digital, interactive, cross-platform or transmedia platforms applied to culture, education or health;
- Innovation in software and IT services;
- Industrial plants with unprecedented characteristics or that have as objective the production of non-manufactured goods in Brazil, in order to promote the expansion of the technological frontier of the Country (minimum financing amount: BRL 10 million); and
- Installation, adaptation of production plants or manufacturing machines or systems to qualify them for Advanced Manufacturing incorporating technologies for production scanning, automation technologies (internet of things, artificial intelligence, analytics and big data), new materials, additive manufacturing, as well as sensing and traceability devices.

Costs necessary for the introduction of innovation in the market, including investments in productive capacity, are financeable and limited to 30% of the value of support for innovation investment plan.

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[105] Exchange rate 31st of July, € 1 = 4.34 Brazilian Real (BRL), www.oanda.com
[106] https://www.cpfl.com.br/releases/Paginas/veiculos-eletricos-trazem-economia-de-ate-nos-gastos-com-combustivel.aspx
[107] https://www.cpfl.com.br/sites/mobilidade-eletrica/Pages/default.aspx

2.4.4.3 BNDES Funtec

BNDES Funtec provides non-reimbursable financial support for applied research, technological development and innovation projects executed by Technological Institutions (IT), selected according to the action points published annually by BNDES. The following institutions can apply:

- Technological institutions (IT): public or private, non-profit institutions, whose institutional mission, among others, is to perform basic or applied research activities of a scientific or technological nature, as well as technological development; and
- Institutions of support (IA): institutions created with the purpose of supporting research, teaching and extension projects and institutional, scientific and technological development of interest to federal, state or municipal higher education institutions or institutions of scientific research and including those created under Law No. 8,958, dated December 20, 1994. Projects forwarded by IA should present an IT responsible for the execution of the project.

The aforementioned institutions may receive the resources of the BNDES Funtec for the development of applied research projects, technological development and innovation, with the participation in the financing operation of companies (intervening company), headquartered in the country, that carry out economic activity directly linked to the scope of the project.

The intervening company, regardless of its size, must appear as an intervener in the BNDES Funtec financial collaboration agreement and must contribute financially with at least 10% of the total value of the financeable items.

One of the focal points of this programme has been funding the development of innovative technologies and systems of low-carbon engines for cars.

2.4.4.4 BNDES Finem

BNDES Finem support national engineering projects with financing starting at BRL 10 million (€ 2.3 million) for projects and engineering services in strategic sectors, such as the automotive sector, aiming to stimulate the improvement of skills and technical knowledge in the country. Funding is provided up to 80% of the project value.

When it was established in 2007, the BNDES Support to National Engineering was the first incentive mechanism to the automotive sector and for financing intangible capital of companies. This programme financed several activities related to the design and re-use/recycle of vehicle materials, the development of new heavy-duty vehicle engines that meet the requirements of environmental legislation, as well as the implementation, expansion and modernization of engineering centres in vehicle manufacturers and automotive parts. The program offers a significant competitive advantage for manufacturers installed in the country, as it strengthens the national subsidiaries of automakers and system companies in the intercompany disputes for the design and physical realization of projects.

This programme finances companies based in Brazil, foundations, associations and cooperatives; and entities and public bodies in the following areas:

- local engineering activities presented in the form of a project and that increase the capacity of companies;
- physical infrastructure for research, development, product engineering and testing; and
- conceptual engineering and basic engineering services performed by consulting engineering companies, provided that they are intended to serve the sectors supported by the program.

2.4.4.5 The funds managed by EMBRAPII

The Brazilian Association of Research and Industrial Innovation - EMBRAPII - is a private non-profit institution. EMBRAPII acts through cooperation with scientific and technological research institutions, public or private, focusing on risk-sharing in the pre-competitive phase of innovation. By sharing project risks with companies, it aims to stimulate the industrial sector to innovate more, in order to boost the competitive strength of companies both in the domestic market and in the international market.

The non-reimbursable funds managed by EMBRAPII are invested in innovation projects undertaken between enterprises and EMBRAPII Units and Hubs. EMBRAPII Units and Hubs are technologically focused Innovation Centers with technical capabilities to meet firm´s demands for technological solutions and innovations.

EMBRAPII allocates up to one-third of the resources needed for an industrial innovation project with non-reimbursable resources, while the remainder is divided between the partner company and the unit. Supported areas are:

- Information and Communication Technologies (ICTs);
- Mechanics and Manufacturing;
- Materials and Chemistry;
- Applied Technologies;
- Biotechnology.

One of the topics related to transport among the EMBRAPII's support offer is the development of RTD projects for Intelligent Automotive Systems, with emphasis on applications projects that make use of vehicle architectures, connectivity, distributed mobile computing and user interaction to provide services aimed at comfort, security, accuracy, location, entertainment, among others (included in the ICTs area).

Among the enterprises that have been beneficiaries of EMBRAPII's support are FCA, with a project for the integration of manufacturing requirements, and Renault, with a project to develop a new brake support device.

EMBRAPII Project examples
The Federal Institute of Minas Gerais (IFMG by its Portuguese acronym) signed a cooperation agreement with the automotive sector in 2014. This agreement allowed the construction of a laboratory dedicated to the study of automotive systems. The experience in the construction and execution of projects through a partnership with a large company and the qualified multidisciplinary team of professors / researchers produced the necessary

environment for the approval of the Minas Gerais Innovation Hub in the scope of public call 02/2014 of EMBRAPII, in the area of Intelligent Automotive Systems[108].
Some other projects listed in the EMBRAPII Website are:
1. FCA Fiat Chrysler Automobiles Brazil: Numerical models of exhaust systems FCA Fiat Chrysler signed a collaboration agreement with Embrapii, Tecgraf / PUC-Rio and the University of Coventry in England for the joint development of a light exhaust system from the R $ 1 million investment (€ 230,000). The focus of the collaboration will be the transfer of technology and knowledge among the institutions in order to advance in the execution of the project, which will have an advanced prototyping manufacturing laboratory at the facilities of Advanced Manufacturing and Engineering (AME), a partnership between the University of Coventry and Unipart Manufacturing.
2. FCA Fiat Chrysler Automobiles Brazil: Numerical models of exhaust systems FCA Fiat Chrysler signed a collaboration agreement with Embrapii, Tecgraf / PUC-Rio and the University of Coventry in England for the joint development of a light exhaust system from the R $ 1 million (€ 230,000) investment. The focus of the collaboration will be the transfer of technology and knowledge among the institutions in order to advance in the execution of the project, which will have an advanced prototyping manufacturing laboratory at the facilities of Advanced Manufacturing and Engineering (AME), a partnership between the University of Coventry and Unipart Manufacturing. The objective of the research project is to work with multi-physics optimization techniques applied to structural components. The collaboration will enable the exchange of knowledge in the areas of theoretical optimization and advanced prototyping[109].
3. General Motors Brazil: Tooling 4.0 The SENAI Institute of Innovation for Manufacturing Systems renewed its partnership with General Motors for the 4.0 Tool project, with a financial contribution of R $ 2.7 million (€ 620,000). In addition to the first phase, the project surpasses R $ 5 million (€ 1.15 million). The goal is to develop vehicle quality control devices based on technological structures 4.0. The final phase 1 tests and the signature of phase 2 occurred at the GM plant in São Caetano do Sul, Brazil, where new technologies are being implemented. • The SENAI Institute of Innovation of Joinville was the leader and main executor of the project, supported by the Institute of Aeronautical Technology (ITA), the Brazilian Industrial Research and Innovation Company (Embrapii) and the SENAI Institute in Pernambuco.

2.4.4.6 National Fund for Scientific and Technological Development (FNDCT)

The FNDCT was created with the purpose of providing financial support to programs and projects for scientific and technological development, notably for the implementation of the Basic Scientific and Technological Development (PBDCT).

Sectorial funds of the FNDCT include various funds including fund for infrastructure and for land transport. The resources for the FNDCT sectorial funds are mainly from contributions of the exploitation of natural resources, from taxes on Industrialized Products as well as from Contribution for Intervention in the

[108] http://embrapii.org.br/if-formiga/
[109] Source: Virgínia Monteiro, collaborator of the EMBRAPII Tecgraf / PUC-Rio Unit and responsible for technical coordination of the project.

Economic Domain (CIDE), collected from the values of the use or acquisition of technology and technology transfer from abroad. These resources are allocated at the National Fund for Science and Technology (FNDCT) and are managed by FINEP.

The **FINEP - Sectoral Funds of Science and Technology**, created since 1999, are instruments for financing research, development and innovation projects part of the FNDCT. There are 16 Sectoral Funds, of which 14 are sector-specific and two are cross-sectional. Of these, one is focused on university-company interaction (FVA - Green-Yellow Fund), while the other is aimed at supporting the improvement of ICT infrastructure (Infrastructure).

Since its implementation in recent years, the Sectorial Funds have been the main instrument of the Federal Government to leverage the country's Science and Technology system. They have enabled the implementation of thousands of new projects in ICT, which aim not only to generate knowledge, but also their transfer to companies. Projects in partnership have stimulated greater investment in technological innovation by companies, contributing to improve their products and processes and also balance the relationship between public and private investments in science and technology.

2.4.4.6.1 CT-Transportes

One of the Sectoral Funds is **CT-Transportes**. The main focus area is on transport engineering, including logistics and other areas of application in transport (such as civil, materials, mechanical, naval and electronics engineering, and the development of systems) and aims to improve the quality of the transport sector, reduce the costs of services and increase the competitiveness of the transport of cargo and passengers in the modalities in question.

The CT-Transportes resources come from the 10% tax on the collection obtained by the National Department of Land Infrastructure - DNIT (former DNER), of the Ministry of Transport, through the contracts of assignment of rights of use of the infrastructure Federal highway by the telecommunications sector - the so-called "infovias".

In general terms, the CT-Transport research, development and studies projects should:

1. aim at the development and modernization of transport in Brazil;
2. be of community interest;
3. be focused on economic reality;
4. generate products capable of subsidizing medium and long-term deployment projects;
5. provide human resources training for the transportation sector as a whole.

The purpose of CT-Transportes is to promote the generation and use of knowledge, techniques, methods and technologies to improve transportation in the country. The vision that underlies CT- Transportes, therefore, is not that of an area of knowledge, closed in on itself, but rather an activity that should benefit from knowledge regardless of its origin.

The environmental impacts are an essential issue to be taken into account in overcoming the obstacles mentioned. As stated in the Environmental Policy of the Ministry of Transport, transport solutions will have to consider the environmental impact of transport undertakings. Programs and projects to be supported with the CT-Transportes will necessarily have to contemplate these principles.

For the concession of CT- Transportes resources, priority will be given to ideas and proposals that, in one way or another, contribute to the following topics:

- Fluidity and traffic safety in order to reduce its externalities;
- Development and application of logistic methods and systems;
- Operation and management of transport systems;
- Development of new technologies in infrastructure and transport equipment, including the use of recycled materials;
- Development and application of Intelligent Transport Systems (ITS);
- Development, maintenance and diffusion of the Transportation Information System;
- Improvement of existing infrastructures through the introduction of new control, maintenance and other technologies;
- Study of the operational conditions of transport systems and their externalities;
- Development of transportation infrastructure management processes;
- Systems of operational management of transport equipment;
- Studies for the technological development of waterway transport (North Region);
- Promotion of human resources training for transport R & D;
- Reduction of adverse environmental impacts resulting from transportation;
- Improvement of management processes of transport companies;
- Promotion of the development of forecasting and simulation techniques and models for transport planning;
- Comparative studies of institutional and regulatory experiences, national and international;
- Development and evaluation of equipment technologies promoting safety in the transportation sector.

The CT – Transportes Fund seeks to encourage R & D programs and projects in Civil Engineering, Transport Engineering, materials, logistics, equipment and software, to improve quality, reduce costs and increase the competitiveness of road passenger transport and of cargo in the country.

CT-Transportes – implementation of the programme

CT-Transportes actions are implemented through public notices, calls, commission or continuous flow, with the aid of various modalities to support projects of diverse natures, such as:

- Cooperative Projects, in which the university executes projects of interest and commissioned by a company or other client/user of the technologies to be generated.
- Cooperative Networks of Technological Innovation, in which several teaching and research institutions, as well as technological institutions, together with companies or other user-users, act jointly to identify obstacles or possible technological solutions, in the formulation of projects and their budgeting, as well as in its execution. The results of these projects will be, in general, pre-competitive technologies.
- Institutional projects are projects to be developed by individual institutions, preferably in response to calls for proposals, within topics prioritized for CT-Transportes;

- Events: CT-Transportes will be able to support the most important science, technology and innovation events that contribute to the discussion of scientific and technological policies for the sector;
- Studies: CT-Transportes provides support for studies and surveys that contribute to the formulation of science, technology and innovation policies in transportation.

Since its establishment, the supply of financial resources for transportation projects was lower than demand. Analysing the projects funded by other funds, it was possible to identify more than 60 projects that would be in the CT-Transportes scope, compared to only nine directly. Additional resources were provided through so-called Cross-Cutting Actions. One occurred in 2007, funding six projects, and in 2009, a new action was published.

When looking at the allocated research budgets, the ones that had more projects funded, as well as greater amount of resources, were those of Intelligent Transport Systems, transportation and logistics and interior waterway transportation. The following table shows the number and funded-amount of projects by topic financed by CT-Transportes and other funds.

Resources	CT-Transportes		Other funds		Total	
Themes	*Projects (#)*	*R $*	*Projects (#)*	*R $*	*Projects (#)*	*R $*
Intelligent Transport Systems (ITS)	1	328.371	15	14.905.626	16	15.233.997
Transport and logistics	1	1.101.748	11	1.585.026	18	4.869.305[110]
Interior waterway transportation			6	3.898.346	6	3.898.346
Development of fossil fuels	1	1.328.757	1	1.697.741	2	3.026.498
Development of vehicles	1	447.662	2	1.361.583	3	1.809.245
Planning and operation of urban transport	1	449.786	5	765.470	6	1.215.256
Transport regulation	1	655.632	1	370.472	2	1.026.105
Pavement infrastructure	1	540.631	3	393.252	4	933.884
Traffic engineering	1	558.548	3	88.393	4	646.941
Rail transport	1	503.465			1	503.465
Events			10	236.583	10	236.583
Maritime transport			1	143.098	1	143.098
Traffic safety			1	99.699	1	99.699
Road transport			2	81.828	2	81.828

[110] This includes 6 projects in the category cross-cutting action

2.4.5 International collaboration in the field of RTD

Electric Sector Innovation Network (RISE)

The ANEEL Strategic Partnership and the German Cooperation Agency (GIZ) organized the initial steps for the structuring of the Electric Sector Innovation Network – RISE in 2018, applied to Electric Mobility. In the process of building network for the RISE, representatives of companies from the electric sector, industry and research institutes and universities were invited to promote innovative environments conducive to the creation of technological products with market insertion, in order to boost electric mobility in Brazil.

ANEEL intends to stimulate applied research aligned with the industrial sector, in the current environment full of disruptive changes, identifying challenges and opportunities for technological development and ensuring the balance between agents and society.

2.4.5.1 Other funding opportunities

The European Commission, the Brazilian National Council for Scientific and Technological Development, the Brazilian Funding Agency for Studies and Projects and the Brazilian National Council of State Funding Agencies signed an administrative arrangement on mechanisms to support EU-Brazil cooperation activities in research and innovation in May 2018. The administrative arrangement makes it possible for co-funding of Brazilian participation in Horizon 2020, extending to the entire country the current co-funding that was only available in eight Brazilian States. In force since 2007, the EU and Brazil Science & Technology Agreement has led to intensive collaboration activities in research and innovation with more than 350 common projects. Main areas for cooperation include marine research, information and communication technologies, health, transport and environmental research[111].

These are the main road transport related calls either specifically targeting cooperation with Brazil or being exceptionally relevant for Brazil in the current 2018-2020 Work Programme[112] :

- LC-MG-1-1-2018 InCo flagship on reduction of transport impact on air quality
- MG-2-1-2018 Human Factors in Transport Safety
- LC-GV-05-2019 Urban mobility and sustainable electrification in large urban areas in developing and emerging economies
- MG-2-9-2019 Integrated multimodal, low-emission freight transport systems and logistics
- MG-2-7-2019 Safety in an evolving road mobility environment
- MG-4-1-2018 New regulatory frameworks to enable effective deployment of emerging technologies and business/operating models for all transport modes

[111] More info at: https://ec.europa.eu/research/iscp/index.cfm?pg=brazil
[112] Source: https://ec.europa.eu/research/participants/data/ref/h2020/other/hi/h2020_localsupp_brazil_en.pdf

- MG-4-2-2018 Building Open Science platforms in transport research

Created in 2006, CONFAP, the Brazilian National Council of State Funding Agencies, gathers Funding Agencies from 25 Brazilian States, plus the Funding Agency of the Federal District, and its 26 members meet in National Forums 4 or 5 times per year. In the framework of International Cooperation, CONFAP was the first Brazilian organization to operate the Newton Fund, due to its strong partnership with the United Kingdom. CONFAP has also partnerships with INRIA and CNRS from France. It is also developing agreements with other European and international countries such as Ireland, Finland, Canada, USA, Belgium and Italy[113].

The Ministry of Development, Industry and Trade has specifically targeted Germany, France, Israel, UK and USA for cooperation on innovation. Calls already published in the past few years were open to any topic but did require the proposals to expect the introduction of a new or improved product, process or service, hence aiming at close to market applications. Such projects get their support on the Brazilian side from the above mentioned CONFAP, the Brazilian Agency for Industrial Research and Innovation (EMBRAPII) and the Brazilian Development Bank (BNDES)[114].

Funding Authority for Studies and Projects (FINEP) is a public company under Brazil's Ministry of Science, Technology and Innovation. It has bilateral agreements with a number of European innovation agencies like CDTI in Spain, BPI in France or Innovate UK. It is also an international partner of the European Network of Innovation Agencies (TAFTIE). The projects supported are generally focused on industrial research, development and innovation with specific topics being captured in individual bilateral calls[115].

2.4.6 Main findings and grant funding practices identified

The support for transport research in Brazil is relatively fragmented, but includes several nationwide programmes, like the EMBRAPII, BNDES Finem and the ANEEL R&D programme. These three programmes have been included into the best practice assessment in Chapter 3.

Funding programmes in Brazil are of a more general nature. RTD programmes are of a general nature and promote the innovative potential for industry as a whole. This may be related to the fact that although Brazil has a large automotive industry, it is not an automotive technology leader. This is shown by the fact that innovation in the automotive sector is not supported by specific research programmes as is the case in the USA, Japan and China.

Interesting good practices in the field of transport policy can be identified, however. Examples are the Brazilian Ethanol Programme and the National Program for Production and Use of Biodiesel. In the field of urban mobility, Brazil was the first country to implement the Bus Rapid Transit System.

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[113] https://www.incobra.eu/en/object/organisation/194
[114] http://www.cooperacaointernacional.mdic.gov.br/
[115] http://www.finep.gov.br/on-international-cooperation

3 Best Practice Analysis and Conclusions

In this chapter a best practice analysis of described grant funding programmes is made based on best practice criteria. A selection of one or two best practice examples per country was made, based on the pre-defined indicators of best practice.

3.1 Proposed method

Within FUTURE-RADAR, the objective of this deliverable is defined as follows:

"Best practice examples for successful road transport technology deployment in each of the regions will be identified. A set of criteria for the analysis of these framework conditions and deployment strategies will be derived, and ideal best practices will be drafted. The framework conditions and deployment strategies will be assessed against these criteria and the best practice examples against the ideal cases. In order to fulfil this objective, within this deliverable, criteria will be developed that enables to identify the best practices in RTD support for each of the countries studied".

In other words, the task is to describe criteria that need to be met in order to adhere to a (pre-defined) best practice of RTD support.

The best practice criteria proposed in this deliverable have been selected based on a number of examples of criteria and indicators identified in international studies and programmes related to innovation. Criteria and indicators have different meanings and are used for different purposes. Criteria can be used in a selection process, e.g. selecting projects to be financed through (RTD) grant projects, including project specific criteria like value for money, environmental benefits, social benefits etc. Indicators are always measurable and enable quantitative comparison between programmes, projects or other items.

Different definitions exist for the terms criterion and indicator, for example:

- Indicator – A pointer or index that indicates something. Example could be a key performance indicator used in financing or management as a "financial or non-financial metric used to help an organization define and measure progress towards its goals". Another example is a so-called innovation indicator of a country, e.g. a percentage of GDP spend on RTD or a certain percentage of employees working in RTD in a country or company.
- Criterion – A standard or test by which individual things or people may be compared and judged

A criterion can be directly measurable, but not necessarily. Sometimes a criterion is also described as "a standard or test by which individual things or people may be compared and judged. Or differently:

- Criteria – conditions that need to be met in order to adhere to a principle or desired state.
- Indicators – measurable states which allow the assessment of whether or not associated criteria are being met.

3.2 Criteria of Best Practice

To be able to identify suitable best practice criteria, a number of documents have been studied, all of them related to assessment of innovation capacities, RTD policies and energy / climate policies.

3.2.1 Examples of criteria

Examples of criteria were taken from European and international studies and programmes:

- Support to assessment of innovation capacities in the European transport sector – This study developed indicators, measuring the innovation capacity of the transport sector in different European and non-European countries (European Commission, 2016a). This study has been part of TRIMIS - The Transport Research and Innovation Monitoring and Information System[116]
- The study "Towards a Single and Innovative European Transport System" – International Assessment and Action Plans of the Focus Areas in six different countries, (STRIA report – European Commission, 2017)[117] -- Brazil, China, India, Japan, South Korea, USA. It provides actions plans on how to overcome existing European barriers towards a single and innovative European Transport System based on best practices and lessons learned in the countries under study.
- The criteria and indicators for the selection of projects and programmes for financing from the Green Climate Fund (GCF)[118] – The GCF developed criteria and indicators for the assessment of both project and programme proposals requesting financing from the Fund (GCF, 2014).
- Several other studies have been consulted that all addressed innovation indicators. They provide useful input for setting best practice criteria. Examples used are:
  - Establishing a set of indicators for measuring the impact of RTD policies – BEFORE project, Benchmarking and foresight for regions of Europe[119]. This project performed a comparative analysis (benchmarking) of efficient support instruments for RTD in several European regions (BEFORE-project, 2008)
  - Policy, Indicators and Targets: Measuring the Impacts of Innovation Policies - European Trend Chart on Innovation – providing a theoretical framework for RTD indicators (European Commission, 2005)[120]
  - FUTRE Project - FUture prospects on TRansport evolution and innovation challenges for the competitiveness of Europe - Support Action (FUTRE Project, 2013)[121]

Within first report carried out within TRIMIS *"Support to assessment of innovation capacities in the European transport sector*" an innovation measurement framework was developed measuring the

[116] For more details see: https://trimis.ec.europa.eu/
[117] https://epub.wupperinst.org/frontdoor/deliver/index/docId/6818/file/6818_European_Transport_System.pdf
[118] The Green Climate Fund (GCF) is a global fund created to support the efforts of developing countries to respond to the challenge of climate change. It was set up by the 194 countries who are parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2010. https://www.greenclimate.fund/who-we-are/about-the-fund
[119] https://www.ibs.ee/wp-content/uploads/BEFORE_Indicators_Study_Final.pdf
[120] Policy, Indicators and Targets: Measuring the Impacts of Innovation Policies, http://digitalarchive.maastrichtuniversity.nl/fedora/get/guid:8a310a8b-6fbf-48d6-9914-b61d7cc16271/ASSET1
[121] http://www.futre.eu/Home.aspx

innovation in the transport sector with the availability of data at sector and subsector level. The study addressed indicators measuring innovation, resulting in the following set of indicators:

Input indicators
1. Level of R&D expenditure from firms in the transport sector and relevant business R&D intensity (share of sector value added)
2. Public R&D expenditure in the transport sector technology area and as a share of GDP
3. Level of R&D personnel involved in R&D activity in the sector and share of total employment in the sector
Process indicators
4. Share of enterprises engaged in cooperation in innovation (%)
5. Level of PCT patent applications in transport related technology areas (total and per million values added)
Context/demand/driver indicators
6. Share of enterprises in the transport sector that receive public subsidies to innovate
7. Share of enterprises considering lack of demand highly important factor of hampering innovation
8. Share of enterprises for which the lack of qualified personnel is a highly important factor of hampering innovation
Output indicators
9. Share of innovative enterprises in the transport sector in the field of:
a. Product innovations (share of enterprises)
b. Process innovations
c. Organisational/marketing innovations
d. Service innovation
10. Share of employees in the transport sector occupied in high-growth enterprises
11. Share of sales from firms in the sector resulting from new-to-firm product innovations
12. Share of sales from firms in the sector resulting from new-to-market product innovations

As can be seen from the list above, in order to compare different situations (status of RTD in different countries) there is a need to have some basic statistical data available. It is not within the scope of this study to make such a comparison. It gives, however, valuable information on how to “measure” innovation capacity in the transport sector and what the underlying criteria for developing indicators could be. Examples of the underlying criteria are:

- To whom is support provided; e.g. to research at universities and/or private entities (incl. SMEs).
- The level of support (financing provided) to universities and/or private entities
- Efforts of public and private entities put into innovation
- Coverage of sectors, e.g. transport sector as a whole or different branches like road, rail transport
- To what extent RTD leads to new innovative products

In the second study *“Towards a Single and Innovative European Transport System”* several examples of good practices in the international arena were described. Focus of the report is the international assessment of six different countries – Brazil, China, India, Japan, South Korea, USA – in five focus areas across all transportation modes. Each best practice example identified was described along the following items:

- Characterisation – short description of the good practice
- Method of implementation – who is implementing the programme (e.g. managing and executing the research)
- Financing – listing financial sources, public or private
- Business models – how are the results to be commercialised
- Technologies employed – description of the technologies applied
- Target user group – directly and indirectly covered target groups
- Enabling framework – (organisational) background in the establishment of the initiative
- Other aspects that may be applicable

Then an *Assessment of Feasibility of Best Practices* was carried out regarding the possibility to implement the measure in (one or more) EU member states. The criteria used here were:

- Availability of Technologies and Know-how within the Necessary Timeframe
- Violation of Legal/Regulatory Framework in the EU – example may not be applicable in EU due to regulatory constraints
- Necessary Standardization Compliant to EU Standardization Policy
- Available funding models – is similar way of funding available in the EU
- Public acceptance due to Cultural Aspects – any obstacles identified related to public acceptance and cultural aspects
- Availability of resources / raw materials – relates both to savings of resources / materials as need for specific rare materials
- Additional aspects – any other issue

The assessment carried out describes for each criterion to what extend each best practice could be applicable in Europe (given EU regulations, standardisation etc.). The assessment itself is qualitative, of a descriptive nature. The comparison or benchmark to be carried out in FUTURE-RADAR will be of a similar qualitative nature.

The third source of information is based on selection criteria and indicators of the international Green Climate Fund. The reason for looking at criteria slightly outside the transport sector has mainly been done to have an example of a method for grant funding of innovative projects leading to greenhouse gas emission reductions, in this case of the Green Climate Fund. The method is useful in that it clearly distinguishes between criteria and indicators.

GCF has established six criteria in its Investment Framework to guide its investment decisions[122]:

- Impact potential

[122] https://www.greenclimate.fund/how-we-work/funding-projects

- Paradigm shift potential
- Sustainable development potential
- Needs of the recipient
- Country ownership
- Efficiency and effectiveness

A detailed overview of GCF Criteria and some underlying indicators for the assessment of project proposals is shown below (GCF, 2015):

CRITERION	DEFINITION	KEY INDICATORS - EXAMPLE[123]
Impact potential	Potential of the programme / project to contribute to the achievement of the Fund's objectives	• Expected tonnes of carbon dioxide equivalent to be reduced or avoided • Expected number of MW of low-emission energy capacity installed and generated
Paradigm shift potential	Degree to which the proposed activity can catalyse impact beyond a one-off project or programme investment Contribution of the project or programme to global low-carbon development pathways	• Opportunities for targeting innovative solutions, new market segments, developing or adopting new technologies, business models, modal shifts and/or processes • Expected contributions to global low-carbon development pathways
Sustainable development potential	Wider environmental, economic and social co-benefits and priorities	• Degree to which the project or programme addresses environmental externalities such as air quality, soil quality, conservation, biodiversity, etc. • Potential for externalities in the form of expected improvements in areas such as expanded and enhanced job markets, job creation and poverty alleviation
Needs of the recipient	Vulnerability and financing needs of the beneficiary country and population	• Intensity of exposure to climate risks and the degree of vulnerability • Level of social and economic development (including income level) of the country and target population
Country ownership	Beneficiary country ownership of, and capacity to implement, a funded project or programme (policies, climate strategies and institutions)	• Programme or project contributes to country's priorities for low-emission and climate-resilient development as identified in national climate strategies or plans • Proposal has been developed in consultation with relevant stakeholder groups
Efficiency and effectiveness	Economic and, if appropriate, financial soundness of the programme/project	• Proposed financial structure (funding amount, financial instrument) is adequate and reasonable in order to achieve the proposal's objectives • Co-financing ratio (total amount of co-financing divided by the Fund's investment in the project/programme) • Economic and financial rate of return with and without the Fund's support

[123] For the full list of indicators, see the following GCF document: https://www.greenclimate.fund/documents/20182/239759/Investment_Criteria.pdf/771ca88e-6cf2-469d-98e8-78be2b980940

Through the Green Climate Fund, it is possible to receive funding for single projects (e.g. large scale renewable energy plants), but also for setting up a national programme or financing framework for small-scale projects that in its turn develops its own selection criteria.

A RTD grant funding mechanism is different from the projects financed through the GCF, but criteria like “impact potential” and “efficiency and effectiveness” are certainly applicable in this analysis of best practices as well.

An interesting criterion is the “Paradigm shift potential”, which in the case of the GCF is mainly related to contributions to global low-carbon development pathways, but it could also be related to targeting innovative solutions, developing or adopting new technologies and business models.

3.2.1.1 Innovation indicators - examples

All EU member states, plus the European Commission, develop and implement policies to improve the innovative capabilities of European firms and (publicly-funded) research organizations. Many of these policies have been in existence for decades. These include financial support for basic research at universities or tax credits for privately-funded RTD (European Commission, 2005)[124].

The 4th example looked at exactly these innovation indicators, existing of a no. of studies related to establishing a set of indicators for measuring the impact of RTD policies in Europe.

Within one of these studies, eight types of policies in widespread use and of relevance to innovation have been identified. They include support for:

1. intellectual property rights,
2. the commercialization of public research,
3. direct or indirect support for RTD programmes,
4. innovation collaboration,
5. innovation finance, including support from commercial (venture) capital
6. human resources for innovation,
7. targeted or strategic technology support, and
8. general innovation policy.

There are many possible methods of classifying innovation support policies. These include classification:

- By the target audience (SMEs or large firms),
- By the target sector (support for strategic technologies like biotechnology or nanotechnology),
- By the type of policy goal (e.g. rationalize innovation policy)
- By a set of overarching or general policy goals (link the RTD to other nation-wide policy objectives).

Many approaches use a mix of two or more of these classifications systems. For example, innovation policy into seven categories based on all four of these systems:

- the type of policy (“enhance industry-science linkages” and “promote collaboration among firms”),

[124] Source: Policy, Indicators and Targets: Measuring the Impacts of Innovation Policies, http://digitalarchive.maastrichtuniversity.nl/fedora/get/guid:8a310a8b-6fbf-48d6-9914-b61d7cc16271/ASSET1

- the target audience (foster innovation among "small and medium-sized enterprises and new technology-based firms"),
- the target sector ("innovation in services") and
- a general goal to "rationalize innovation policy".

This classification system reflects shifts in innovation policy in five EU Member States plus Japan.

3.2.1.2 Barriers and drivers to innovation

Transport RTD around the world is influenced by numerous drivers and barriers. As stated in the Ricardo Innovations capacity study: "The increasing pace of technological progress, as well as global competition, has been changing the context of transport innovation profoundly. For example, digitalisation brings forward new actors with business models (based on collaborative platforms) that complement and/or rival large corporates. Connectivity (and subsequently automation) is changing the ways in which personal mobility and collective transport happen within and across modes.

A good example of a new form of innovation is electrification of vehicles driven by needs and policies to decarbonise and reduce oil dependency as well as technological advances. At the same time, there are rapid changes in public transport and the logistics sectors, particularly in the urban context.

Within the EU financed FUTRE project (2013)[125] barriers and drivers to innovation are listed, classified according to their nature: market, financial, legal, technological or organisational. The identified barriers and drivers from this study were ranked by category and are shown in the table below.

NATURE OF BARRIER	BARRIER NAME
Market barrier	Economic outlook, Uncertain market demand, Uncertain RoI, Domination of established enterprises, lack of business partners, lack of cooperation
Financial barrier	Uncertain RoI. long lead times, lack of funds, insufficient access to subsidies, lack of external financing
Legal barrier	Legal background lacks incentives to innovate
Technological barrier	Lock-ins (of incumbent technology), limited access to information & technical support
Organisational barrier	Lack of qualified personnel & technology

NATURE OF DRIVER	DRIVER NAME
Market driver	Economic outlook, expected energy price increase, good business partners, increased green product demand, limited access to materials, good cooperation
Financial driver	Current high energy prices, current high material prices, access to subsidies & incentives
Legal driver	Existing regulations, expected new regulations

[125] FUTRE Project - FUture prospects on TRansport evolution and innovation challenges for the competitiveness of Europe - Support Action - http://www.futre.eu/Home.aspx

Technological driver	Access to information & technical support
Organisational driver	Technological and management capabilities

These barriers and drivers can then be ranked related to their duration and their impact. A quick view of the tables below shows that major barriers and drivers identified are market or financial related. This suggests a need to look both into the financing of research and development and to regulation and legislations.

It is clear from the ranking below that most of the barriers that have both considerable and long-lasting impacts are financial in nature. The most important barriers are in the bottom right, with severe and lasting impacts. Absent or inaccessible monetary resources and external funds have the capacity to cripple the development and the uptake of new ideas. Lock-ins and the domination of incumbents (often leading to inefficient monopolies) are hard to break, especially because of the conflict of interest with the well-established and leading institutions in the transport sector.

IMPACT DURATION IMPACT SEVERITY	SHORT-TERM BARRIERS	LONG-TERM BARRIERS
Low	Uncertain market demand Uncertain RoI	Lack of qualified personnel & technology Long lead times Lack of business partners Lack of cooperation
High	Economic outlook Legal background lacks incentives Limited access to information & technological support	Lack of funds Insufficient access to subsidies Lack of external financing Lock-ins Domination of established enterprises Lack of mutual recognition of standards

IMPACT DURATION IMPACT SEVERITY	SHORT-TERM DRIVERS	LONG-TERM DRIVERS
Low	Secure or increase of market share Existing regulations	Economic outlook Good business partners Technological and management capabilities Expected new regulations Good cooperation

High	Current high energy prices Current high material prices Access to information & technological support	Expected increase in energy prices Access to subsidies & incentives Increased demand for green products Future market scarcity Limited access to materials

As the table shows, there are significantly more drivers with longer impact periods identified than those with short impact periods. The most powerful drivers are mostly related to the need to change current unsustainable operational practices across all areas, although the transport sector is perhaps even more affected than others. The scarcity of energy sources and raw materials, and the resulting price increases, will drive a profound change in innovations. Designs will have to be modified to reflect the changes that have taken place, while consumers, becoming increasingly aware of the situation, will be increasingly driven towards more sustainable products and services, generating demand and innovations in this area. This fundamental change in mindsets should be taken advantage of when designing policy instruments to facilitate transport research in the future.

From these sources we can select the most important drivers towards transport RTD that will help in the selection of criteria for best practice RTD programmes. These are:

- Environmental drivers: decarbonisation of the transport sector.
- Security drivers: reduction of fossil fuel (mainly oil) dependency.
- Innovation drivers: Technological advances around the world in the field of electrification and IT (e.g. autonomous driving).
- Policy drivers: including policy and regulation aimed at emission reduction, but also aimed at limiting traffic congestion, improving road safety. These can be national, regional policy drivers, but also drivers on international level (e.g. EU transport policy documents or stricter emission standards for gasoline and diesel cars.
- Economic drivers: saving fuel costs, savings costs of raw materials, dependence on precious metals.

3.2.2 Proposed criteria

The selection of the proposed criteria is based on the examples of criteria and indicators mentioned in the sections above and funding conditions in the four countries addressed.

The following criteria have been proposed for the assessment within FUTURE-RADAR:

- **Environmental criteria:**
    - *The programme supports the realization of environmental and climate protection strategies*. For the EU and other countries around the world this is an extremely important target that is highlighted in a large number of policy documents.

- **Financial criteria:**
    - *Does the programme combine public and private capital?* – Private companies in the transport sector often do their own research. When programmes combine public and private financing, advantages could be the following: 1) it enables commercialisation of public research, 2) it helps industry to invest in research with more long-term return on investments
    - *The programme is (cost-)effective in reaching the target*. This relates to the financial means needed for reaching the targets set by the programme and single projects. Barriers to transport research and innovation often relate to the lack of funds. Therefore, it is of utmost importance to effectively use available (public) budgets. While important, it is not possible to include this criterion when data are not available for evaluation
- **Programme related criteria:**
    - Are the targets clearly defined in the programme? – it should be clear what type of research the programme is supporting
    - What sectors are addressed by the programme? – is it a programme that addresses industrial innovation, or is it transport related and aimed at specific transport modes?
    - Does the programme address fundamental research, applied research or support market entry of new technologies? Or in terms of TRL / MRL:
        - *What Technology Readiness Levels (TRL) are covered by the programme*?
        - *What Manufacturing Readiness Levels (MRL) are covered by the programme*?
    - Does the programme support the commercialisation of research results?
- **(Macro-)economic criteria:** The programme assists in development / improving competitiveness of the economy in general and the automotive sector specifically? – it is important to know that there is an overall objective that addresses the outlook and challenges of the automotive sector.

In addition, there are other criteria that can be compared and give some interesting information about the programme. Examples of additional questions to be asked, that could result in additional criteria, are the following:

- What sectors are covered in the programme, or is the programme cross sectoral?
- Does the programme specifically address SMEs and/or Start-ups?
- Have the targets been evaluated and met? Is the programme evaluated afterwards?
- What stakeholders are involved in the programme, are these public research organisations, manufacturers, public administration?

- What innovative technologies and solutions are deployed (examples can be taken from the STRIA thematic transport research areas[126])?
- What other specific societal challenges (e.g. aging of society, example of Japan) are directly or indirectly addressed by the programme?
- How many years after the completion of the research can the research results be exploited? I.e. when is a positive business case expected to be realized (in years)

Due to lack of data, these additional criteria may not be that suitable to compare.

3.2.3 Best practice fact sheet

Based on the identified criteria, the following best practice sheet was developed.

NAME OF FUNDING ORGANISATION	
Name of programme / project	
Description of programme / project	Short description of main objectives
Covered sector within the programme	Manufacturing sector, subsectors: • Automotive industry • Electricity sector Transport sector, subsectors: • Road transport • Electric vehicles • Intelligent transport systems Technology subsectors, e.g.: • Battery development • Next generation biofuels
Main objective(s) of the programme	Environmental / climate change related: • Reduction of air pollution in cities • Reduction of greenhouse gas emissions in the transport sector Energy / resource efficiency: • Reduction of fossil fuel consumption Economic: • Improve competitiveness of automotive industry

[126]Towards a Strategic Transport Research & Innovation Agenda (STRIA), http://ec.europa.eu/programmes/horizon2020/en/news/towards-strategic-transport-research-innovation-agenda-stria

How are the targets / objectives defined?	Quantitative: • National / regional emission reduction targets (for e.g. PM, NO_x or CO_2) • Targets for EVs • Fully automated vehicles on the road by the year 202x Qualitative: • Improve competitiveness of the automotive industry • Move towards full EV by the year 202x
Financing of the programme **(% of funding, % of co-financing required) – programme open to public and/or private entities?**	Programme to be financed with X% by own funding / no own funding needed Share of % of private financing required
TRL addressed (or categorise fundamental research, applied research, commercialisation) [127] **MRL addressed (concepts, prototypes, full production)**	If TRL, Does the programme address fundamental research, applied research or support market entry In case of research of higher TRL (e.g. 7 -9), the MRL is mentioned as well.
Examples of business cases and commercialisation of projects results	Examples depend on programme, possible questions: • Is commercialisation of results required in the programme? • …
Verification of project results	Are / how are the project results compared / verified with the objectives
Openness / transparency of the funding process	To what extent is the information for applicants freely available, e.g. online.
Duration / flexibility of the application process	What is the duration of the application process, e.g. time for submission from call announcement to submission deadline. What is the duration of the evaluation process and the contract negotiation process.
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	Overview by the authors: Strengths: • … Weaknesses: • …
Comments	Comments to strengths and weaknesses by other experts
Main data sources	List of main literature

[127] Information limited to TRL, as info on MRL was not available in any of the grant programmes and would have been based on rough estimates only.

To enable comparison and ranking of different funding programmes, a pre-defined best practice example was developed. The best practice example is defined based on the analysis of the grant programmes in the study. The criteria in red are those that are measured, the ones in blue are compared but without awarding a score.

NAME OF FUNDING ORGANISATION	BEST PRACTICE
Name of programme / project	Name
Description of programme / project	Description
Covered sector within the programme	Covering more sectors is not necessary an example of best practice, but it has certain advantages. It generally attracts more applicants; research results are usually noticed by a larger group of stakeholders (increasing the exposure of results) and it enables cross-sectoral exchange of experience and know-how. However, there may also be an advantage of a more strictly specified (sub-)programme, e.g. for the automotive sector. This may attract a specific group of specialised stakeholders.
Main objective(s) of the programme	A best practice funding programme has identified clear long-term targets for society. These can be social, economic or environmental targets, or a combination of these.
How are the targets / objectives defined?	Targets can be both qualitative as well as quantitative. Programmes should usually include a combination of both, qualitative targets that show the general objectives and direction of the programme and quantitative targets that enable evaluation afterwards.
Financing of the programme **(% of funding, % of co-financing required) – programme open to public and/or private entities?**	The possibility to co-finance research differs between public and private actors (e.g. more difficult for universities than for private enterprises), but in general, co-funding research may increase the commitment to utilise the research results afterwards. Applied research usually requires more co-financing from the applicant as basic research. [128] Related to this, programmes open to both public and private entities more likely facilitate the exchange of ideas between the research community and private actors. It must be noted that the percentage of support is not assessed as a higher funding percentage does not necessarily mean a better programme.
TRL addressed (or categorise fundamental research, applied research, commercialisation)	Not so much a criterion of best practice as a way to categorise research funded by the programme.

[128] E.g. in the EC HORIZON 2020 programme, research and innovation actions do not require co-financing from private entities while innovation actions do (financing projects with a higher TRL)

Examples of business cases and commercialisation of projects results	This depends on the TRL / MRL that is addressed by the project, but it is important to mention how the research results are used afterwards (e.g. for follow-up research or commercialisation)
Verification of project results	Research results of the projects should be monitored and at regular intervals compared / verified with the objectives of the programme
Openness / transparency of the funding process	What is mentioned here is to what extent the information for applicants is freely available. The more information publicly available, the easier it is for a potential applicant to consider whether it is meaningful to prepare a project proposal.
Duration / flexibility of the application process	A combination of enough time for application and fixed timeline (without delays) for the evaluation and contract negotiation process.

3.3 Assessment of research funding examples

This section includes an assessment of research funding examples based on the pre-defined best practice example from the previous section. For each country, at least three examples are presented.

3.3.1 United States

For the United States, in total 4 funding programmes are assessed. The first example presented for the United States is for a specific programme under the management of ARPA-E, an office that is part of the US Department of Energy.

NAME OF FUNDING ORGANISATION	ADVANCED RESEARCH PROJECTS AGENCY–ENERGY (ARPA-E)
Name of Programme	**NEXTCAR** – NEXT – Generation Energy Technologies for Connected and Automated On-Road Vehicles The FOA is from 2016, Under NEXTCAR 11 sub-projects have been financed and all are running from 2017 to 2020.
Description of the programme / project	**Objective:** to create new control technologies that reduce the energy consumption of future vehicles by using connectivity and vehicle automation; All supported projects include enabling technologies that use connectivity and automation to co-optimize vehicle dynamic controls and powertrain operation, thereby reducing energy consumption of the vehicle. The technologies contemplated in this program include solutions that consider powertrain optimisation as a part of the vehicle fuel or energy efficiency improvements of future CAVs
Covered sector within the programme	Technological research in the field of: • Hybrid / electric vehicles • Automated driving
Main objective(s) of the programme	Energy / resource efficiency: • Reduction of fuel/energy consumption in CAV Ultimate goal: • Future commercialisation of energy efficiency optimisation technologies for the future vehicle fleet that take advantage of advances in vehicle connectivity and automation
How are the targets / objectives defined?	Quantitative: • 20% reduction in energy consumption of future connected and automated vehicles compared to vehicles with these VD&PT[129] control technologies

[129] Vehicle dynamic and power train control technologies

	Qualitative: • Lessening US dependence on imported oil • Helping to improve urban air quality and decreasing the sector's carbon footprint. • Solidify the United States' status as a global leader in CAV technology, • More efficient vehicle fleet to reduce energy cost/mile driven and increase competitiveness
Financing of the programme	In ARPA-E, the Prime Recipient must provide at least 20% of the Total Project Cost. Large businesses are strongly encouraged to provide more than 20% of the Total Project Cost as cost share. At the same time, there is a reduced cost share requirement for educational institutions and SMEs (varying from 0 - 10%). Under the FOA, ARPA-E announced that awards may vary between \$250,000 and \$10 million. Finally, 11 projects were awarded, with budgets ranging from 1.4 to 5 million US\$ (1.2 – 4.2 million €). The total NEXTCAR budget was 34 million USD, out of a total ARPA-E budget of 300 million USD (FYs 2016, 2017).
TRL addressed (or categorise fundamental research, applied research, commercialisation)	According to ARPA-E documents the agency supports transformative research that has the potential to create fundamentally new learning curves. NEXTCAR projects are generally within the category of TRL 2-4. At the end of the project there should be a proof of concept. This is confirmed by other sources (ITIF, 2017) looking at the typical TRL of ARPA-E projects that is in the range of TRL 2-4.
Business cases and commercialisation of projects results	NEXTCAR projects are not yet ready for commercialisation but stop at proof of concept. Nevertheless, ARPA-E states in its programme description that it is interested specifically in the commercialization of the technologies that it supports. A recent study (ITIF, 2017) shows, however, that many ARPA-E projects are producing both basic research that is publicly available to any peer and intellectual property that may serve as the basis for the creation of marketable products and services.
Verification of project results	Verification process in place: qualitative and quantitative verification (related to the 20% reduction target)
Openness / transparency of the funding process	Information about funding procedures are on the website. A detailed Funding Opportunity Announcement was published in 2016.
Duration / flexibility of the application process	There is a fixed duration of application process, which is as follows: There are 6 weeks from FOA announcement (April 12, 2016) to submission of concept paper. After receiving the Encourage/Discourage notification, there are approx. 45 days for submission of full proposal. Selection

	Notifications received by October 2016. Start of project early 2017 (Feb. 2017). The total procedure lasts for about 9 months.
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	**Strengths:** • Integrated approach: combination of energy efficiency and CAV in one programme / project • Quantitative as well as qualitative targets defined • Method of verification defined in detail **Weaknesses:** • Not fully clear from FOA how commercialisation should be addressed • ARPA-E is a successful programme, some uncertainty remains about its future (ITIF, 2017)
Sources of information	Official documents and website of ARPA-E, including FOA documentation for NEXTCAR, available at: https://arpa-e.energy.gov/?q=arpa-e-programs/nextcar

The second example presented for the United States is for a specific programme under the management of NSF, part of the Directorate of Engineering.

NAME OF FUNDING ORGANISATION	NATIONAL SCIENCE FOUNDATION (NSF) - DIRECTORATE FOR ENGINEERING (ENG)
Name of Programme	Energy, Power, Control, and Networks (EPCN), part of the Division of Electrical, Communications and Cyber Systems (ECCS) A new call for proposals is open since June 2018.
Description of the programme / project	EPCN's goal is to encourage research on emerging technologies and applications including energy, transportation, robotics, and biomedical devices & systems. EPCN also emphasizes electric power systems, including generation, transmission, storage, and integration of renewable energy sources into the grid; power electronics and drives; battery management systems; hybrid and electric vehicles.
Covered sector within the programme	EPCN covers four areas: 1) control systems, 2) energy and power systems, 3) power electronics systems (including electric and hybrid electric vehicles), 4) learning and adaptive systems
Main objective(s) of the programme	The EPCN Program supports innovative research. Main programme priorities stated at the level of ECCS Division.

	The Division of ECCS supports enabling and transformative research at the nano, micro, and macro scales that fuels progress in engineering system applications with high societal impacts. ECCS strongly emphasizes the integration of education into its research programs to ensure the preparation of a diverse and professionally skilled workforce. ECCS also strengthens its programs through links to other areas of engineering, science, industry, government, and international collaborations.
How are the targets / objectives defined?	Objectives are stated very generally. E.g. encouraging research in emerging technologies
Financing of the programme	Neither the complete call budget nor limits in project budget could be found. Budgets of existing projects under EPCN are from 100,000 US$ to 1,000,000 US$ (average projects around 250,000 US$). The budget of the ECCS division is approximately 115 million USD (FY2016), the EPCN programme is one of 20 programmes part of that. The estimated amount available for EPCN is estimated at 5 – 10 million USD
TRL addressed (or categorise fundamental research, applied research, commercialisation)	From the description it is clear that EPCN addresses fundamental research, meaning TRL from 1 to 3
Business cases and commercialisation of projects results	As it considers fundamental research, commercialisation is not yet an option. Another of NSF are concerned with commercialisation[130]. All funded projects must submit a project outcomes report[131]. This report is intended to provide the general public with a complete picture of the results of the funded research.
Verification of project results	The merit review process evaluates project proposals, during project execution, so-called Research Performance Progress Reports (RPPR) have to be submitted. Projects are closely monitored.
Openness / transparency of the funding process	Information about funding procedures are available on the website in detail, including e.g. a frequently asked questions section. Information on previous funded projects available.
Duration / flexibility of the application process	Since August 2018, submission of EPCN proposals is flexible. In general, the NSF Proposal and Award Process is as follows: • Phase I – Proposal preparation and submission – 90 days (for EPCN flexible) • Phase II – Proposal review and processing – 6 months • Phase III – Award processing – 30 days
Preliminary assessment of the programme	

[130] NSF Innovation Corps (I-Corps) programme – https://www.nsf.gov/news/special_reports/i-corps/
[131] https://www.nsf.gov/pubs/policydocs/porfaqs.jsp

Overview of strengths and weaknesses of the programme	**Strengths:** • Information about funding procedures clearly stated on the website • Application process transparent at first glance (fixed duration for proposal review etc), FAQs and guidelines available online • EPCN proposals do not have fixed deadlines but can be submitted at any time. **Weaknesses:** • Objectives of the programme remain very general and are not quantified. But may be related to the fundamental nature of the research • Not fully clear how project results are monitored afterwards (although beneficiaries have to report on their progress during the project and afterwards) • Duration of the proposal review (6 months)
Sources of information	Official documents and website of NSF, Directorate of Engineering (ENG): https://www.nsf.gov/funding/programs.jsp?org=ENG

The third example is from the Department of Energy, a programme from the Office of Energy Efficiency and Renewable Energy.

NAME OF FUNDING ORGANISATION	DEPARTMENT OF ENERGY (DOE) OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY (EERE)
Name of programme / project	Advanced Vehicle Technologies Research Funding Opportunity Announcement
Description of programme / project	To support U.S. economic growth and offer consumers and businesses additional transportation choices, DOE's Vehicle Technologies Office invests in early-stage research to enable future private-sector development and commercialization of affordable, energy-efficient transportation technologies that can strengthen the US energy security.
Covered sector within the programme	The programme covers a broad scale of vehicle technologies. The stated areas of interest within the programme are: 1. Batteries and electrification – topics like development of next-generation Li-ion batteries, Plug-In Electric Drive Vehicle extreme fast charging and EV charging infrastructure cybersecurity 2. Materials – topics like modelling of corrosion/oxidation of materials 3. Technology integration – topics like First/Last Mile for people & goods movement, platooning, residential charging infrastructure innovations 4. Off-Road R&D - Energy Efficient Commercial Off-Road Vehicles 5. Co-Optimization of Engines & Fuels

Main objective(s) of the programme	For EERE, one of its 7 strategic goals address transport, accelerating the development and adoption of sustainable transportation technologies. This is achieved through improvements in engine efficiency, vehicle weight reduction, battery performance, drop-in biofuels, fuel cell performance, and reduced biofuel and hydrogen production costs. Each FOA sets specific targets for each call. This one seeks research projects to address priorities in the following areas: batteries and electrification; materials; technology integration and energy efficient mobility systems; energy-efficient commercial off-road vehicle technologies; and co-optimized advanced engine and fuel technologies to improve fuel economy.
How are the targets / objectives defined?	Qualitative: • General qualitative targets for the FOA and some specific targets per area of interest Quantitative: • There are quantified targets for some areas of interest, e.g. performance targets for Next-Generation Lithium-ion Batteries
Financing of the programme (% of funding, % of co-financing required)	Certain share of % of cost sharing required. Depends on the area of interest, from 20% to 50% Maximum total budget for this FOA is $68.3 million. There are maximum budgets per area of interest. E.g. for "Plug-In Electric Drive Vehicle Extreme Fast Charging Research" there is $10 million available.
TRL addressed (or categorise fundamental research, applied research, commercialisation)	The programme addresses applied research in its early stage. Estimated at TRL 3 to 5
Examples of business cases and commercialisation of projects results	Commercialisation not directly addressed in this FOA, but EERE has a specific Technology-to-Market Program (Tech-to-Market)[132]
Verification of project results	Not fully clear yet, but verification against performance targets should be possible.
Openness / transparency of the funding process	Information about funding procedures are available on the website in detail, including e.g. a frequently asked questions section.
Duration / flexibility of the application process	Fixed duration of application process. • FOA Published May 1, 2018. • Submission of concept paper on May 29 (4 weeks) • Date of Concept Paper Notifications June 15 • Submission of full proposals by July 13 (4 weeks) • Anticipated Date for EERE Selection Notifications – September 2018.

[132] https://www.energy.gov/eere/technology-to-market/home

	• *Expected project start date not yet known*
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	**Strengths:** • Information about funding procedures clearly stated on the website • Application process transparent at first glance (fixed duration for proposal review etc), FAQs and guidelines available online **Weaknesses:** • Way of monitoring / verification of projects not fully clear from FOA
Sources of information	Fiscal Year 2018 Advanced Vehicle Technologies Research Funding Opportunity Announcement, (EERE, 2018)

The fourth and last example is from the DOT, the U.S. DOT's Small Business Innovation Research (SBIR) program, administered by the VOLPE Centre.

NAME OF FUNDING ORGANISATION	DEPARTMENT OF TRANSPORTATION, VOLPE CENTRE
Name of Programme	DOT's Small Business Innovation Research (SBIR) program
Description of the programme / project	U.S. DOT's Small Business Innovation Research (SBIR) program awards contracts to small businesses to pursue research on and develop innovative solutions to the US transportation challenges. The SBIR Program encourages small businesses to engage in R&D that has the potential for commercialization and meets Federal R&D objectives
Covered sector within the programme	The programme covers the transportation sector, especially the development of new businesses. The solicitation procedure for FY 2018 addressed specific research topics organized into five sections (per Operating Administration): A. Federal Highway Administration (FHWA) B. Federal Railroad Administration (FRA) C. Federal Transit Administration (FTA) D. National Highway Traffic Safety Administration (NHTSA) E. Pipeline and Hazardous Materials Safety Administration (PHMSA) E.g. under the FHWA four topics are addressed, one of them being: *Machine Vision System to Support Vehicle to Infrastructure (V2I) Safety Applications* This topic requests the development of a proof-of-concept system in which on-board vehicle machine vision, using standard resolution imaging, can identify and interpret specialized markings on roadside signs.

Main objective(s) of the programme	General goals and objectives of the SBIR Program are to: • Stimulate technological innovation; • Meet Federal research and development needs; • Foster and encourage participation in innovation and entrepreneurship by socially and economically disadvantaged persons; and • Increase private sector commercialization of innovations derived from Federal R&D funding.
How are the targets / objectives defined?	General targets / objectives stated above. Specific targets and objectives are set per topic.
Financing of the programme	The U.S. DOT permits cost sharing for Phase II; however, cost sharing is not required, nor will it be a factor in evaluation of offers. For phase I, the maximum funding amount per project is $150,000, in Phase II the maximum is $1,000,000 Maximum budget (calculations based on solicitation document): $3,300,000 for Phase I and $12,800,000 for Phase II.
TRL addressed (or categorise fundamental research, applied research, commercialisation)	The topic addressed requires proof of concept. This relates to TRL 3 or 4
commercialisation of projects results	The SBIR programme includes three phases, up to different degrees of commercialisation. Phase III to be financed by private parties.
Verification of project results	Not fully clear yet, but verification against performance targets should be possible.
Openness / transparency of the funding process	Information about funding procedures are available on the website in detail, including e.g. a frequently asked questions section.
Duration / flexibility of the application process	Fixed duration of application process, as follows: • Solicitation published on January 17, 2018 • Deadline for submission of proposals was March 20, 2018 (9 weeks) • Award recommendations were published July 2, 2018 (approx. 3.5 months after deadline)
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	**Strengths:** • Information about funding procedures clearly stated on the website • Programme identifies three phases, gradually increasing cost sharing from other sources (and involvement of third parties). **Weaknesses:** • Not fully clear how verification will take place

Sources of information	Official documents and website of Volpe Center, including solicitation documentation for the SBIR Program, retrieved from https://www.volpe.dot.gov/work-with-us/

3.3.2 Japan

The first example presented for Japan is from the Strategic Innovation Promotion Programme (SIP). The example is from one of the core themes of the programme "automated driving systems". (sub-) projects under this programme are financed by NEDO.

Name of funding Organisation	**CTSI - Council for Science, Technology and Innovation (management) & NEDO – New Energy and Industrial Technology Development Organisation (financing)**
Name of Programme	Strategic Innovation Promotion Programme – Automated driving system (SIP-ADUS)
Description of the programme / project	SIP-ADUS is developing new transportation systems including technologies for avoiding accidents and alleviating congestion This five-year research program on connected and automated driving led by the Japanese government started in 2014. In 2016, the project prioritized five research themes (Dynamic Map, HMI, cyber security, pedestrian collision reduction and next generation transport). Large-scale field operational tests started in October 2017 to integrate and evaluate results so far. For each year tenders are announced for subprojects (funded by NEDO). In 2017, there were tenders for funding related to Automated Driving System Large Scale Trial Tests, specifically on topics like "Dynamic Maps" and "Human Machine Interface". Another call was published for 2018.
Covered sector within the programme	Manufacturing sector, subsectors: • Automotive industry Technological research, e.g.: • Automated driving / information technology
Main objective(s) of the programme	Social: • Reducing the number of traffic fatalities (priority no. 1) Automated driving systems are thought to have major potential for reducing traffic collisions Technical: • Realize and spread automated driving systems as soon as possible

	• Realize next-generation urban transport system in time for the 2020 Tokyo Olympic and Paralympic Games Beginning in 2016, the programme prioritized five themes (Dynamic Map, HMI, cyber security, pedestrian collision reduction and next generation transport). These activities are being conducted in cooperation with industry and academia.
How are the targets / objectives defined?	(Semi-)quantitative: • To achieve a high-end Level 2 automated driving system by 2020 as a step towards Level 3 • Advance R&D in cooperative fields necessary to commercialise Level 3 automated driving systems by around 2020 and Level 4 (full automation) systems by around 2025[133] Qualitative: • Improve competitiveness of the automotive industry • Move towards full automation by the year 2025
Financing of the programme **(% of funding, % of co-financing required) – open to public and/or private entities?**	The programme has a five year, from 2014 to 2018. Each year, there is a ¥ 2 to 3 billion JPY budget, ¥ 3.32 billion (€ 26 million) for FY 2017, ¥ 10.9 billion from 2014-2017 (€ 85 million). The budget for funding calls for smaller subprojects amounted to 1,300 million JPY (€ 10 million) in FY 2017. *It was not possible to find funding percentages (only accessible to those parties with an account in tendering system)*
TRL addressed	The programme addresses applied research (TRL 4-6) with some activities supporting market entry (TRL 7 and higher)
Examples of business cases and commercialisation of projects results	• Demonstration of project results before the 2020 Tokyo Olympics • Start-ups established to commercialize project results (e.g. Dynamic Map Planning Co. Ltd)[134]
Verification of project results	Details not fully clear, but verification against performance targets and milestones in 2017 (field tests) and 2020 (demonstration project) is possible and will probably be monitored
Openness / transparency of the funding process	Some information on funding available on the NEDO website (in Japanese), but not all. E.g. co-financing requirements are not published
Duration / flexibility of the application process	Not fully clear, the website of E-rad lists calls for applications of different R&D agencies with fixed start and end date.
Preliminary assessment of the programme	

[133] Timeframe of targets set by Japanese government to enable commercialization by the private sector
[134] Company website: http://www.dynamic-maps.co.jp/en/index.html

Overview of strengths and weaknesses of the programme	**Strengths:** • Demonstration of project results at major event • Start-ups established with the aim to commercialize project results **Weaknesses:** • Relatively difficult to find information on all relevant tender conditions (e.g. co-financing)
Sources of information	SIP-ADUS website (http://en.sip-adus.go.jp/) NEDO – project code P17007 - 2017 funding related to SIP program for Automated Driving System / Large Scale Trial Tests: http://www.nedo.go.jp/activities/ZZJP_100125.html Translation by experts from Ricardo Japan

The second example from Japan is directly from the Agency NEDO and related to RTD in the field hydrogen utilisation (for transport).

Name of funding Organisation	NEDO – New Energy and Industrial Technology Development Organisation
Name of Programme	Technologies for hydrogen usage - R&D program (Call no. P13002). The programme is running from 2013 to 2017
Description of the programme / project	NEDO has an ongoing research programme in the field of Fuel Cells & Hydrogen Infrastructure since 2013 (ending 2020). There are 6 research topics, the "Technologies for Hydrogen Usage" is one of them (Call no. P13002). This research topic is aimed at acceleration of market access of hydrogen technology (already existing but not yet commercialised). Since 2013, the main R&D topics financed since 2013 are: • R&D related to setting appropriate Japanese standards for hydrogen fuelling infrastructure and for Fuel Cell Vehicle, & working towards international standards • R&D related to low cost components and systems for hydrogen station and Fuel Cell Vehicles • R&D related to basic safety equipment for hydrogen stations • R&D related to CO_2 free hydrogen production and working with International Organizations
Covered sector within the programme	Transport (hydrogen tanks in vehicles) and hydrogen infrastructure (including pipelines for transporting hydrogen)

Main objective(s) of the programme	The general RTD objective of the funding call is: • To improve hydrogen station performance and achievement of cost reduction • To get feedback from first hydrogen station deployment in 2015 (e.g. for safe operation management, and for components and system technology) • To plan the architecture of hydrogen stations that can be accepted by society, necessary for FCV expansion in 2025, by developing affordable and safe technology. These RTD objectives include specific performance targets for: • Hydrogen stations (costs, durability, fuelling precision, fuelling time) • Hydrogen tanks in vehicles (volume, costs, performance)
How are the targets / objectives defined?	Programme call includes • Overall RTD objectives • Objectives per RTD topic (final objectives and intermediate objectives) • Specific performance targets In addition, there is a target for 2025, and project results need to be monitored against this target to see if the RTD programme is on track.
Financing of the programme **(% of funding, % of co-financing required) – open to public and/or private entities?**	It was not possible to find funding percentages (only accessible to those parties with an account in the tendering system). In the progress reports of the programme 13002 there is a list of already financed projects. From here, we can conclude that so-called outsourcing projects are financed by 100% through NEDO and common research activities by 50%. Co-financing is requested here. The total programme budget from 2013 to 2017 was 18,448 million JPY (€ 142 million), the budget for 2017 was 4,100 million JPY (€ 31.6 million)
TRL addressed / MRL addressed	Programme addresses the acceleration of market access of hydrogen technology in Japan, so applied research with TRL 7 – 9 Given the high TRL, an estimate is given for the MRL, estimated at 6 – 7 Capability to produce an integrated system in a production relevant environment.
Commercialisation of projects results	Commercialisation is priority for NEDO. The progress reports give some information from research results achieved and press releases published on the NEDO website
Verification of project results	Annual periodic reports showing if projects are on track to reach objectives, verification against performance targets is possible.
Openness / transparency of the funding process	Some information on funding available on the NEDO website (in Japanese), but not all. E.g. co-financing requirements are not published (details accessible for registered applicants only)

	Grant application is possible through the Electronic System E-rad: https://www.e-rad.go.jp/en/ Information is partly available in English, but for completing a full application, knowledge of Japanese is necessary
Duration / flexibility of funding programme	Not fully clear, the website of E-rad lists calls for applications of different RTD agencies with fixed start and end date.
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	**Strengths:** • Specific research call targeted at the improvement of hydrogen infrastructure, expected to attract applications with the correct knowledge **Weaknesses:** • Knowledge of Japanese crucial for application • Question if government agencies should finance research at TRL 7-9
Sources of information	NEDO website – funding related to Fuel Cell & Hydrogen: http://www.nedo.go.jp/activities/ZZJP_100061.html, translation by experts from Ricardo Japan

The third and last example from Japan is directly from the Agency NEDO and related to RTD in the field energy storage (battery research)

Name of funding Organisation	NEDO – New Energy and Industrial Technology Development Organisation
Name of Programme	Funding related to energy storage: - R&D program related to evaluation of advanced and revolutionary battery material (Call no. P13007) - Fundamental R&D related to expansion of revolutionary battery type (Call no. P16001) Programme P13007 is running from 2013 to 2022 (split into two periods: 2013-2017, 2018-2022), programme P16001 from 2016 to 2020 (with intermediate evaluation mid-2018
Description of the programme / project	P13007: Development of technologies for evaluation of reliability, safety and characteristics evolution (calendar, cycle) of solid state battery material → development plan for advanced Li-ion battery and materials P16001: 1) advanced analysis of RD, 2) development of revolutionary battery cell P13007 is a cooperation between research institutes and OEMs, making assessments of future battery technologies.

	P16001 should lead to the actual development of a revolutionary battery cell (solid state battery) for commercialisation by 2030.
Covered sector within the programme	Battery technology for electric vehicles
Main objective(s) of the programme	Both programmes are related to battery technology and their strategic goal is to maintain and improve the competitiveness of Japanese companies in the storage battery industry. High-performance, low-cost storage batteries should be developed ahead of other countries and introduced into the market. The P13007 project will propose new materials from domestic material manufacturers and improve development efficiency of domestic battery manufacturers. Expected results are: 1: Development of an advanced lithium ion battery with high performance, high durability and low cost using high potential / high capacity positive electrode material, high capacity negative electrode material, electrolyte material with high voltage resistance, etc. 2: Development of a new innovative storage battery that can be expected to be put into practical use beyond the theoretical limit (250 Wh / kg) of the energy density of lithium ion batteries. The general objectives of funding call P16001 are: Development of fundamental technology for promoting practical application of innovative storage batteries Full-scale dissemination of electric vehicles (EVs) and plug-in hybrid vehicles (PHEVs), innovative models that exceed the performance of lithium ion batteries (LIBs) installed in EVs and PHEVs with the same range as gasoline-powered vehicles Practical application of storage batteries is expected. Collaboration between universities / research institutes and enterprises (intensive research method) enables to develop and utilize the world's highest and most advanced analytical technologies, while maintaining energy density and durability, Research and development of innovative type storage batteries that make the performance required for automotive storage batteries such as safety at a high level compatible with practical storage batteries (capacity: 5 Ah class) will be implemented. This project should develop the basic technology for practical application of innovative batteries with energy density of 500 Wh/kg by 2030.
How are the targets / objectives defined?	Programme call includes • Overall R&D objectives • Objectives per R&D topic (final objectives and intermediate objectives) • Specific performance targets

Financing of the programme **(% of funding, % of co-financing required) – open to public and/or private entities?**	The budget for call no. P13007 (first period 2013 – 2017) is 2300 million JPY (€17.7 million), with 370 million JPY (€2.9 million) for 2017 The budget for call no. P16001 (first period 2016-2018) is 9,780 million JPY (€ 75 million), with 3,100 million JPY (€ 24 million) for 2018. It was not possible to find funding percentages (only accessible to those parties with an account in tendering system).
TRL addressed	The programme addresses mainly applied research (TRL 4-6). The P16001 project starts at lower TRL (e.g. 3)
Commercialisation of projects results	Commercialisation is priority for NEDO. Remaining competitive in EV development (being one step ahead) The progress reports give some information from research results achieved and press releases published on the NEDO website
Verification of project results	Annual periodic reports showing if projects are on track to reach objectives, verification against performance targets is possible.
Openness / transparency of the funding process	Some information on funding available on the NEDO website (in Japanese), but not all. E.g. co-financing requirements are not published (details accessible for registered applicants only) Grant application is possible through the Electronic System E-rad: https://www.e-rad.go.jp/en/ As this programme is aimed at improving the position of Japanese industry in battery technology, it's only open to Japanese companies.
Duration / flexibility of funding programme	Not fully clear, the website of E-rad lists calls for applications of different R&D agencies with fixed start and end date. Relatively quick application process, e.g. from announcement in April to evaluation in July. Companies have to apply each year for their tasks, but application process is fast.
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	Strengths: • Programme with a clear long-term objective for society • Programme aimed at commercialisation in the long-term (until 2030) Weaknesses: • Knowledge of Japanese crucial for application
Sources of information	NEDO website - NEDO – funding related to Energy Storage P13007: http://www.nedo.go.jp/activities/ZZJP_100064.html P16001: http://www.nedo.go.jp/activities/ZZJP_100121.html Translation by experts from Ricardo Japan

3.3.3 China

The example presented for China is from the National S&T Major Projects. The example is from one of the NKPs of the programme "New Energy Vehicles".

Name of funding organisation	National Key R&D Programme (NKP) (Managed by Inter-Ministerial Joint Council and Ministry of Science and Technology)
Name of Programme	NKP – New Energy Vehicles
Description of the programme / project	The NKP "New Energy Vehicles" is one of 42 NKPs financed through the National Key R&D Programme. It promotes the transformation towards pure electric drive technology (EVs)
Covered sector within the programme	Manufacturing sector, subsectors: • Automotive industry Technological research, e.g.: • Research on batteries of EVs • Other components of EVs • Fuel cells
Main objective(s) of the programme	Overall goals: • Transformation towards pure electric drive (*priority no. 1*) • By 2020, innovations for NEV should be established to support the large scale industrial development of NEVs Technical goals: • Upgrade the power system of NEVs • Seize new technological transformation opportunities for NEVs brought by new materials & information technology The NKP includes 6 innovation chains: 1. power battery and battery management system, 2. motor drive and power electronics assembly, 3. electric vehicle intelligence technology, 4. fuel cell power system, 5. plug-in/extended-range hybrid power system and 6. pure electric power system.
How are the targets / objectives defined?	Qualitative: • Transformation towards pure electric drive (*priority no. 1*) • By 2020, innovations for NEV should be established to support he large scale industrial development of NEVs

	Quantitative: Per research topic, so-called research contents and assessment indicators are stated. The latter one can be considered as a quantitative target
Financing of the programme **(% of funding, % of co-financing required) – programme open to public and/or private entities?**	The programme published calls for proposals for 2016 and 2017: • 2016 call – 17 projects selected – 1,015 million RMB (€ 128 million) • 2017 call – 20 projects selected – 716 million RMB (€ 90 million) Private companies have to co-finance at least 50% of the project costs itself. Public organisations (universities, research institutes) receive 100% funding.
TRL addressed	Based on the assessment indicators it can be said that the programme addresses applied research (TRL 4-6) The assessment indicators are related to the development of technology components and reaching certain performance results. This suggests reaching the level of "Technology demonstrated in relevant environment", up to TRL 6.
Examples of business cases and commercialisation of projects results	No examples so far, most projects are running since 2016 and 2017 only. Among project coordinators are universities, but also OEMs (interested in commercialisation of project results). It is recommended in the proposal to include strong application and industrialisation prospects
Verification of project results	Evaluation of running projects takes place after each year, after each key milestone
Openness / transparency of the funding process	Based on a recent EU-funded report (European Commission, 2018) it can be concluded that the NKP is among the most transparent of the Chinese research funds. Tender guidelines are accessible online (in Chinese). Some NKPs are judged to be more transparent than others depending on whether international cooperation is encouraged or not. The NEV is considered as the among the more transparent ones.
Duration / flexibility of funding programme	NKP application process has a standardised duration. The tender cycle usually lasts six months.
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	**Strengths:** • Supports the general trend of EV development, and China to play a key role in tech. development **Weaknesses:** • Apparently, no quantitative targets established for the programme as a whole

	• Tender guidelines are in Chinese only
Sources of information	Tender documents of the NKP (translated into English by Ricardo China), EU-funded study on R&D in China Tender documents for 2017 call retrieved from Ministry of Science and Technology (in Chinese): http://service.most.gov.cn/u/cms/static/201610/14101453d5ex.pdf

The next two examples are from the upcoming NKPs (Intelligent Transport Systems and IoT & Smart Cities). The call text for the first NKP on Intelligent Transport Systems was published on August 3, 2018.

Name of funding organisation	**National Key R&D Programme (NKP)** **(Managed by Inter-Ministerial Joint Council and Ministry of Science and Technology)**
Name of Programme	NKP – Integrated Transportation and Intelligent Transportation
Description of the programme / project	The NKP "Integrated Transportation and Intelligent Transportation" is one of the new NKPs financed through the National Key R&D Programme, launched in 2018. The NKP document states that it was launched to "solve the problems in the comprehensive transportation system". A total of 15 key research tasks will be deployed in the NKP according to 6 innovative chains (technology directions): intelligent traffic infrastructure, intelligent synergy of tools, supervision and coordination of traffic operation, collaborative operation of large transportation hubs, integration of multi-mode integrated transportation, and safety risk prevention & control and emergency rescue of integrated transportation. The implementation period for the special program is 5 years (2018-2022).
Covered sector within the programme	Transport sector, including road transportation, urban transportation, logistic systems, waterways & ships, infrastructure (and life cycle of infrastructure)
Main objective(s) of the programme	General objective of the NKP: Promote the technological progress of transportation and accelerate the development of a safe, convenient, efficient and green modern comprehensive transportation system To solve specific problems like low multi-mode cooperation efficiency (i.e. insufficient integration of transport services), poor active prevention and control ability in transportation safety, etc. Focus on the breakthrough of major key technologies of integrated transportation and carry out the demonstration of new applications.
How are the targets / objectives defined?	Qualitative: The programme specifies the need of developing a transport system integrating transport modes with the use of innovative technologies.

	Quantitative: Per research topic (15 in total), so-called research contents and assessment indicators are stated. The latter one can be considered as a quantitative target. Assessment indicators are specified in detail.
Financing of the programme **(% of funding, % of co-financing required) – programme open to public and/or private entities?**	The available budget for the 2018 call is 436 million RMB (€ 55 million) and the call text mentions that 16 to 32 projects will be funded. Co-financing is slightly different to the previous NKP. The budget allocated for projects belonging to the category of "generic key technologies" should respect a 1:2 ratio with funds provided by the consortium (67%). The ratio increases to 1:3 (75%) for projects belonging to "application and demonstration" category.
TRL addressed	Based on the assessment indicators, the programme addresses applied research (TRL 4-6). These indicators are related to the development of technology components and reaching certain performance results. This means reaching the level of "Technology demonstrated in relevant environment", up to TRL 6. Some research topics include testing in operational environments, meaning TRL 7.
Examples of business cases and commercialisation of projects results	No examples so far, but in all NKPs it is recommended in the proposal to include strong application and industrialisation prospects.
Verification of project results	In other NKPs, evaluation of running projects takes place after each year, after each key milestone
Openness / transparency of the funding process	Based on a recent EU-funded report (European Commission, 2018) it can be concluded that the NKP is among the most transparent of the Chinese research funds. Tender guidelines are accessible online (in Chinese). Some NKPs are judged to be more transparent than others depending on whether international cooperation is encouraged or not. This is a new NKP, so no judgement can be made here.
Duration / flexibility of funding programme	NKP application process has a standardised duration. The tender cycle for NKPs in 2016 and 2017 usually lasted six months.
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	**Strengths:** • Specific definition of research topics with assessment indicators **Weaknesses:** • Tender guidelines are in Chinese only
Sources of information	Tender documents of the NKP (translated into English by Ricardo China), EU-funded study on R&D in China Draft tender documents for 2018 call retrieved from Ministry of Science and Technology (in Chinese): http://service.most.gov.cn/u/cms/static/201801/24091822d12t.pdf

The third example is from the NKP on IoT & Smart Cities. At the moment of finalising the report (mid-August 2018), only a draft tender document has been published.

Name of funding organisation	**National Key R&D Programme (NKP)** **(Managed by Inter-Ministerial Joint Council and Ministry of Science and Technology)**
Name of Programme	NKP – Key Technology and Demonstration of Internet of Things and Smart Cities
Description of the programme / project	The NKP "Key Technology and Demonstration of Internet of Things and Smart Cities" is one of the new NKPs financed through the National Key R&D Programme, launched in 2018. The NKP document states that it was launched to "focus on breakthrough of key technologies for smart cities".
Covered sector within the programme	A total of 15 key research tasks will be deployed in the NKP according to 5 innovative chains (technology directions): • intelligent technology and intelligent terminals, • IoT ubiquitous access technology and integration system, • urban modelling technology and dynamic cognitive system, • urban comprehensive decision-making technology and intelligent service platform, • as well as urban trust integration technology and support system. The implementation period for the special program is 5 years (2018-2022).
Main objective(s) of the programme	General objective of the NKP: The overall goal of key special program is to focus on the breakthrough of key technologies for smart cities based on the national cyber development strategy and demand of social and economic transformation, build the integrated service system of Internet of Things (IoT) and smart cities, In addition, the NKP should assist in demonstration application of integrated innovation and integration services in the typical urban agglomerations, such as, Beijing-Tianjin-Hebei Economic Circle, Pearl River Delta, Yangtze River Economic Belt, Belt and Road Initiative, etc., so as to support the demonstrative construction of more than 50 national new smart cities. This should improve the urban governance capabilities and public service levels and promote China in becoming a global leader in technology innovation and industrial application of smart cities.
How are the targets / objectives defined?	Qualitative: The programme specifies key technologies that should assists in the development of the IoT and support the construction of more than 50 smart cities.

	Quantitative: Per research topic (15 in total), so-called research contents and assessment indicators are stated. The latter one can be considered as a quantitative target. Assessment indicators are specified in detail.
Financing of the programme **(% of funding, % of co-financing required) – programme open to public and/or private entities?**	In other programmes, private companies have to co-finance at least 50% of the project costs itself. Public organisations (universities, research institutes) receive 100% funding. Programme call budget not known yet.
TRL addressed	Based on the assessment indicators it can be said that the programme addresses applied research (TRL 4-6). These indicators are related to the development of technology components and reaching certain performance results. This means reaching the level of "Technology demonstrated in relevant environment", up to TRL 6. In some research topics, testing in an operational environment is required, meaning TRL 7.
Examples of business cases and commercialisation of projects results	No examples so far, but in all NKPs it is recommended in the proposal to include strong application and industrialisation prospects.
Verification of project results	In other NKPs, evaluation of running projects takes place after each year, after each key milestone
Openness / transparency of the funding process	Based on a recent EU-funded report (European Commission, 2018) it can be concluded that the NKP is among the most transparent of the Chinese research funds. Tender guidelines are accessible online (in Chinese). Some NKPs are judged to be more transparent than others depending on whether international cooperation is encouraged or not. This is a new NKP, so no judgement can be made here.
Duration / flexibility of funding programme	NKP application process has a standardised duration. The tender cycle for NKPs in 2016 and 2017 usually lasted six months.
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	**Strengths:** • Specific definition of research topics with assessment indicators • Programme that addresses both IoT and smart cities **Weaknesses:** • Tender guidelines are in Chinese only
Sources of information	Tender documents of the NKP (translated into English by Ricardo China), EU-funded study on R&D in China Draft tender documents for 2018 call retrieved from Ministry of Science and Technology (in Chinese): http://service.most.gov.cn/u/cms/static/201802/14142126lc3k.pdf

3.3.4 Brazil

The first grant funding examples for Brazil is the ANEEL R&D Programme, the BNDES Finem fund and the EMBRAPII programme.

NAME OF FUNDING ORGANISATION	ANEEL (NATIONAL ELECTRICITY REGULATOR AGENCY)
Name of Programme	ANEEL R&D
Description of the programme / project	R&D programme funded by energy companies (that are obliged to invest a certain percentage of Net Operating Revenue in R&D)
Covered sector within the programme	Originally energy sector, recently also transport sector (EV) Electromobility (topics: network impacts resulting from massive EV insertion, fast charging stations, electric buses, etc.)
Main objective(s) of the programme	Development of components in production of EV and HEV
How are the targets / objectives defined?	Relatively broad, no specific topics mentioned
Financing of the programme	16 projects approved until 2017 – total budget of EUR 35 million (average project budget 2.2 million EUR). There is no information on funding % provided.
TRL addressed	Estimated at TRL 7 – 9
Examples of business cases and commercialisation of projects results	Projects funded are close to innovation. As the funds are provided by electricity companies, there is high interest in commercialisation
Verification of project results	The research projects financed by the electricity companies in Brazil are subject to verification by ANEEL at the beginning and at the end of the project. The criteria under which the projects are approved are: originality, applicability, relevance and cost-efficiency. In case of disapproval or partial approval, the amounts must return to the R & D account of the company.
Openness/transparency of the funding programme	No information available on application process
Duration / flexibility of funding programme	Call frequency is at least once a year, but depends on each electricity company
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	Too little information to give opinion

The BNDES Finem fund is the second example from Brazil.

NAME OF FUNDING ORGANISATION	BNDES (BRAZILIAN NATIONAL DEVELOPMENT BANK)
Name of Programme	BNDES Finem – Support to national engineering
Description of the programme / project	The BNDES Support to National Engineering grants loans of a minimum of BRL 10 million (€ 2.4 million) for investments in innovation for companies based in Brazil, foundations, associations, cooperatives and public bodies.
Covered sector within the programme	The programme is cross-sectoral
Main objective(s) of the programme	Programme generally aimed at investments in innovation for projects and engineering services in strategic sectors, aiming to stimulate the improvement of skills and technical knowledge in the country.
How are the targets / objectives defined?	Targets are broadly defined, funds for RTD that provides proven market opportunity
Financing of the programme	The programme provides loans, Minimum amount is R$ 10 million (€ 2.4 million, funding of up to 80% of project value)
TRL addressed	TRL 7 – 9, close to market entry
Examples of business cases and commercialisation of projects results	Projects are addressing innovation. Costs for getting innovative product to the market is also covered by the programme
Verification of project results	During the monitoring phase, in which the financing resources are made available to the client, the compliance with the applicable provisions and the physical and financial evolution of the supported project are verified, in accordance with the BNDES Follow-up Norms and Instructions.
Openness/transparency of the funding programme	No information available on application process
Duration / flexibility of funding programme	Programme is open permanently, proposals can be submitted at any time
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	Too little information to give opinion

The EMBRAPII R&D programme is the third example from Brazil.

NAME OF FUNDING ORGANISATION	EMBRAPII – BRAZILIAN ASSOCIATION OF RESEARCH AND INDUSTRIAL INNOVATION
Name of Programme	

Description of the programme / project	Funding of industrial innovation projects. This sub-project covers R&D for Intelligent Automotive Systems.
Covered sector within the programme	Automotive industry
Main objective(s) of the programme	It has the goal of supporting technological research institutions in selected areas of competence to carry out technological innovation development projects in cooperation with companies in the industrial sector
How are the targets / objectives defined?	One of the selected areas is Intelligent Automotive systems
Financing of the programme	EMBRAPII funds 1/3 of project budgets (non-reimbursable resources), remainder covered by participant. Total budget not known, but in the project examples, contributions vary between € 200,000 to € 600,000.
TRL addressed	Estimated at TRL 3 to 6
Examples of business cases and commercialisation of projects results	Cooperation between OEMs and researchers ensure commercialisation
Verification of project results	No information available
Openness/transparency of the funding programme	No information available on application process
Duration / flexibility of funding programme	Call sequence is at least once a year
Preliminary assessment of the programme	
Overview of strengths and weaknesses of the programme	Too little information to give opinion

3.3.5 Assessment of grant funding programmes

This section includes the assessment of the abovementioned grant programmes with respect to the best practice identified. The result of the comparison of the grant funding programme with the best practice example is shown with a scoring table. With the scoring the aim is to illustrate how each programme copes with the best practice criteria developed. Proposed scoring is from **+ +** to **– –**, meaning**:**

+ + fully covering criterion – fully in line with best practice

+ partly covering criterion from best practice

0 no information available / no assessment possible

– not covering criterion from best practice

– – not in line at all with best practice.

The scoring table with example scores is shown below. The column on the left shows the best practice criteria while the other columns show the programmes assessed:

Criteria	Programme 1 Country 1	Programme 2 Country 2	Programme 1 Country 2	Programme 2 Country 2	Programme 3 Country 3
Covered sector of the programme	No scoring, only descriptive				
Main objectives of the programme	No scoring, only descriptive				
How are targets / objectives defined					
Financing of the programme					
TRL addressed	No scoring, only descriptive				
Commercialisation of project results					
Verification of project results					
Openness of the funding programme					
Flexibility of the application process					
Scoring	2	3	0	1	2
Comments to scoring					

A final scoring table will be shown with an explanation why a certain score came out of this assessment. Given the relatively subjective assessment, the final selection of "best practices" is not only based on scoring but supported by arguments. The scoring will be in line with the definitions in the table below.

3.3.5.1 Definition of scoring related to best practice

Criteria	2 + score	1 + score	0 score	1 – score	2 – score
Covered sector of the programme	No scoring, only descriptive assessment				
Main objectives of the programme	No scoring, only descriptive assessment				
How are targets / objectives defined	Both specific qualitative & quantitative targets of call included in line with programme objectives	Only qualitative targets of call included in line with programme objective	Lack of data	Only general objectives, related to project call	No information on call targets apart from overall programme objectives
Financing of the programme	Clear co-financing guidelines, information about expected programme size	Information about financing guidelines, expected programme size available	Lack of data	Only general information about expected project size or call budget available	No information about expected project size or call budget available
TRL addressed	No scoring, only descriptive assessment				
Commercialisation of project results	Commercialisation or results is directly mentioned in call text	Commercialisation of results is among main objectives of the programme, not the call	Lack of data	Commercialisation of results is only vaguely mentioned in programme	No mention of commercialisation of results
Verification of project results	Quantitative and qualitative verification process in place	Qualitative verification process in place	Lack of data	Verification is possible based on performance targets set	No indication that project could be verified based on targets
Openness of the funding programme	All required information for funding application / selection process and earlier selections online	All required information for funding application online	Lack of data	Contact details for more information online	Basically, no information about funding programme available online

Duration of the application process	Fixed timeline for proposal submission (with sufficient time) and for evaluation / contract negotiation	Published timeline for proposal submission and for evaluation / contract negotiation, but subject to changes depending on call	Lack of data	Fixed timeline, but often subject to changes, delays in evaluation	No fixed timeline, time for submission is surprise with each call

3.3.5.2 Assessment of US programmes

The assessment of 4 US programmes shows the following results:

Name of funding organisation	ARPA-E	NSF	EERE	DOT / Volpe
Name of Programme	*NEXTCAR*	*Energy, Power, Control and Networks (EPCN)*	*Advanced Vehicle Technologies Research*	*DOT' s SBIR program*
Covered sector within the programme	*HEV / EV and CAV*	*4 areas covered incl. power electronics systems*	*Vehicle technologies (batteries, materials)*	*Transportation sector (topics specified - e.g. safety applications)*
Main objective(s) of the programme	*Reduction of fuel cons in CAV* *Commercialisation of proposed technologies*	*Support of innovative research – progress in engineering system applications*	*Accelerating development and adoption of sustainable transport technologies*	*Support technological innovation meeting federal research needs*
How are the targets / objectives defined?	2 + Specific qualitative and quantitative targets	1 – Only general objectives	1+ Qualitative targets	1+ Qualitative targets
Financing of the programme	2+ Info on cost sharing & budget per project	0 No info on cost sharing / budget per project	1+ Info on cost sharing	1+ Info on cost sharing
TRL addressed	*Low TRL – 2- 4 - proof of concept*	*Fundamental research, TRL 1 - 3*	*Applied research in early stage - TRL 3-5*	*TRL 3- 4 proof of concept required*

Commercialisation of projects results	1+ Not in FOA, will be the next step / for ARPA-E this is priority	1+ Not mentioned in this program but NSF has program for commercialisation	1+ Commercialisation not addressed in this FOA, but by separate DOE program	2+ SBIR includes three phases, commercialisation in stage III
Verification of project results	2+ Quantitative / qualitative verification (related to targets)	1+ Review during project execution	0 Not fully clear yet (possible to verify against perf targets)	0 Not fully clear yet (possible to verify against perf targets)
Openness/transparency of the funding programme	1+ Required info on website	**2+** [135] Required info on website, database of older projects	1+ Required info on website	1+ Required info on website
Duration of the application process	1+ Fixed duration	2+ Flexible submission, fixed duration for evaluation	1+ Fixed duration	1+ Fixed duration
Scoring	**8+**	**4+**	**5+**	**6+**

Additional explanation to the scoring:

- Targets / objectives defined – for this criterion 2+ when programme has quantitative / qualitative targets (case of ARPA-E), 1+ if the programme has specific targets for the call (EERE / DOT). In case of the NSF programme only very general objectives are set that cannot be related to the project call, so 1- was given.
- Financing of the programme - for this criterion 2+ when programme includes information on cost sharing & estimated budget per project proposal (case of ARPA-E), 1+ if there is information on cost sharing. In case of NSF, there was no information on cost sharing / budget per project, but a database of older projects shows typical budgets, so choice between 1+ and 1- leads to a score of 0.

[135] The NSF programme has database of previously approved projects available.

- Commercialisation of projects results, here only the DOT SBIR programme received 2+ as commercialisation of results is key point in programme. A score of 1+ / 2+ for ARPA-E programme as for ARPA-E this is priority, but not directly mentioned in call text. 1+ for EERE programme as EERE addresses commercialisation in general. In the NSF programme, commercialisation is more vaguely defined, so a score of 0/ 1+
- Verification of project results – For the ARPA-E programme, a 2+ as there is quantitative / qualitative verification (related to targets), 1+ for the NSF programme as projects are closely monitored during project duration, 0 for the EERE and DOT programmes due to lack of data (but it is possible to verify against performance targets for the calls)
- Openness/transparency of the funding programme – each programme has the required information available on the website, so at least 1+ for all programmes. A score of 1+/2+ for NSF as potential applicants can find a database of older projects on the website (but it's not so user friendly)
- Duration of the application process – for all programmes at least a score of 1+ as there is a fixed duration for evaluation. A 2+ for the NSF programme due to the flexible submission (no fixed deadline). This is a plus for the applicant

The final scoring shows that the ARPA-E project NEXTCAR is coming closest to best practice with 8+/9+. Based on the six criteria a perfect score (best practice for all criteria) would be 12+.

3.3.5.3 Assessment of Japanese programmes

Assessment of 3 Japanese programmes leads to the following scoring

Name of funding organisation	CTSI & NEDO (SIP) - Japan	NEDO - Japan	NEDO - Japan
Name of Programme	*Automated driving system (SIP-ADUS)*	*Technologies for hydrogen usage (Call no. P13002)*	*Energy Storage (Call P13007 and P16001)*
Covered sector within the programme	*Automotive industry / CAV / IT*	*Hydrogen infrastructure*	*Vehicle batteries*

Main objective(s) of the programme	*Reducing traffic fatalities* *Increase of automated driving*	*Improving performance*	*RTD related to evaluation of advanced and revolutionary battery material* *Fundamental RTD related to expansion of revolutionary battery type*
How are the targets / objectives defined?	(semi-)quantitative and qualitative targets Clear milestones for 2017 (field test) and 2020 (demonstration) 1+	Quantitative Long-term objectives, e.g. no. of FCEV and hydrogen fuelling stations, quantified performance targets 2+	Long-term objectives until 2020 and 2030 regarding battery performance. Very specific performance indicators 2+
Financing of the programme	Budget of programme known, cost sharing not easily accessible 1+	Budget of programme knows, cost sharing not easily accessible 1+	Budget of programme known, cost sharing not easily accessible 1+
TRL addressed	*TRL 4-6*	*TRL 7-9, MRL estimated at 6-7*	*TRL 4-6?, starting at TRL3, by TRL 7 at end of project*
Commercialisation of projects results	Target to demonstrate at 2020 Olympics, start-up established 2+	Technology is already pre-commercial, and commercialisation is key objective 2+	Commercialisation of new battery by 2030, stay ahead of foreign competition 2+
Verification of project results	Details not fully clear, but verification against performance targets and 2020 milestone possible +1	Annual periodic reports, verification against performance targets and LT targets possible +1	Annual periodic reports, verification against performance targets and LT targets possible 1+
Openness/transparency of the funding programme	Required information online (in Japanese)[136], names of award winners published +1	Required information online (in Japanese), names of award winners published +1	Required information online (in Japanese), names of award winners published. *For Japanese entities only*[137]

[136] Some basic information about funding processes available in English on: https://www.e-rad.go.jp/en/
[137] Specifically mentioned here, but better to keep this info out.

			1+
Duration of the application process	No details on his call 0 [138]	No details on his call 0	Subprojects tendered each year, in relatively short time 1+
Scoring	**6+**	**7+**	**8+**

Additional explanation to the scoring for Japan:

- Targets / objectives defined – for this criterion 2+ when programme has quantitative / qualitative targets, +1 when only qualitative targets. For both programmes score is between 1+ and 2+
- Financing of the programme - for this criterion 2+ when programme includes information on cost sharing & estimated budget per project proposal, 1+ for both programmes as cost sharing information is not publicly available.
- Commercialisation of projects results: A score of 2+ for both programmes. For the SIP programme, commercialisation was a key target of the programme and there is already a start-up using part of the results. The NEDO programme on hydrogen has commercialisation as main objective
- Verification of project results – for this criterion 2+ as there is quantitative / qualitative verification (related to targets), 1+ as verification details are not fully known.
- Openness/transparency of the funding programme – each programme has the required information available on the website, so at least 1+ for all programmes. The minus is that almost all information is only available in Japanese.
- Duration of the application process – no details could be on his call, but fixed duration is common for NEDO programmes at and at least a score of 1+ could be applied.

The final scoring shows the highest score for the NEDO programme on energy storage.

[138] Fixed duration of funding calls is common for NEDO as can be seen on the grant funding website e-Rad.

3.3.5.4 Assessment of Chinese programmes

Assessment of 3 Chinese programmes leads to the following scoring

Name of funding organisation	NKP	NKP	NKP
Name of Programme	*NKP – New Energy Vehicles*	*NKP – Integrated Transport*	*NKP – IoT and Smart Cities*
Covered sector within the programme	*Automotive industry, research on EV components and fuel cells.*	*Road transport (private, public, freight) and waterways*	*Internet of Things and IT applications for Smart Cities*
Main objective(s) of the programme	*Transformation towards pure electric drive*	*Development of an intelligent, integrated transportation systems using different transport modes*	*Developing IT applications for Smart Cities in China*
How are the targets / objectives defined?	General targets and specific assessment indicators set +1	General targets and specific assessment indicators set +1	LT targets regarding the creation of 50 smart cities General targets and specific assessment indicators set +1
Financing of the programme	Budget for each year known, co-financing known +1	Budget for the 2018 call known, co-financing known +1	Pre-announcement, budget not yet known. Expected that it will be, like in every NKP 0
TRL addressed	*TRL 4-6*	*TRL 4-6, up to TRL 7 in some cases*	*TRL 4 – 6?*
Commercialisation of projects results	Participation of OEMs. Some commercialisation targets +1	Given the TRL, commercialisation is a must +1	Results to be used in creation of smart cities +1
Verification of project results	Evaluation of running project takes part after each year and/or key milestone	Not known yet, probably same as in other NKP	Not known yet, probably same as in other NKP

	Verification against assessment indicators possible +1	Verification against assessment indicators possible +1	Verification against assessment indicators possible +1
Openness/transparency of the funding programme	Required information online (in Chinese) Evaluation scoring table published, as well as winning project titles +1	Required information online (in Chinese) 0	Required information online (in Chinese) 0
Duration of the application process	The tender cycle is standardised for all NKPs and lasts approx. 6 months 1+	0	0
Scoring	**6+**	**4+**	**3+**

The NKP on New Energy Vehicles is the only one that is open, that's why there is more information than in the programmes on integrated transport and those on IoT & Smart Cities. The NKP on integrated transport opened early August 2018, the NKP on IoT and Smart Cities not yet. Funding requirements for both programmes are not yet fully known, so this slightly limits the assessment of the Chinese programmes.

In addition, there are already several funds for commercialisation of research results established recently. Unfortunately, it was not possible to find details about these funds yet and these programmes have been left out in the assessment.

3.3.5.5 Assessment of Brazilian programmes

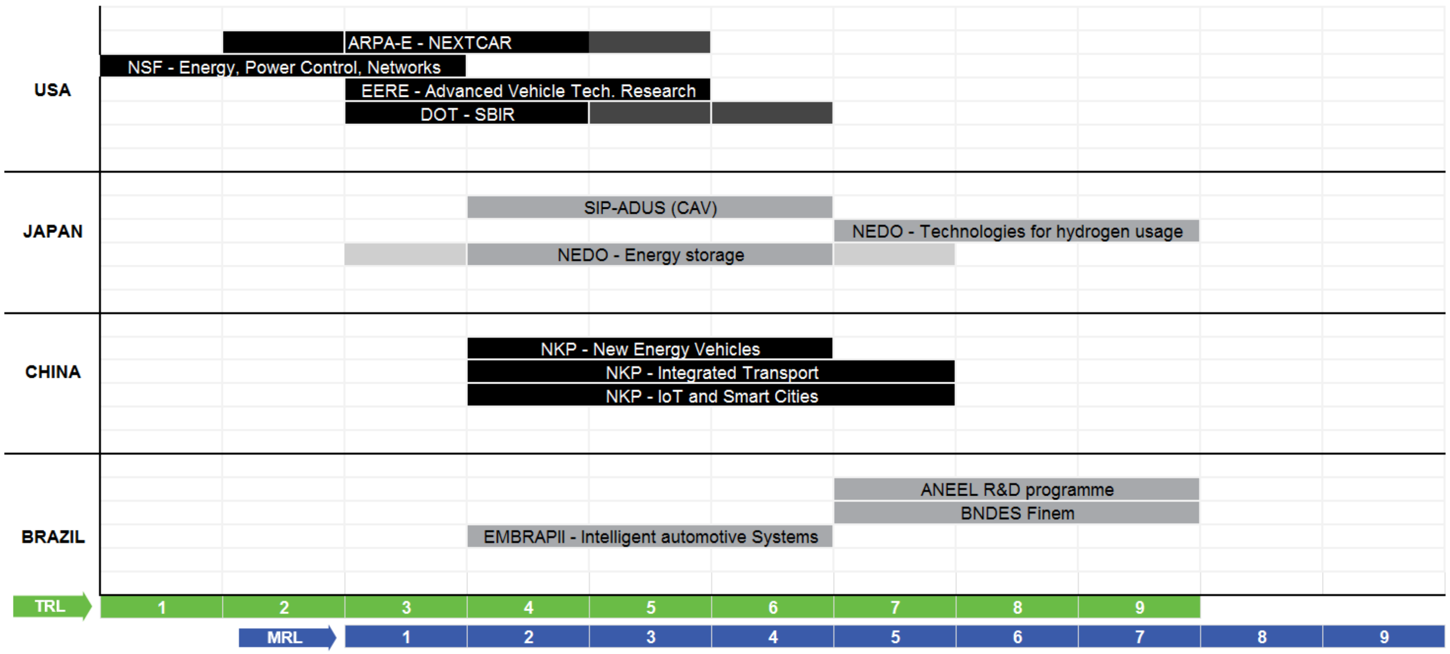
Assessment of 3 Brazilian programmes leads to the following scoring

Name of funding organisation	ANEEL (National Electricity Regulator Agency)	BNDES (Brazilian National Development Bank)	EMBRAPII
Name of Programme	*ANEEL R&D Programme*	*BNDES Finem - Support to national engineering*	*EMBRAPII*

Covered sector within the programme	*Originally energy sector, recently also transport sector (EV)*	*BNDES Innovation line grants loans of a minimum of EUR 2.0. Cross-sectoral programme*	*RTD for in the automotive sector*
Main objective(s) of the programme	*Development of components in production of EV and HEV*	*Investments in innovation*	*Stimulation of industrial innovation, specifically in the automotive sector*
How are the targets / objectives defined?	Relatively broad, no specific topics mentioned 1-	Broadly defined, funds for RD&I that provides proven market opportunity 1-	Specific programme for Intelligent Automotive Systems 1+
Financing of the programme	Total budget of USD 41 million. Not info on funding % 0	Loans, Minimum: EUR 2.4 million (R$ 10 million), up to 80% of project value 1+	EMBRAPII funds 1/3 of project budgets, remainder covered by participant 1+
TRL addressed	*Estimated at TRL 7-9*	*TRL 7 - 9*	*TRL 3 - 6*
Commercialisation of projects results	Close to innovation. Funds for electricity companies, high interest in commercialisation 1+	Close to innovation. Costs for getting innovative product to the market is also covered by the programme 1+	Cooperation between OEMs and researchers ensure commercialisation 1+
Verification of project results	Verification at the beginning and at the end of the project 1+	Monitoring and verification included in the programme 1+	No info 0
Openness/transparency of the funding programme	No info	No info	No info
Duration / flexibility of the application process	Call frequency approx. once a year 1+	Proposals can be submitted at any time 1+	Call frequency at least once a year 1+
Scoring	**2+**	**3+**	**4+**

The information that could be collected on the Brazilian research programmes was slightly more limited, so the scoring is difficult to compare to the programmes in the USA, China and Japan. The EMBRAPII programme with a specific automotive research area scored the highest.

Before addressing the complete findings of the benchmark analysis, it is possible to look at the funding programmes from another viewpoint. The programmes assessed in the best practice examples are shown in the following figure based on the TRL and MRL[139] that they are addressing. The programmes studied did not address the higher MRL (8 and 9).

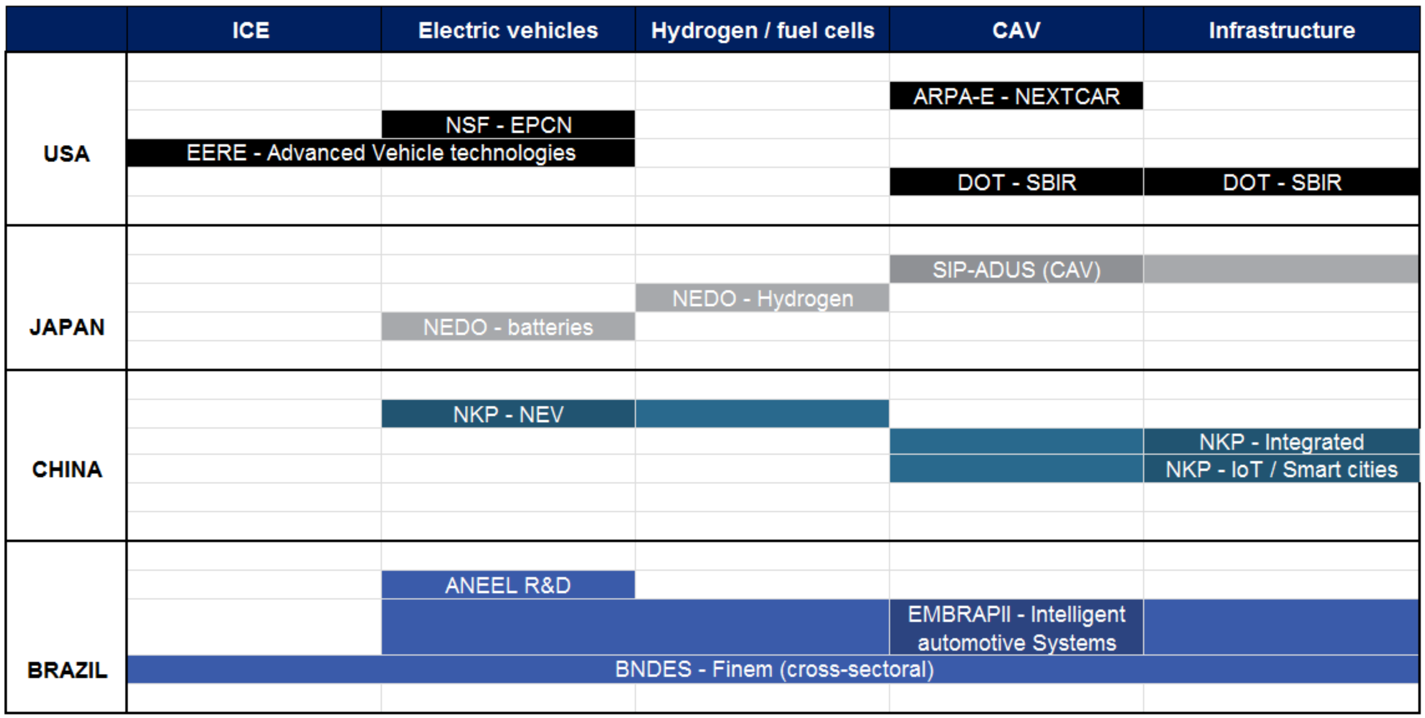


TRL and MRL addressed by selected funding programmes

[139] The scale of TRL and MRL is based on a publication of the UK Automotive Council: "Technology and Manufacturing Readiness Levels"

The programme calls addressed cover the whole scale of TRL, from 1 to 9. An interesting finding is that the programmes from the USA generally cover lower TRL than those in the other three countries.

It is also possible to look at the spread of the programmes over research topics. For that purpose, five research topics have been chosen: 1) Internal combustion engines (ICE), 2) Electric vehicles, 3) Hydrogen and fuel cells, 4) connected and Automated Vehicles (CAV) and 5) Infrastructure. When looking at the research topics, split over five categories, we get the following result.



Research topics addressed by selected funding programmes

All five research topics are covered within the programme, with some specific topics more interesting for single countries. The USA is strongly focusing on research in the field of CAV and for Japan the topic of hydrogen remains important. In the field of electric vehicles all four countries have a research programme that addresses this topic.

This very brief overview is basically in line with some of the finding from the research. These findings show that each of the countries have their research topic in which they would like to excel, examples are CAV for the USA, hydrogen / fuel cells for Japan and electric vehicles for China.

3.4 Main findings and conclusions

This report contains the assessment of the national funding mechanisms for automotive RTD in the United States, Japan, China and Brazil. Apart from the description of funding practices in the four countries, it also includes a suggestion of criteria for the identification of best practice examples of RTD funding.

It would have been possible to carry out the assessment for four specific entity types, 1) Funding organisations, 2) Funding programmes, 3) Funding calls and 4) Funded projects. In this study, the choice was made for the assessment of 3) Funding calls.

3.4.1 Results of the benchmarking and best practice criteria analysis

Best practice criteria were determined based on literature research, these were eight in number, in the first instance qualitative criteria. With these criteria, a best practice example was defined against which the actual programmes were benchmarked, relative scoring, on a scale of +2 to -2, was made for six of the eight criteria.

After carrying out the assessment of best practices, it can be concluded that the best score among the programmes was for the US ARPA-E programme NEXTCAR (addressing CAV) and for the Japanese programme from the NEDO programme on energy storage (battery development). Both programmes received 8 points from a maximum of 12 (being the ideal best practice) and represent the best practice for the USA and Japan.

The best practice programme for China, based on those studied, is the NKP New Energy Vehicles. This programme received 6 points. It comprehensively covers the topics of electric and hydrogen fuelled vehicles. It mentions very specific performance targets and the impression is that through RTD funded within this programme, China wants to become the world leader in electric vehicles.

The dataset for Brazil was slightly less complete and it was, therefore, difficult to make up a representative score. Nevertheless, the EMBRAPII programme on Innovation (including Intelligent Automotive Systems as specific research area) scored slightly better than the two other programmes, which only addressed innovation in general.

The assessment of single best practice criteria gives a more differentiated picture. For each criterion there are more programmes that score the full 2 points. The results per criterion are the following:

- The criterion "How are the targets and objectives defined", gave a 2+ scored for the ARPA-E, and the two NEDO programmes in Japan (both the hydrogen and energy storage programmes).
- Related to "Financing of the programme" – best practice can be best defined by the ARPA-E programme as information on cost sharing and budget per project was the most complete.
- "Commercialisation of projects results" gave a 2+ for DOT's SBIR programme and all three RTD programmes in Japan. All programmes included clear commercialisation objectives. All of them include a specific milestone, such as developing batteries for new serial developed vehicles after 2030 or commercialisation of hydrogen infrastructure. When looking into the future, potentially the highest impact could be expected from the NEDO battery storage programme.

- Related to “Verification of project results”, the most complete information was provided by ARPA-E, receiving a 2+ score. The majority of programmes received a 1+, all of them are setting performance targets that enable detailed evaluation, but the limited information available from call documents (uncertainty how verification or monitoring really works) did not allow to give the full score of 2+.
- On “openness and transparency of the funding programme” the US programmes have a certain advantage as the availability of all documents in English allowed for a more detailed assessment. From the US programmes, the best score was received by the NSF programme Energy, Power, Control and Networks (EPCN). Not only is all documentation available on the website, also all older funded programmes can be checked to see what type of topics were funded in the past. This is the advantage of a long running programme as is the case for the NSF.
- On “duration and flexibility of the application process”, here a US programme also received the highest score. A 2+ was only gained by the NSF programme because of the flexible submission (no fixed deadline) timeframe, this is considered beneficial for applications.

The best practice assessment gave the possibility to benchmark the programmes based on a specific set of criteria. Apart from the relatively scored criteria, there are other criteria that are interesting to mention with the view of developing funding best practices.

The best example, the level of RTD funded in terms of TRL, is considered but not included in the scoring. The reason is that it is impossible to judge if research at lower or higher TRL is better or not: a continuous development towards higher TRL is needed. But, in terms of TRL categories, some general recommendations can be given:

- Fundamental research, generally of TRL 1 to 3, has an impact in the long term. At the start of such a project, it may not be exactly known when project results will be available or usable for commercialisation. Programmes funding this type of research cannot have strictly defined targets but should allow a certain creativeness of the researcher. This can be seen in the funding programme of the NSF - Energy, Power, Control and Networks (EPCN). Objectives of this RTD programme are not as strictly defined as objectives of RTD programmes generally addressing higher TRL.
- At the medium TRL of 4 to 6 there is applied research, this research should already consider research questions and challenges faced from industry or society, but the research results may not yet be directly marketable. An element of best practice in this category is that commercialisation of project results is directly addressed as a priority in the funding call.
- At the high TRL, from 7 to 9, the technology is already existing but additional support is provided to make it ready for commercialisation. A good example of this type of research is the hydrogen programme from NEDO. It supports the acceleration of market access of hydrogen technology, meaning FCEV and hydrogen fuel stations. The topics addressed are supportive to this development, such as the development of components of hydrogen filling stations and RTD related to safety requirements. At this TRL it is important to consider that supporting a certain technology directly may provide direct advantage for one private company (e.g. an OEM) and a disadvantage for another not having this technology.

3.4.2 Other findings

In addition to the scoring-based trends, there are other overall findings from the best practice examples.

The USA, China and Japan have specific research programmes (programmes, calls) for automotive research in the field of electric vehicles, hydrogen vehicles and automated vehicles. All three countries declare that they would like to be or remain world leader in one of these fields.

In contrast, RTD funding programmes in Brazil are of a more general nature, funding RTD topics that have an innovative potential for industry. This may be related to the fact that although Brazil has a large automotive industry, it is not an automotive technology leader. This is shown by the fact that innovation in the automotive sector is not supported by specific research programmes.

Other findings from the study are the following:

- With the topics of its NKP, China hopes to support the transformation to electric vehicles – the programmes are clearly focused on results that support the Chinese automotive sector
- US programmes in the automotive sector also aim for technological leadership but, due to the generally lower TRL of the research, results may not directly lead to commercial use by the automotive sector. Nevertheless, commercialisation of project results is important in the US, as shown by the large number of initiatives from research organisations in this field (e.g. DOE, DOT and the NSF have specific programmes for commercialisation of research results).
- A specific feature of many research programmes in Japan is the prominent role of the OEMs. Apart from doing their own RTD, the OEMs have a prominent role in nationally funded research in fields such as battery development and automated driving. Also visible in Japan is the integration of long term objectives for society and industry into the research programmes. Three examples can be mentioned:
    - The aging of Japanese society has led to research initiatives in the field of automated driving that should increase road safety even with higher shares of older drivers, and initiatives in the field of truck platooning to reduce the need for truck drivers.
    - The wish to remain competitive and one step ahead of the automotive sector in other major economies, has led to the battery research programme of NEDO. This programme aims to develop a revolutionary battery for electric vehicles by 2025 to be ready by 2030 for full commercialisation (i.e. assembly of these batteries in new cars by this time).
    - The Japanese government sees an important role for hydrogen in both the energy and transport sector as this will lead to improved energy security and CO_2 emission reductions. Therefore, Japan would like to remain the world leader in hydrogen-based transport. RTD for hydrogen is also supported in the USA and China, but there is no national policy like in Japan that would make hydrogen a national priority.

3.4.3 Recommendations

Based on the description of the grant funding programmes in the four countries and the benchmarking of funding programmes to a best practice, it is possible to make recommendations that are applicable for funding programmes in the EU and all over the world.

It can be concluded that programmes that score high in the best practice assessment, i.e. include more elements that could be defined as best practice, have several common features:

- RTD funding programmes with clearly defined objectives and (performance) targets enable specific results to be achieved. This also makes verification and/or evaluation of projects and programmes much easier.
- Programme targets that are in line with the (long-term) objectives of the automotive industry and/or with long-term objectives of society will most likely lead to commercialisation of project results.
- Programmes that are specifically aimed at the commercialisation of research results.

Other interesting findings from funding practices, outside from the best practice assessment, lead to the following recommendations:

- Monitoring of the use of project results for a number of years after the end of the funding (e.g. the case of NEDO funded projects in Japan) can tell if the research projects funded lead to the (long-term) results that were stated at the start of the work. Such monitoring may better identify lessons learned from existing funding practices and improve upcoming funding programmes.
- Promoting the use of research results by setting up a fund for commercialisation (including establishment of start-ups), like the examples from US SBIR and SME Fund in China, could be the right way of ensuring that RTD project results are really used.
- Openness and transparency of the application process helps applicants to orient themselves quickly in the different grant funding opportunities. A nationwide platform, as developed in the United States (web-portal www.grants.gov), is a useful tool for that. China and Japan have established similar web-portals that provide information about funding opportunities in a structured way.

3.4.4 Future work

This study was the first of three activities. The second activity will be a similar assessment of automotive RTD in six EU Member States. Thirdly, on the basis of these two assessments the funding mechanisms in the EU are compared to those outside the EU. This will form the basis of recommendations to ERTRAC and EGVIA on key policies to support and strengthen the automotive industry and research.

The results will not only be presented in a report but also at a workshop to stakeholders of FUTURE-RADAR, in order to obtain feedback on the recommendations given.

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Annexes

Tender documents Japan – NEDO

NEDO Funding – Fuel Cells & Hydrogen

NEDO funds research in the field of Fuel Cell & Hydrogen. The following research topics were funded between 2013 and 2018:

- Technology Development of SOFC (Solid Oxide Fuel Cell), call no. P13001, budgets:
    - 2013: 328 million JPY
    - 2014: 816 million JPY
    - 2015: 1133 million JPY
    - 2016: 1962 million JPY
    - 2017: 390 million JPY
- R&D business related to hydrogen technology, call no. P13002
    - 2013: 1734 million JPY
    - 2014: 3593 million JPY
    - 2015: 4649 million JPY
    - 2016: 4372 million JPY
    - 2017: 4100 million JPY – call details are presented below
- R&D business related to hydrogen usage introduction, call no. P14021, budgets:
    - 2014: 1277 million JPY,
    - 2015: 1455 million JPY,
    - 2016: 1296 million JPY,
    - 2017: 879 million JPY,
    - 2018: 900 million JPY
- R&D business related to hydrogen society construction, call no. P14026:
    - 2015: 1810 million JPY,
    - 2016: 4430 million JPY,
    - 2017: 6653 million JPY,
    - 2018:8930 million JPY
- R&D business related to acceleration of PEFC (Proton Exchange Membrane Fuel Cell), call no. PP15001, budgets
    - 2015: 3165 million JPY,
    - 2016: 3094 million JPY,
    - 2017: 2311 million JPY,
    - 2018: 2220 million JPY
- R&D business related to expansion of infrastructure of high pressure hydrogen, call no. P18011 Budget for 2018: 2400 million JPY

NEDO Funding – hydrogen technology
Funding for this topic started in 2013 and is continuing every year from then[140]. The main R&D topics financed are: a- R&D related to appropriate Japanese standard for hydrogen fueling infrastructure and for Fuel Cell Vehicle, & international standard b- R&D related to low cost components and system for hydrogen station and Fuel Cell Vehicles c- R&D related to basic safety equipment for hydrogen station d- Research and survey related to Hydrogen and International Organization: Politics / Market / R&D The 2017 report summarizes the progress for each R&D topic above (in Japanese): http://www.nedo.go.jp/content/100863728.pdf

NEDO Funding – Energy Storage

The research funding topics in the field of Energy Storage are the following:

- R&D related to evaluation of advanced and revolutionary battery material[141] - Call no. P13007 - budgets:
    - 2013: 306 million JPY,
    - 2014: 524 million JPY,
    - 2015: 600 million JPY,
    - 2016: 500 million JPY,
    - 2017: 370 million JPY)
- Fundamental R&D related to expansion of revolutionary battery type[142] - Call no. P16001 – budgets:
    - 2016: 3580 million JPY,
    - 2017: 3100 million JPY,
    - 2018: 3100 million JPY

Tender documents China

List of research topics of the following calls for proposals:

- New Energy Vehicle Call - 2017
- Integrated Transportation and Intelligent Transportation – proposed call 2018

[140] http://www.nedo.go.jp/activities/ZZJP_100061.html (information in Japanese)
[141] http://www.nedo.go.jp/activities/ZZJP_100064.html (information in Japanese)
[142] http://www.nedo.go.jp/activities/ZZJP_100121.html (information in Japanese)

- Integrated Transportation and Intelligent Transportation – proposed call 2018

China's NKP research topics – New Energy Vehicles 2017:

1. **Power battery and battery management system**
    a. High-safety and high-energy-density lithium ion battery technology (major common key technologies)
    b. Power battery system technology (major common key technologies)
    c. High-power-density power battery technology with a long life (major common key technologies)
2. **Motor drive and power electronics assembly**
    a. Development and industrialization of semiconductor motor and controller with wide band gap (major common key technologies)
    b. Technology and industrialization of efficient, lightweight and cost-effective motor (major common key technologies)
3. **Electric vehicle intelligence technology**
    a. Research and development of electronic and electric framework of smart electric vehicles (basic frontiers)
    b. Electric autopilot vehicle technology (major common key technologies)
4. **Fuel cell power system**
    a. Study on process modelling simulation of electric reactor, status observation and life evaluation method (basic frontiers)
    b. Research and development of fuel cell engine with high power density (major common key technologies)
    c. Research and development of long-life fuel cell engines (major common key technologies)
    d. Research and development of rapid dynamic response fuel cell engines (major common key technologies)
    e. Sino-German international technology cooperation of fuel cell vehicles (demonstration and application)

5. **Plug-in/extended-range hybrid power system**
    a. Development and vehicle integration of new cost-effective hybrid power assembly for passenger cars (major common key technologies)
    b. Hybrid power performance optimization of mainstream plug-in passenger car model (major common key technologies)
    c. Development of hybrid power engines (major common key technologies)
    d. Development and research of hybrid power system for super energy-saving heavy-duty trucks (major common key technologies)
6. **Pure electric power system**
    a. Development of distributed pure electric car chassis (major common key technologies)
    b. Development of pure electric car chassis and whole vehicle with high performance and low energy consumption (major common key technologies)
    c. Power platform technology for pure electric bus (major common key technologies)

China's NKP research topics – Integrated Transportation and Intelligent Transportation – 2018

1. **Maintenance and enhancement of service capacity in traffic infrastructure**
    a. Intelligent simulation of service performance for road infrastructure (basic research)
    b. Intelligent perception theory and method of road infrastructure (basic research)
2. **Intelligent online monitoring and early warning of major traffic infrastructure**
    a. Intelligent online monitoring and early warning of road facility status (major common key technology)
    b. Intelligent monitoring & early warning and information service of inland waterway facilities (major common key technologies)
3. **Coupling characteristics and group intelligent control of traffic elements in synergy environment**
    a. Coupling mechanism and collaborative optimization method of vehicle infrastructure cooperative system elements (basic research)
    b. Intelligent control theory and test verification of vehicle groups in vehicle infrastructure cooperative environment (basic research)
4. **Intelligent Internet-of-vehicle control system**
    a. Large-scale networked vehicle collaborative service platform (major common key technologies)
5. **Integration and demonstration of collaborative intelligent vehicle infrastructure system**
    a. Test evaluation and demonstration application of intelligent vehicle infrastructure system under closed and semi-open conditions (application demonstration)
6. **Supply and demand balance and dynamic coordination of multi-mode traffic system**
    a. Supply and demand balance mechanism and simulation system of urban multi-mode transportation (basic research)
7. **Intelligent collaborative control and service of urban traffic system**
    a. Key technology and system integration for cooperative control of urban multimode traffic system (major common key technologies)
8. **Data intelligent integration and demonstration for urban traffic management**
    a. Intelligent computing platform for urban traffic big data (application demonstration)
9. **Synergetic operation of large-scale traffic hub**
    a. Key technology and demonstration application of efficient operation and intelligent services for integrated passenger transportation hub (application demonstration)
10. **Intelligent passenger transportation system of urban agglomerations**
    a. Key technology for integrated operation of multimode passenger transportation hub in Beijing-Tianjin-Hebei urban agglomeration (major common key technologies)
11. **Efficient freight transportation and intelligent logistics system**
    a. Key technology for smart logistics management and intelligent services (major common key technologies)
12. **Shipping safety and emergency search and rescue based on ship/shore cooperation**
    a. Key technology for ship intelligent navigation and control based on ship/shore cooperation (major common key technologies)

13. **Synergetic prevention and control of regional traffic and urban safety**
    a. Traffic and security synergetic control system in Winter Olympic Games (application demonstration)

China's NKP research topics – Key Technology and Demonstration of Internet of Things & Smart Cities (2018):

1. **Intelligent Technology and Intelligent Terminals**
    a. Intelligent perception terminal platform system and application verification of the Internet of Things (Common key technology and application demonstration)
    b. Research and standardization of IoT terminal evaluation platform key technology (common key technology and application demonstration)
2. **IoT Ubiquitous Access Technology and Integration System**
    a. Research and simulation demonstration of key technologies for Internet platform architecture of application-driven heterogeneous IoT system (common key technology and application demonstration)
    b. IoT intelligent open service operation supporting system (common key technology and application demonstration)
3. **Urban Modelling Technology and Dynamic Cognitive System**
    a. Urban multi-scale comprehensive perception technology and system (common key technology and application demonstration)
    b. Urban space acquisition, modelling and virtual-reality integration dynamic simulation system (common key technology and application demonstration)
4. **Urban Comprehensive Decision-making Technology and Intelligent Service Platform**
    a. Research on the basic theory and key technologies of situation identification and service calculation in Smart Cities (common key technology and application demonstration)
    b. Study and demonstration of key technologies for comprehensive operation monitoring of urban underground infrastructure (common key technology & application demonstration)
    c. Study and application demonstration of service integration and governance technology for mega cities (common key technology and application demonstration)
5. **Urban Trust Integration Technology and Support System**
    a. Development and application of key technologies for smart city information - logistics integration (common key technology)
    b. New smart city technology standard system and standard service platform (common key technology and application demonstration)
    c. Evaluation platform of new-style smart cities (common key technology and application demonstration)