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TER4RAIL
Deliverable 2.2
Review of the state of progress of roadmaps

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Content

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1. Executive Summary

The need for a higher share of railways in the European mobility is self-evident when considering the increasing pressure European institution place on the transport sector to maintain high mobility levels while reducing the burden on the environment vis a vis GHG emissions.

In the context of ERRAC 2050 vision, Task 2.2 aims at supporting TER4RAIL in providing a comprehensive vision of the strategic planning of the rail sector by a review of the key roadmaps. This document aims at providing an explanatory framework with the chronological development of transport roadmaps, including a detailed review of the most relevant roadmaps published. Furthermore, Task 2.2 aims at identifying relevant gaps in the roadmaps, which are impeding the achievement of ERRAC vision of railway as the backbone of sustainable European mobility.

Task 2.2 developed and followed a thorough methodology articulated in three steps and characterised by data collection and data analysis.

Firstly, the research focused on data collection from transport experts through interviews, the Delphi study carried out in Task 2.1, the World Café activity and group discussions. In parallel with the data collection, the research carried out an analysis of the roadmaps published by the ETPs. The roadmaps were collected and monitored to create a database containing the keywords with higher frequency. Lastly, the research identified the nature of the gaps by using the database as a filter for the data resulting from the interaction with transport experts.

As a result, the research clustered the identified gaps in the following four areas:

- **Railway users.** The ETPs underestimate users individual needs, while their roadmaps fail to adopt and understand the needs and habits of the prospective users. The lack of a user centredness approach, together with the lack of inclusion of mobile apps and of adequate service quality policy are acting as inhibitors to the sector shift from a "production culture" to a "service culture" which is currently driving the market.
- **Policymakers.** The analysis of roadmaps suggests the long-term vision for the rail sector is often not supported by the necessary actions, due to lack of short-term benefits for the policymakers. The current roadmaps do not stress adequately the needs for political support in the development of connectivity, infrastructure and hard technologies.
- **Multi-modal approach.** The multi-modal approach is heavily included in rail-based roadmaps, while other transport sectors fail to adopt such vision. However, the role of exponential technologies and specific safety and security measures in providing an effective multi-modal approach is often overlooked in the current roadmaps.
- **On-demand mobility.** The roadmaps do not stress the importance of on-demand mobility services in boosting public transportation. However, on-demand mobility affects the everyday life of European citizens, thanks to new technologies able to assist the end-user by supporting the phases of booking, trip planning and connectivity. Although the role of technology is also expected to be central in the multimodal approach and in the context of railways users, it is rarely mentioned in the current roadmaps.

Each area presents recommendations to improve the status quo and thus achieve the ERRAC vision. In particular, it is recommended to integrate the perspective of social-oriented aspects into

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the roadmaps to be able to understand which barriers prevent the modal shift to rail. Similarly, a stronger and sustained government involvement might be able to overcome the difficulties in adopting a long-term vision. Furthermore, this research stresses the importance of including the rail sector and the multi-modal approach in other transport sectors, which are currently not incorporating rail in their research priorities. Lastly, the enhancement of on-demand mobility services, currently lacking, might be able to support declining public transportation in rural areas.

In conclusion, despite the analysed roadmaps belonging to the state of the art, the identification of certain gaps must be seen as a valuable finding for the transport sector. This task shows which obstacles rail has to overcome to become the sustainable backbone of an energy-efficient transport chain for both passengers and freight. Within the context of sustainable mobility, rail has the chance to provide an integrated and efficient transport system. A sustained modal shift to rail will also act as a major driver for de-carbonisation of the transport sector, meeting the objective of the Green Deal without sacrificing the European mobility levels.

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2. Abbreviations and acronyms

Abbreviation / Acronyms	Description
ACARE	Advisory Council for Aviation Research and Innovation in Europe
ALICE	Alliance for Logistics Innovation through Collaboration
APMO	Average Percent of Majority Opinion
DG MOVE	Directorate-General for Mobility and Transport
EPoSS	European Technology Platform on Smart Systems Integration
ERRAC	European Rail Research Advisory Council
ERTRAC	European Road Transport Research Advisory Council
ETIP SNET	European Technology & Innovation Platforms Smart Networks for Energy Transition
ETP	European Technology Platforms
GHG	Greenhouse Gases
ICT	Information and Communications Technology
MAAS	Mobility as a Service
PAG	Permanent Advisory Group
S2R JU	Shift 2 Rail Joint Undertaking
STRIA	Strategic Transport Research and Innovation Agenda
UIC	International Union of Railways
UIC RICG	International Union of Railways Research and Innovation Coordination group
WP	Work Package

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3. Background

The rise of global temperature is a highly relevant issue with profound effects on every aspect of society. However, the transport sector is a key factor in relation to global warming.

The TER4RAIL project Work Package 2 Task 2 (WP2.2), partly addresses the question regarding how rail can play a role in reducing global warming, limit rising global temperature and ensure a liveable environment for the next generations. Before diving further into the specifics of the research as done in WP2.2, this chapter will introduce the overall context within which this work package, as well as the entire TER4RAIL project, assume high relevance. The present document constitutes the Deliverable of WP2 Task 2.2. "Review of the European transport roadmaps". It contributes as well to Task 2.3 and Task 2.4. WP 2 is part of the grant Number 826055 IP/ITD/CCA[1].

The scientific community is predominantly united in considering the current trend of rising temperature as a result of human activities (NASA, 2020). Greenhouse gases (GHG) are the highest in history, thus leading to a greenhouse effect which warms the planet's surface above its natural temperature (IPCC, 2014; National Geographic, 2019). In 2019, the United Nations Environment Program (UNEP) published the Environment Emissions Gap Report, with the important unwelcoming notice that "countries collectively failed to stop the increase in greenhouse gases, meaning that deeper and faster cuts are now required" to achieve the net-zero emissions by 2050 (United Nations Environment Programme, 2019).

Despite the scientific warnings and political commitments, GHG emissions continued to rise by 1,5% per year during the last decade (United Nations Environment Programme, 2019).

As Figure 1 shows, the current policy scenario still is expected to lead to a considerable different outcome than the one expected by the international policy commitment vis a vis the GHG reduction to limit the increase of 1.5°C (United Nations Environment Programme, 2019). As the 2030 scenario shows, a significant change in approach and policy is needed.

[1] *IP* means any of the Innovation Programmes listed in Article 1(3) of the Shift2Rail Joint Undertaking Statutes, Annex I to the Council Regulation (EU) No 642/2014 of 16 June 2014 ('Shift2Rail JU Regulation') (OJ L 177, 17.6.2014, p. 9).
ITD means any of the Integrated Technology Demonstrators described in the Master Plan as adopted by the Shift2Rail Joint Undertaking Governing Board Decision no3/2014.
CCA means actions with relevance across several IPs and/or ITDs and requiring coordination and management across the IPs and/or ITDs for the optimal delivery of the overall objectives of Shift2Rail Joint Undertaking.

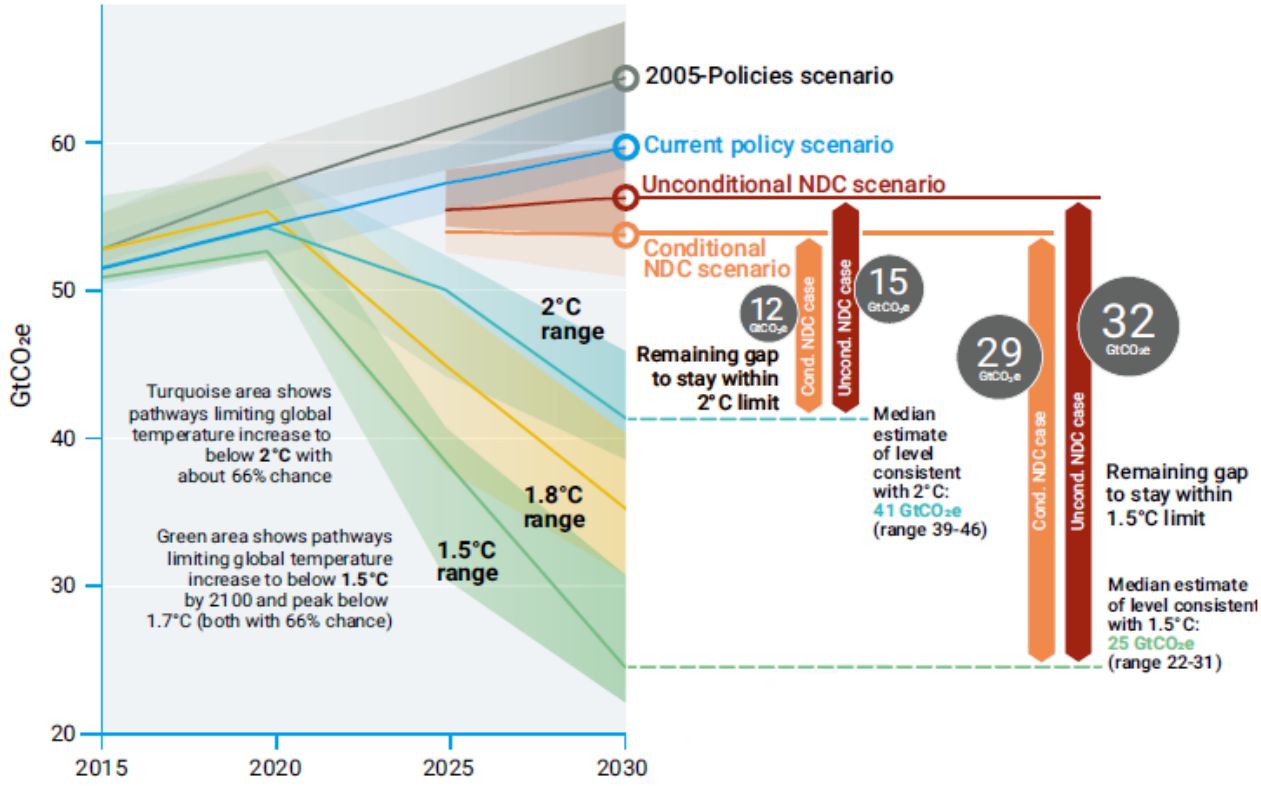

Fig. 1: Expected °C variation according to policy scenarios. Source: United Nations Environment Programme, 2019

In this context, European authorities are struggling to provide sustainable, satisfactory and affordable mobility. The high urbanisation levels of the Union increase the congestion in cities, while commuting distances and commuting times are growing EU-wide. Both the longer commuting distance and the longer time to commute increase the level of GHG emissions, in the first case, because of the distance and in the second because of traffic jam. Furthermore, the transport sector is characterised by a growing demand for cheaper, faster, longer and more frequent and comfortable passenger transport solutions when it comes to medium and long-distance mobility.

These demands are also matched by request for similar approaches to freight transports and logistics. Under these circumstances, and considering the current transport modal share, it seems difficult to satisfy the growing demand for transports while remaining environmentally friendly.

Within the context of the climate emergency, in 2019 the European parliaments presented the Green Deal to tackle GHG emission. (The European Commission, 2019; Timmermans et al., 2019).

The importance of transport in the EU global share of GHG emission is, in fact, highlighted by the fourth key political area[2] of the Green Deal, sustainable mobility (European Commission, 2019). In particular, the relevance of sustainable mobility for the Green Deal is striking when considering

[2] The seven political areas are: 1) clean energy, 2) sustainable industry, 3) building and renovation, 4) *sustainable mobility*, 5) biodiversity, 6) from farm to fork, 7) eliminating pollution.

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the transport sector is the first source of CO2 in Europe, with a total share amongst the other sectors of 27% (European Federation for Transport and Environment AISBL, 2018).

The fact that sustainable mobility is referred to in one of the Green Deal seven political areas highlights the significance of this sector in tackling climate change and the need for a profound change. If on one side it is now considered necessary to tackle GHG emissions resulting from the transport sector, on the other side the level of mobility reached by EU citizens and goods has to be safeguarded as mobility is one of the driving forces of European sustainable prosperity (Federal Ministry of Transport and Digital Infrastructure, BMVI, 2019).

The European institutions are acknowledging the role of railways in finding the balance between maintaining high mobility levels and reducing the burden on the environment. In this sense, the European Green Deal published by the European Commission agreed on establishing the year 2021 as the European Year of Rail, which is seen as the leader in sustainable transport in Europe. The decision of establishing the European Year of Rail highlights the three major values of railways over the other transport sectors:

1. Rail is sustainable by producing only 0,5% of the GHG emissions in transport (EU-28, 2017);
2. Rail connects people by having 217.000 km railways in Europe, compared to the 202.000 km in The United States, the 127.000 km in China or the 87.000 km in Russia (European Commission Directorate-General for Mobility and Transport, 2019);
3. Rail is one of the safest transport modes by having only a 0,1 fatalities per billion passengers per kilometre in the period 2011 – 2015, compared to the 2,7 fatalities amongst car occupants (The European Commission, 2020).

In order to tackle the challenges of the European transport sector in the next decades, the European Technology Platforms (ETPs) have developed industry-focused strategic research and innovation agendas with the aim of providing technological roadmaps and operational plans. These platforms support and assist the implementation of the European Union Program for research Horizon2020. The five ETPs related to the transport sectors are: ACARE, focusing on the aviation sector; ALICE, focusing on logistics; ERRAC, focusing on the rail sector; ERTRAC, focusing on the road transport sector; and Waterborne, focusing on the maritime transport. ERRAC, in particular, proved to be a prominent stakeholder in guiding the agenda of the European Commission, pushing forward the vision of rail as the backbone of intermodal chains providing Mobility as a Service (MAAS) for passengers and Delivery as a Service for goods.

The relevance of the roadmap "Rail 2050 Vision" (ERRAC, 2017) lies on its role as a blueprint to establish a Single European Railways Area. Recently, the roadmap was followed by the ERRAC 2030 Research and Innovation priorities in September 2019.

The production of roadmaps is an integral step towards the creation and delivery of strategies and innovation in the transport sectors. The ETPs research roadmaps provide a flexible planning technique to drive strategic and long-range technological advancements, by matching short-term, medium-term, and long-term goals. The relevance of commonly agreed vision for the entire sector is extremely high, as it identifies specific technological solutions and indicates the research and resource priorities. At the same time, each roadmap does not only focus on the sectors from which

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it is originated, but it also delivers objectives such as stronger alignment and dialogue between and across sectors.

In WP 2.2, the research takes a closer look at the research roadmap published by the ETPs and analyses them with the inclusion of transport experts feedbacks, to understand in which fields the roadmaps can be improved and how. In the context of the challenges that the European transport sector is facing and will face in the future, such as demands for decarbonisation, higher frequency and capacity and lower costs of mobility services, this task is characterised by a sense of urgency and is deeply intertwined with the effects of the Green Deal on sustainable mobility. Furthermore, this WP enhances the networking and clustering of Europe's research and innovation capacities. It promotes the European commitment to research and technological development, with the double aim to ensuring that the Union remains an attractive region for researchers, and to boost the global competitiveness of its transport industries.

4. Objective

TER4RAIL relies upon the identification of railway as the backbone of the future European mobility formulated by the ERRAC Rail 2050 Vision, published in December 2017. TER4RAIL aims at raising arguments that can sustain ERRAC position, by understanding where research and development need to focus within the European rail sector to fully exploit any novel innovation.

In the context of WP2 supporting the aforementioned goal, Task 2.2 is characterised by the overarching objective of providing a comprehensive vision of the strategic planning of the rail sector through a review of the key roadmaps.

To reach this goal, Task 2.2 aims at providing an explanatory framework with the chronological development of transport roadmaps, including a detailed review of the most relevant roadmaps published.

At the same time, Task 2.2 aims at identifying relevant gaps in the roadmaps which are impeding the achievement of ERRAC vision of railway as the backbone of sustainable European mobility, thus improving the quality of the transport sector strategic planning. As such, Task 2.2 aims at addressing the question "What are the gaps in the current EU mobility roadmaps that need to be bridged for promoting rail as being the backbone of European mobility?"

5. Methodology

The work of TER4RAIL involves reviewing and supporting the progression of roadmaps' and identifying the relevant gaps for the next major phase of the revision. This work is done through desktop research, interviews with major stakeholders at TER4RAIL events, webinars to present the research and also by seeking updates from the invited experts from both internal and external sectors. As the relationship between the rail sector and other various transport modes is fundamental, the verification of the state of the roadmaps together with experts from various European Technology Platforms (ETPs), Shift2Rail Joint Undertaking (S2R JU), the European Commission and the European Rail Research Advisory Council (ERRAC) is of paramount importance.

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Task 2.2 developed and subsequently followed a thorough methodology to achieve the objectives mentioned above.

As this task aims at identifying the gaps in the EU mobility roadmaps that prevent the establishment of rail as the backbone of European mobility, the focus of the TER4RAIL project in this instance has been on the inclusion of selected transport experts to the study to review the ERRAC vision and emphasise the research topics which are still needed to achieve such vision.

In particular, the methodology employed from Task 2.2 consists of opinion-extracting tools, desk research and trends' analysis.

The methodology behind Task 2.2 is composed of two elements: data collection and data analysis.

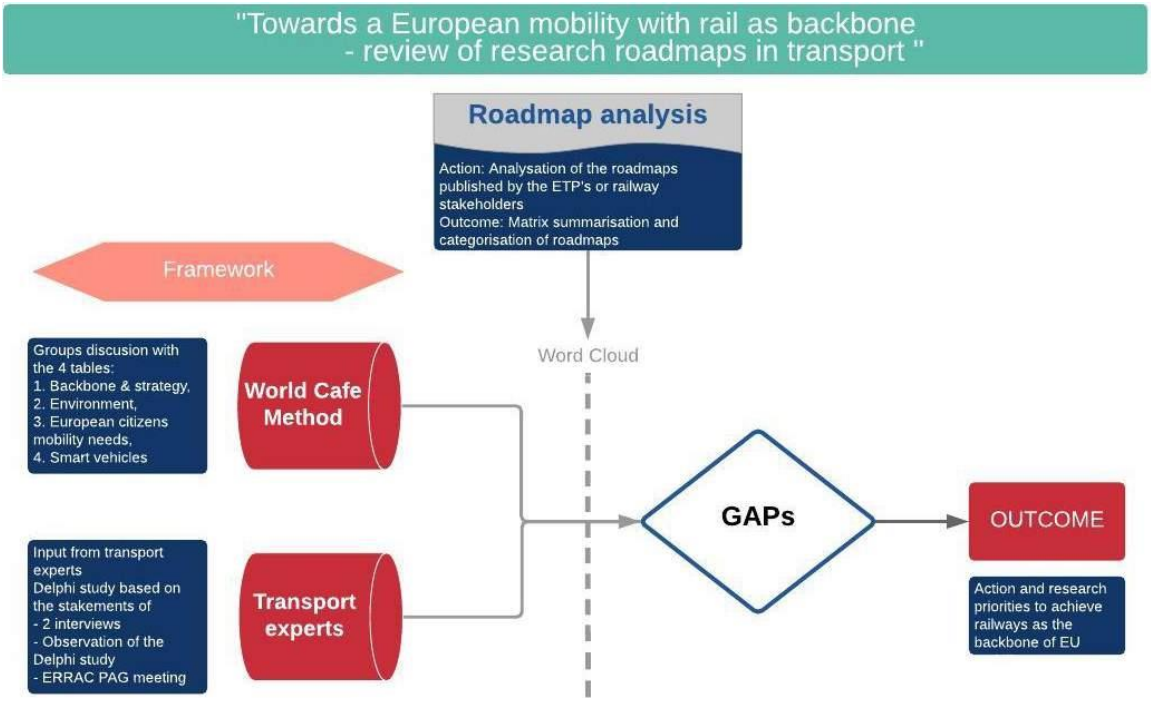

Fig. 2: Methodology of Task 2.2

Data from transport experts have been collected from three different sources and in different steps.

Firstly, the research carried out two separate interviews with two transport experts to include cross-sectoral innovation processes to the research question.

Secondly, data was collected from the Delphi study issued with the aim of verifying rail statement based on the RAIL 2050 vision of ERRAC.

Thirdly, data was gathered by employing the World Café Method. Task 2.2 utilise data collected through one World Café activity held in London on 26 June 2019 with focus on the themes of "Rail as backbone and systems strategy", "environment", "European citizens mobility needs" and "smart vehicles". The advantage of the World Café Method lies in the possibilities of creating a system thinking approach and cross-sectoral inputs.

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Lastly, the research applies data from the group discussions held at the ERRAC PAG meeting of November 2019.

In parallel with the data collection, the research carried out an analysis of the roadmaps published by the European Technology Platforms. The roadmaps were collected and monitored to scale and prioritise keywords of the transport sectors. The roadmap analysis provided a database and a word cloud of the keywords with a higher frequency throughout the roadmaps.

Lastly, the research undertook an analysis to identify the nature of the gaps by using the word cloud – based on the roadmap analysis – as a filter for the data resulting from the interaction with transport experts. This last step provided the research with an indication of the gaps in the European research agenda and allowed to identify emerging gaps that affect future research steps aiming at establishing railway as the backbone for European mobility.

In Task 2.2, the following partner of the TER4RAIL project are involved; EURNEX (1), NEWOPERA (0.5), FFE (0.5).

5.1 Data collection – Interviews

The first step of the research employed two interviews with two transport experts with the aim of including cross-sectoral innovation processes to the research question. The interviews have been carried out as part of the state-of-the-art research activities within the Drive2theFuture European project. The research results from this project have been included in Task 2.2 with the purpose to include considerations over the bottlenecks that transport is facing and over the blind spots of rolling out innovations on a larger scale.

The selected experts were Dr Niels van Oort from the Technical University of Delft, the Netherlands, and Prof Christian Hoffmann, from the Technical University of Berlin, Germany.

5.2 Data collection – Delphi Study

Task 2.1 conducted a Delphi study to evaluate the assumptions and state-of-the-art underlying the current roadmaps to provide core evidence-based updates for the subsequent round of road mapping.

Task 2.2 employed such study to extract data relevant to its analysis of roadmaps.

The Delphi technique can be employed in both quantitative and qualitative research and has been selected as it represents a technique to collect, aggregate and analyse the informed judgements of a panel of experts on previously identified issues. This technique has also been selected as it provides unbiased input, as negative effects of group dynamics and peer pressure are avoided, and allow to achieve consensus on some formerly recognised issues.

Stable consensus in the research is measured through the formula of Average Percent of Majority Opinion (APMO):

$$\text{APMO} = \frac{\text{Aggregate of Majority Agreement} + \text{Aggregate of Majority Disagreements}}{\text{Total Opinion Expressed}} \times 100$$

In the Delphi study, European transport experts aware of ERRAC vision were asked to fill in their opinion on 20 statements in order to determine whether a consensus has been achieved.

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5.3 Data collection – World Café Method

On 26 June 2019, the World Café activity has been carried out with a total of 21 participants hosted by the Newcastle University in London, United Kingdom. The activity allowed a discussion addressing different mobility questions amongst the cross-sector transport experts participants and functioned as a validation for the initial findings of the Delphi study.

The activity was structured in a way to allow the participants to exploit their creative and engaging mindset while reviewing the discussion with a 360 degrees approach (Brown and Isaacs, 2007).

To guide the World Café, the following abstract provided guidance throughout the event:

"World Café for working together on a European multimodal transport with railways as the backbone of mobility. Having a sustainable, inclusive, affordable, approachable alternative for the near future".

The one-day process included rounds of an in-depth discussion in the four topics – based on the document "Rail 2050 Vision" by ERRAC – of "Rail as backbone and systems strategy", "Environment", "European citizens mobility needs" and "Smart vehicles".

To navigate the groups and stimulate the discussion, the following questions were designed in advance.

Table	**Discussion**	**Questions**
Table 1 - Backbone and systems strategy	Rail in Europe in 2050 is the backbone of urban mobility, with intelligent stations at the heart of smart cities, being life-centric places to work, meet and communicate.	• What question, if answered, could make the greatest difference in achieving this vision? • What is missing from our understanding of rail and transport in Europe, where do we need more clarity or insight? Is this vision valid? • On what research aspects do we need more clarity or insight?
Table 2 - Environment	By 2050 European railways are a core part of any smart city planning, mobility management systems, and city fulfilment and delivery services, promoting interconnection by freeing up land which was previously needed by private road vehicles and minimising pollution and congestion	• What is the intention here? What is the deeper purpose that is worthy of our effort? • Is railways use more important than road to fight climate change while being able to satisfy mobility needs? • How can we highlight the benefits for spatial planning, lifestyle and general standards of living? • If we were guaranteed success, what

		would we do to achieve this vision?
Table 3 - European citizens mobility needs	The European rail system in 2050 is able to detect, understand and respond to individual and collective European citizens mobility needs, delivering tailored, on-demand, integrated end-to-end mobility solutions to which the rail system is a prime contributor, integrating seamlessly with all other available transport modes in an easy and friendly way	• What opportunities can we see if this vision is achieved? • What has been your major learning or insight here? • What's possible here, and who cares about it? • If we started a conversation today that could ripple out in a way that created new possibilities for this vision, who would be having it, and what would they be discussing?
Table 4 - Smart vehicles	A European rail network of fully- smart vehicles that may be self- regulating by 2050 in traffic, negotiating vehicle-to-vehicle and vehicle-to-X to determine movement priority and resolve potential conflicts at junctions in the network and reacting to unexpected situations.	• What is missing from our understanding of how or if we can achieve this vision? • What assumptions do we need to test or challenge about this vision? What needs our immediate attention going forward? • Are there mistakes we could make now that could jeopardise this vision

Table 1: Composition of the World Café activity

The objective of the World Café method is to create an understanding of system thinking. This research tool presents a holistic approach and is able to produce discussion statements that the participants can place in a larger context. This method has been employed in the TER4RAIL project to design and create an open group discussion involving cross-sector transport experts. The structure of the method tool provides awareness on the kind of conditions appeared during the discussion that the mobility sector is facing.

The participants have been involved through all the project members of the Ter4Rail project. The resulting participants' group was diverse and thus generated optimum results for a World Café session. The presence of diverse interdisciplinary backgrounds is not only considered an essential factor in the design of the World Café Method, but it is also identified as the trigger that allows an essential outcome of the group discussions in contrast to the cross-disciplinary group (Heimerl et al., 2014). Appendix A provides the list of participants' professions and the country of their employers.

During the group discussion, the four tables were based on the most unstable statements from the Delphi study in round one (see WP2, Task 1). In smaller groups, the participants explored how contextual factors as key social, economic, political, and cultural factors influence the society-

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related topic, in relation to railways. With these ingredients, the participants were expected to create innovative collaborations that open new views on the presented statements.

5.4 Data collection – ERRAC PAG

The four outstanding statements of the Delphi study and the results of the World Café activity have been presented at the ERRAC Permanent Advisory Group (PAG) meeting held on 28 November 2019 in Brussels, Belgium.

This step has been undertaken with the object of collecting the opinion of the members of the Group on the "unstable" statement and the research as a whole. The inclusion of the Group members' opinion allowed the research to highlight more effectively towards which direction the trend resulting from the analysis of roadmaps will lead railways. At the same time, the inclusion of this third step allowed the research to validate the results from the World Café activity, including insights that might have been overlooked and revaluating the extracted data.

5.5 Analysis of the roadmaps

The importance of analysing roadmaps derive directly from the importance of research roadmaps in the context of research activities carried out within the EU.

Research roadmaps are a flexible technique to drive strategic and long-range technological planning. This object of roadmaps implies that the medium-term and long-term goals will be matched with a commonly agreed holistic vision that includes specific technological solutions. Road-mapping is a powerful technique that has become integral to the creation and delivery of strategies and innovation in numerous sectors. Similarly, the transport sector has development goals that can only be achieved with a long-term proposal, planning and budget. The construction and improvements in infrastructure, as well as research and development activities, are multi-year projects, where roadmaps are a supportive political tool.

Furthermore, roadmaps can be a powerful tool in delivering dialogue and alignment of projects within one sector and across sectors, such as road-rail, air-rail, and so on. In Task 2.2, the research analyses the research roadmap published by the ETPs to compare them with the vision of the transport experts.

The main goal of the roadmap analysis is to provide a strategic plan which defines a goal or desired outcome and includes the major steps or milestones needed to reach the goal of the project. It also helps to articulate the strategic method behind both the goal and the plan for its execution.

Following the data collection, the research focused on the analysis of the roadmaps published by the European Technology Platforms and key stakeholders.

As the quality and vision of the roadmaps depend on the publisher and its interests, the research selected publications from research institutes with profound knowledge of the sector and different interests to provide a detailed and robust analysis on the roadmaps. As such, the TER4RAIL project selected the following ETPs or stakeholders.

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ETP or railways stakeholder	Full name	ETP or Stakeholder	Scope
ERRAC	European Rail Research Advisory Council	Stakeholder	Representing the railway industry, therefore, creating innovative roadmaps for EU mobility.
ERTRAC	ERTRAC Working Group: Joint ERTRAC-ERRAC-ALICE	Stakeholder	Pushing forward the car industry forward. Electrification and optimisation of truck transportation.
ERTRAC, EPoSS and ETIP SNET	European Road Transport Research Advisory Council	Stakeholder	Improving mobility in urban areas, energy and resource efficiency, decarbonisation and air quality. Developing an efficient and resilient road transport system.
Waterborne	Waterborne Technology Platform	ETP	Transforming shipping into clean, green, safe, secure and cyber resilient. Maintaining leadership in competitive and production, blue and circular.
ACARE	Advisory Council for Aviation Research and Innovation in Europe	ETP	Protecting the environment and the energy supply which helps in ensuring safety and security. Prioritising research, testing capability and education.
ALICE	Alliance for Logistics Innovation through Collaboration	ETP	Enhanching transport chain design and operations for Synchro modality by Deploying ICT as integrating technology.
S2R JU	Shift2Rail European rail initiative research and innovation	Stakeholder	Delivering, through railway research and innovation, the capabilities to bring about the most sustainable, cost-efficient, high-performing, time driven, digital and competitive customer-centred transport mode for Europe

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STRIA	Strategic Transport Research and Innovation Agenda	ETP	Focusing on active management of automated technologies and innovative hybrid vehicles by integrating big data, automation and connectivity.
UIC	The International Union of Railways	Stakeholder	Involved in making Railway practices sustainable as reasonably practical. Open and attractive for innovation and talent Outward-looking with global horizons
UIC - RICG	International Union of Railways – Research and Innovation Coordination group	Stakeholder	Involved in making Railway practices sustainable as reasonably practical. Open and attractive for innovation and talent Outward-looking with global horizons
DG MOVE	Directorate-General for Mobility and Transport	Stakeholder	Focusing on suboptimal market functioning, infrastructure deficiencies, low emission mobilities and negative externalities.

Table 2: List of selected ETPs or stakeholders

Through monitoring the publications, the research was able to collect the common thread of the outstanding research and monitor the development of their long-term planning. To be suitable for the research, the roadmaps had to follow four specific criteria: the documents were not older than six years (i); the documents have been published by either a key entity (association) of the European transport sector (water, road, air and rail) or by a European Technology Platform (ETP) acknowledged by the European Commission (ii); the documents have been labelled as a roadmap or describe a vision of the long-term perspective of Europe's mobility (iii); the review documents have been published up to week 12 of the TER4RAIL project (iv).

The 11 chosen documents are outlined in the following table.

Title of the document	**Sector**	**Stakeholder**	**Full name of the Stakeholder**	**Year**
Rail the Backbone of Europe mobility, Vision 2050	Rail	ERRAC	European Rail Research Advisory Council	2017
Integrated Urban Mobility Roadmap	Rail, Road, Air, Water	ERRAC	ERTRAC Working Group: Joint ERTRAC-ERRAC-ALICE	2017
European Roadmap	Road	ERTRAC,	European Road Transport Research	2017

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Electrification of Road Transport		EPoSS and ETIP SNET	Advisory Council	
The Maritime Future: an Ocean of Opportunities for Europe	Water	Waterborne	Waterborne Technology Platform	2018
Strategic research and innovation agenda, Flight plan for 2050	Air	ACARE	Advisory Council for Aviation Research and Innovation in Europe	2017
Corridors, Hubs and Synchromodality, research and Innovation Roadmap	Cross-modal	ALICE	Alliance for Logistics Innovation through Collaboration	2016
Multi- Annual Action Plan, part A	Rail	S2R JU	Shift2Rail European rail initiative research 2018 and innovation	2018
Roadmap on Connected and Automated Transport	Road, Rail, Waterborne	STRIA	Strategic Transport Research and Innovation Agenda	2019
Railway Technical Strategy Europe	Rail	UIC	The International Union of Railways	2019
The 12 Capabilities a presenter's guide	Rail	UIC - RICG	International Union of Railways - Research and Innovation Coordination group	2018
Transport in the European Union, Current Trends and Issues	Cross-modal	DG MOVE	Directorate-General for Mobility and Transport	2019

Table 3: List of selected documents

The roadmap analysis focused on the publications' aspects of outstanding research topics and their long-term perspectives, so to provide a holistic overview of the entire transport sector.

The analysis produced a structured database composed of relevant keywords. The parameters which led to the extraction of research roadmaps were: future development perspectives (i), decisive criteria that will influence future railway (ii), a compact description of the document's implications(iii). Appendix E presents this overview.

The process for the production of the database relies on the inclusion of bullet points summarising each roadmap into a matrix. This step allows an overview of the roadmaps by listing the five most markable keywords for each document. With this process, a total of 55 keywords are categorised based on the themes that are presented by ERRAC Vision 2050.

Lastly, the analysis produced a Word Cloud to indicate keywords with higher frequency resulting from the analysed roadmaps. The Word Cloud has been selected as the method for displaying the frequency as it is an effective visualisation tool able to present an overview of the collected data, including the specific weight of each keyword. The relevance of the keywords within the Word cloud is ranked by size, colour and position (Heimerl et al., 2014).

5.6 Analysis of the Gaps

Following the roadmap analysis, the research focused on the identification of the gaps that need to be addressed to reach ERRAC vision of rail as the backbone of European mobility.

To be able to do so, Task 2.2 employed the keywords that are displayed in the roadmaps analysis to filter the data resulting from the four phases of data collection. This technique provided the research with an indication of the gaps in the European research agenda and allowed to identify novel emerging gaps that affect future research projects aiming at establishing railway as the backbone for European mobility.

As Figure 3 shows, the process can be visualised as a funnel that filters the keywords from the different sources and distils the gaps within the ETPs research agenda. In particular, this research focuses on the underrepresented issues, as they might signal appearing gaps in the research roadmap and can induce to a stagnation of the European rail sector agenda.

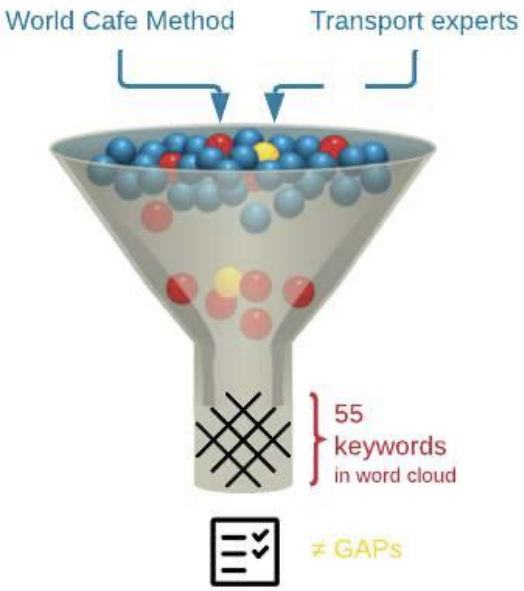

Fig. 3: Methodology in the gap detection

The output that is produced with the methodology in Task 2.2. is a robust foundation for Task 2.3 to highlight key points for the development of the guiding thread for the webinars. In the same manner, the results from this task will facilitate the identification of the possible gaps in research in Task 2.4.

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6. Results

In this task, the overall objective is to provide a comprehensive vision of the state-of-the-art of the roadmaps that addressing the future of the European railway and the results of the World Café Method. The review of the recently published roadmaps will pave the way to enhance the ongoing strategic planning of the transport sector in general and the future of railways in particular. An explanatory framework who organised the mentioned themes and trends of roadmaps will be supplied along with an output of the hierarchical relations among different roadmaps developed so far within the European framework.

This chapter presents the opinions of the experts the data and findings of the research. First, the results of the World Café Method are presented, followed by the results of the observation of the roadmaps. All the findings will be a crucial fundament for the later discussion and recommendations in Chapter 7.

The TER4RAIL project foresees that the outputs produced in this task will provide a robust foundation for Task 2.3 to highlight key points for the development of a guiding thread for the webinars. In the same manner, the results from this task will facilitate the identification of possible gaps in research in Task 2.4. In relation to the content of the work packages of TER4RAIL, the following milestone will be achieved: MS10, Review of the state of progress of roadmaps (EURNEX, M10).

6.1. Results of World Café activity

Within the World Café activity, 21 transport experts contributed interactively and mutually to the generation of valuable content. Such content was generated through a co-creation process that included the rotation of smaller groups from table to table.

Each table was characterised by a moderator who structured the discussion and used the suggestions from the transport experts to steer the conversation. At the same time, the moderator encouraged the participants to share their opinions on table posters, presented in appendix C. In this instance, the experts identified barriers, hindrances and mismatches with the unstable statements resulting from the Delphi study. The expert feedback in this context provided valuable insight for the identification of the occurring gaps and their nature.

The results of the World Café Summit have been clustered into four categories focusing on: benefits of railways, political vision, multi-modal approach, technology and infrastructure.

1. *Benefits of railways*

The experts agreed on the necessity to consider the benefits of railways in terms of cross benefits analyses, including novel parameters to the usual economic benefits. In particular, the scheme for a viable modified cross benefits analyses has been developed and detailed within the SPECTRUM project by Sicilano et al. (2016).

Furthermore, the experts agreed that not only railways are frequently underestimated but also that considerable deficits often characterise their marketing and presentation. As such, the discussion identified three key points that could promote the benefits of railways:

i. Promotion of railways and highlighting rail's green credentials and energy efficiency

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ii. Promotion of rail as a core component of the future transport network

iii. Promotion of railways' prominent role in society by achieving sustainable objectives

Lastly, the experts highlighted the need for the rail sector to be self-critical when experimenting and creating new products and services. The possibility for a self-critical attitude has been identified in the development of small pilots projects and their adaptation within small or closed ecosystems. Research activities based on these projects can provide useful and direct feedback to improve the concept behind the pilot activity and lead it to higher technical and market readiness.

2. Political vision

The mobility development, as well as the laws and regulations behind it, are important topics of discussion which appeared in multiple tables during the World Café activity. The experts were transversally aligned on the position that local and national politics strongly determine different mobility developments, and that therefore the political vision has a strong influence on this topic. The participants expressed in their opinions that a short-term vision generally characterises politicians and thus execute short-term implementation processes for railways. As such, the political understanding of mobility often develops into an obstacle for rail mobility, when it could instead be a powerful enabler. In this context, the experts reiterated the necessity for a long-term vision matched with clear project implementation for successful and suitable mobility solutions – urban or rural alike – for society.

Furthermore, the experts identified a perceived disconnection between urban and rail development. To avoid this detachment, it has been proposed that the process and its design phase should be more strongly linked and more realistic, in order to develop a suitable and reliable infrastructure.

Additionally, it was suggested that society needs to be critical of the use of space in urban areas. The experts agreed that not only transport planners should provide space for every transport mode, but they should limit the extension of urban areas in which car use is allowed to allow fair competition between transport modes. In this context, the participants underlined how negative frictions such as traffic jams, critical traffic victims or occupation of valueless public space are issues which can be resolved through the development of alternative transport modes.

Lastly, the participants introduced the concept of push and pull measurements (Kemp and Rotmans, 2004) to generate the push towards sustainable mobility. The employment of this concept has to be aware not only of the government policy and regulation but also of user adaptation and behaviour.

3. Multi-modal approach

Regarding the multi-modal approach, the experts underlined how the concept of Mobility as a Service (MAAS) needs to be a basic standard for the urban and national transport network. However, in the discussion, it appeared that there is a stagnation in collaboration of MAAS at the EU level, especially for freight transport.

In particular, the current ICT systems have been evaluated as not capable of fulfilling the need for MAAS. As examples, the lack of an independent international (freight) transport platform or

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organisation and a one-stop-shop for international ticketing, planning and transport (passengers/ freight) have been pointed out as open criticalities in achieving an EU-wide MAAS network.

Furthermore, the lack of advertising of night train services, together with a less than widespread knowledge of these operations amongst the general public, have also been highlighted as an inadequacy in support of strong national and international rail connections and as a limiting factor.

Lastly, the participants stressed the importance to identify how travel behaviour of mixed user profiles can produce cross-links between different modes. Participants recommended the use of large stream and cross-sector data to identify novel travel trends. The early identification of new trends is especially relevant as rail proved not to be flexible enough in case of peaks in the mobility network and to struggle in adapting to unique peak flows, for instance in the cases of one-time or annual events.

4. *Technology and infrastructure*

Regarding the role of technology and infrastructure in railways, the participants underlined how the sector is in need of expertise capable of understanding the consequences of adopting new technologies in railway.

Furthermore, the experts focused on the need for supplying smart cities with certain goods by dividing the bulk transport needs of well-located ports and terminal for rail freight operations or other freight modes. In particular, the participants agreed on the need for terminals seamlessly connected with other freight modes. These facilities should be developed with a top-down approach based on a long term vision.

At the same time, the participants agreed on the importance of updating the technology of the current life cycle system of the rolling stock, which has not been evaluated as sufficient. In particular, a critical issue has been highlighted in the ageing of the current rolling stock without sufficient investments in its replacement.

Moreover, the experts highlighted how the European rail network has yet to be fully utilised. To reach a higher degree of utilisation, the experts agreed upon the fact that the rail network should focus on short fast freight trains rather than large freight trains with large volume. Such an arrangement would allow these freight trains to enter the existing timetables without causing distortion to the slots available to passenger trains. However, while short fast freight trains might be compatible with timetables, it would also be interesting to assess the possible contribution of both longer, slower freight trains with higher capacity in specific cases, as well as long fast trains equipped with automatic coupler and electropneumatic brake with distributed traction.

Furthermore, shorter autonomous trains could be considered as a viable alternative to the status quo.

Lastly, the discussions identified the need for the ergonomic design of stations and interchanges as a key requirement for new infrastructure which current users are facing.

In conclusion, during the World Café activity, the participants identified several key areas within the rail sector that need to be strengthened in order to achieve ERRAC's 2050 rail vision. The experts underlined how the sector need to focus on research, as of yet the sector is characterised by a lack of knowledge or research priorities essential to understand how to achieve this vision.

The following picture represents an overview of the bullet points identified during the World Café Method, presenting the X-axis as a balance between railways and cross-sector and the Y-axis as a balance between policies and infrastructure. Green observations are extracted from round table 1, orange observations are extracted from round table 2, pink observations are extracted from round table 3, blue observations are extracted from round table 4.

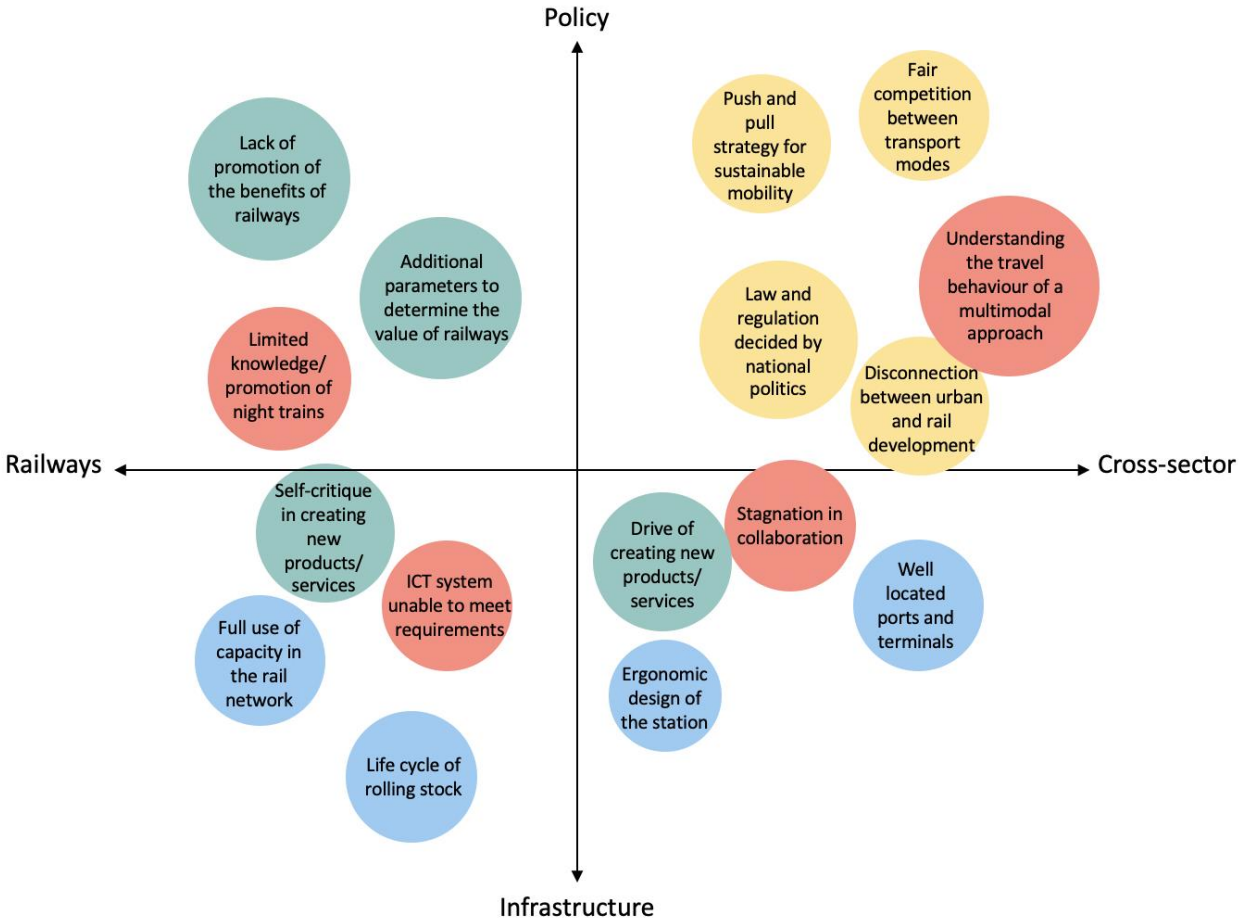

Fig. 4: Overview of the World Cafe Method.

6.2. Results of transport experts involvement

6.2.1. Interviews to transport experts

The two interviews to Dr van Oort and Prof Hoffman focused on the issues of innovation in the transport sector and the strategies on how to overcome the societal challenges presented in the Horizon 2020 program, particularly challenge 3.4 "Smart, Green and Integrated Transport" (Horizon 2020, 2014). Research and innovation activities in this context are expected to deliver focused and timely advances for all transport modes that will help achieve key Union policy objectives, while boosting economic competitiveness. This research selected eight keywords from the Horizon 2020 program which are expected to play a fundamental role in achieving Challenge 3.4: "training", "trust", "sustainability", "inclusion", "user centeredness", "human factors", "security" and "safety". The candidates for the interview choose one of the selected keywords to

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dive into and to which apply the term "innovation". Appendix B includes the data of the interview structure as their topic, potential sub-topics, solution, type of vehicle, approach, issues, issues addressed, and lessons learnt.

In his interview, Dr van Oort focused on the sustainability aspects of the innovation program. In particular, Dr van Oort discussed the topic of innovation as derivative from an approach that is applicable to the network and accessible for many of the end-users. He identified how, re-integrating bicycles and the correct mindset in public transport, it will be possible for the transport network to increase the number of daily users and greatly enlarge its target group. Furthermore, Dr van Oort identified in bicycle-based solution the key for compensating the current lack of services in the first and last-mile solution. In this context, bicycles provide an effective solution to the first and last-mile trip, thus facilitating their integration into the chain of public transport services. In this context, Dr van Oort strongly suggested employing a comprehensive and multi-modal approach to develop a truly efficient public transport network. Similarly, this approach is also expected to promote in the future to the implantation of more sustainable means of transport (Van Oort, Van der Bijl, & Verhoof, 2017).

In his interview, Prof Hoffman focused on the role of the human factor during the innovation process. In particular, Prof Hoffman stressed the importance of integrating the end-users in the design processes of the transport service to obtain the best results during the design phase. The involvement of end-users in an early stage is thought to be twofold: on one side it allows to understand and design the service to be able to adapt to their travel behaviour. On the other side, the involvement of end-users will enable a high rate of success in changing new mobility behaviour. Prof Hoffman suggested that the development of appropriate public transport infrastructure and its related services should be achieved in a participative manner by means of a co-creation process that includes the end-users such as passengers and freight operators. Another innovation process that has been mentioned is the development of a single digital platform (e.g. a mobile app) to improve the quality and user-friendliness of public transport, while ensuring the protection of user data. Furthermore, Prof Hoffman highlighted how services contracts should be signed with multiple and diverse stakeholders such as government, operators and technology companies to provide a long-term commitment for a continuous flow of data and operational support. In this context, new vehicles and applications need to be supported by robust institutions as start-ups survival chances are notably higher in a solid and predictable environment. Similarly, the trend amongst users is to privilege long-standing commitment with the services of their choice, as they generally need time to get used to the services and find out how they work best for their requirements. Prof Hoffman discussed the three main issues regarding the role of innovation processes. Firstly, the co-creation phase needs to have a high priority within the design process. This approach needs to include users participation from the early start until the moment a certain innovative solution becomes "proven technology". Secondly, the newly developed mobility services must be capable of hosting a multi channelling mobility approach, both in terms of IT support but also considering their pricing model as not affecting the sustainable choices. Public transport needs to remain the most economical choice in transportation. Thirdly, Prof Hoffman underlined how the development of any innovation is characterized by more than its mere technical implementation, but it rather concerns aspects as social acceptance and public trust. Innovation initiators in the mobility sector must be aware of this aspect.

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6.2.2. ERRAC PAG

As introduced in the methodology section, the outcomes of the discussion tables at World Cafè activity and the four unstable statements from the Delphi study have been presented at the ERRAC PAG meeting held in Brussels, Belgium, on November 28th, 2019. The inclusion of the ERRAC PAG meeting allowed the research to include the following key statements relevant to the gap analysis.
Railways' functionality must undergo a review process to assess whether it might meet contemporary requirements or if it is instead lacking the necessary capabilities to meet these novel functionalities.
Railways need to actualize their high energy efficiency as a result of proper engineering design. At the same time, it is necessary to promote the railways' low impact on the environment as higher use of rail is expected to answer emergent societal questions towards the creation of a sustainable society.
Railway operators might be critically approaching the on-demand services business model. As the costs for realizing this type of service is high, especially in the context of long-distance journeys, its implementation costs might be even higher as a result of the small number of commuters benefiting the service.
Railways must co-operate with other freight transport modes in order to be more competitive in a competing transport network. However, top-down decision, especially those of a political vision, are necessary to provide equal opportunities to each transport mode. These decisions might not only promote railways but should also increase the costs for the transportation process of other sectors, keeping into consideration ballast and occupation on infrastructure, pollution and social effects.
Appendix E includes the minutes of the ERRAC PAG meeting, which underlined these statements.

6.3. Results of roadmap analysis

The analysis of roadmaps under the context, the criteria and the statements resulting from the experts' consultation led to the production of a structured database featuring relevant keywords. Appendix E includes the full database.

The five most frequent keywords are addressed in the following table. Their high frequency underlines their influence on the political agendas behind the roadmaps production, not only considering the railway sector but also the other transport modes. Below a brief definition of the keywords is shown, together with their connection to the railway sector.

Keyword	Relation to the rail sector
Cross-sectoral and cross-disciplinary research	ETPs and stakeholders indicate with this keyword that research should learn more from other (transport) sectors. Interaction should be linked to political science and technical development to get a better understanding or exchange knowledge.

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Information management system	Software that facilitates the incoming data, storage and communication protocol. This creates a logistics platform that uses online processing to execute and optimise the physical movements in the mobility network (people or freight). In the roadmaps, the ETPs and stakeholders describe the level of integration of the information management system.
Physical transport network	This presents the integration between the transport modes. By having the aim of working on a physical transport network, all transport modes are interconnected. The digital exchange of information between the transport networks will provide information on the movements.
Safety and security	Safety and security applied to railways mean that the physical infrastructure, (stations, vehicles), the construction processes, the digital surrounding as well as the railway service must be high-end with a limited or no risk on having accidents.
Digitalisation and interconnecting rail network	Railways are capable of interconnecting with other transport modes or other sectors or services (weather forecast, events, emergency services, local government). The transport sectors are building up to big data content that can be used to increase the performance of the railways.

Table 4: Definition of the most common keywords and their connection to the railway sector

The following table includes the themes presented in the roadmaps within the context of the nine detected categories.

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Technologic solution Digitalisation Robotics Information management system Cognitive computing	**Economy** Balanced investment in infrastructure Cost efficiency reliable trains or infrastructure New business cases
Sustainable consumption Decarbonisation Alternative fuels Energy efficient	**Holistic view** Delivering the vision Long term aspects for the rail network New intelligent
Scale of transport Urban Mobility City Dynamics Connectivity Long-distance transport	**EU level** Safety and security EU innovation leader Education
Connectivity Accessibility Interconnecting rail network Physical transport network Sharing economy solutions Cross-sectoral / disciplinary research	**Policies** Trends and policies impacting User behaviour and needs
Infrastructure Electric and hydro charging stations for EV (car/train / truck/ small vehicle) in infrastructure	

Table 5: List of the themes identified within the selected roadmaps

Appendix F includes a graphic visualisation of the trends and themes resulting from the selected roadmaps.

Additionally, a set of word clouds, as indicated in Figure 5, highlights which keywords are more frequent within the analysed roadmaps. This further step allowed the research to identify the outstanding keywords.

Fig. 5: Visual representation of the most frequent keywords

6.4. Results of the gaps analysis

The comparison of the roadmap analysis with the World Café Method and the Delphi study resulted in misalignments that lead to the gaps identification. Table 6 shows the percentage of the overlap between the roadmaps and the collected data from the transport experts during the Delphi and World Café.

Data	Remark	Mentioned in the roadmaps
Delphi study	1. EU rail sector should anticipate individual citizen's needs	**2%**
	1. EU rail sector should anticipate collective citizen's needs	**7%**
	2. EU rail sector should provide tailored, on-demand mobility solutions	**13%**
	3. EU rail sector should be seamless integrated with other transport modes	**29%**
World Café Method	1. Benefits for Railways: Promote that railways have green credentials	**7%**
	1. Benefits for Railways: Promote that railways are core part of the mobility network	**11%**
	1. Benefits for Railways: Promote that railways are the core for achieving sustainable development	**11%**
	2. Political vision: Disconnection between urban and rail development	**2%**
	2. Political vision: Balance between push and pull measurement for creating the modal shift	**15%**
	3. Multi modal approach: MaaS	**35%**
	3. Multi modal approach: Integrated ICT system	**42%**

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Table 6: Percentage of the overlap between roadmaps and the collected data

As a result of the aforementioned observations, the gaps are clustered into four areas: 1) railway users, 2) policymakers, 3) multi-modal approach, 4) on-demand mobility.

Gap 1: Railway users

Users needs are not sufficiently taken into account in the roadmaps, especially in those considering rail. In fact, aspects like user acceptation and integration play an important role in the roadmaps focusing on other transport modes.

The lack of a clear user-centric vision is significant both in the context of railway passengers and freight as well as in the context of urban transportation needs. Current roadmaps do not employ a user centredness approach, which to be most effective must engage in marketing activities to enlarge the user base. As such, the ETPs underestimate the aspect of inclusiveness, and it does not consider the users' perceptions as a key element for railways evolution in the upcoming years.

At the same time, the roadmap analysis underlines that more research is needed for gaining a more in-depth insight on those functionalities of road and rail transport which can strengthen a sustainable performance. More investigation should be carried out on the perceived obtrusive social barriers that prevent a sustained modal-shift from private car to public transport, as well as on the social incentives which would be able to effectively promote the shift from aviation to high-speed rail. Therefore, it is recommended to integrate the perspective of social-oriented aspects into the technical innovation characterising the roadmaps, in order to establish innovative railway transport solutions.

Similarly, it is essential to adopt and understand the needs and habits of the prospective users, as they all require a custom-oriented approach to meet their needs and loyalty in terms of railway services. Similarly, the current roadmaps do not include factors which are essential in today's user mobility choices such as the role and availability of mobile apps.

Lund et al (2017) argues that while integrated mobility services were typically considered the backbone of public transport, railways will be able to show a higher success rate of success if the services are personalised. Therefore, an early integration of parameters such as 'ease of transactions' and 'payment', 'personal preference' and 'dynamic journey management' into the design phase of the service would be able to improve the passengers share on railways. However, not only the roadmaps do not take into account these paramenters, they also do not include the needs for an advancement in the service quality. In this context, obtaining information from the current and potential customer base might ensure the railway sector is able to meet their needs and thus sustain the modal-shift to railways.

Similarly, the roadmaps do not address the fact that the railway sector must shift from the current "production culture" to a "service culture" which currently driving the market due to its powerful action as psycological barrier.

Lastly, the interviews conducted with Prof Hoffmann and Dr van Oort underlined how the users' perspective must be better implemented, as the research roadmaps do not include passengers' lifestyle, the perceived quality experience and the resulting social atmosphere during travelling.

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Gap 2: Policymakers

The second relevant topic is connected to the influence of policies on transport developments, and is in particular related to the dichotomy between short-term and long-term planning, being especially the latter relevant for the railway sector. In particular, the analyses of the interviews and the roadmaps highlights how the long-term vision is often not supported by the necessary actions.

Furthermore, the transport experts indicated that the short-term transport goals are often integrated into the political agendas with the purpose to act as negotiable goals, therefore lacking the possibility of supporting and achieving ERRAC's long-term vision (ERRAC Vision 2050, 2017) (ERRAC Vision 2030, 2019). This process is particularly worthy of attention as, to generate the necessary shift in mobility to achieve carbon neutrality of the transport sector, political leaders are expected to secure the short-term vision to be able to achieve to the long-term vision of reducing CO2 production. Similarly, the transport experts highlighted how political actors often focus on the period in government, which is generally four years throughout the EU. Such a timeframe is not considered sufficient to realise the long-term goals or action plans of railway, especially considering the high costs and time of its infrastructure.

At the same time, the analysis underlined how a government-driven approach to the identification of transport hubs might be needed to secure the transitions facilities necessary to develop railways as the supporting infrastructure that connects and is integrated into other transport modes. In this context, the current roadmaps do not stress adequately the needs for political support in the development of connectivity, infrastructure and hard technologies.

The current research roadmaps barely mention these research point. Troche (2019) introduced the urgency of creating transport hubs, and to this end, the transport experts stressed the need for stronger government involvement.

Gap 3: Multi-modal approach

The research finds that in the ETPs roadmaps, the following research priorities are frequently mentioned: "multi-modal approach", "seamlessly integrated mobility network" and "integrated ICT system". As indicated by Prof Hoffmann and highlighted by the transport experts during the World Café activity, an integrated communication system and a strong ICT system are essential requirements to establish a sound multi-modal approach. Furthermore, the role of exponential technologies and safety & security measures in providing an effective multi-modal approach is often overlooked in the current roadmaps.

Moreover, as the keyword "multi-modal approach" has a higher frequency in the roadmaps from the railway sector, in comparison with the roadmaps from other transport sectors, a gap might be present in relation to the multi-modal approach to railway as the backbone of European mobility. In particular, the lack of this keyword in roadmaps from other transport areas might indicate a lack of research priorities from non-rail transport sectors to include railways into the multi-modal transportation network. For the railway to be the backbone of European mobility, it is necessary to include this vision in other transport sectors. As such, railway experts should not only be involved within their own sector but also infiltrate other transport modes roadmaps.

Gap 4: On-demand mobility

Both the transport experts and the roadmap analysis highlighted the lack of relevance for tailored and on-demand mobility services within the rail-related roadmaps. On-demand mobility services are often overlooked, although their introduction could improve mobility services in rural areas and urban zones. The lack of such services is more evident in rural areas, characterised by the decline of daily passengers and the shortage of government support. Public transport in these areas might be supported by on-demand mobility services capable of connecting rural areas thanks to railways. However, the importance of on-demand mobility is not limited to rural areas, but it is rather widespread affecting the everyday life of European citizens also in more populated districts, thanks to new technologies able to provide assistance to the end-user by supporting the phases of booking, trip planning and connectivity. The role of technology is also expected to be central in the multimodal approach and in the context of railways users since, as Prof Hoffman mentioned, it might manage travellers' behaviours.

7. Conclusions

The EU is facing the challenge to provide sustainable, satisfactory and affordable mobility. In this context, the EU mobility roadmaps play a fundamental role in designing the future of the Union's transportation.

This research aims at answering the question about which misalignments and gaps characterize the EU mobility roadmaps and whose trends which are not mentioned should be included to ensure rail will be the backbone of the future European mobility.

The data show the mobility roadmaps lack focus on certain topics which are instead essential for achieving ERRAC vision. These topics are related to the following four topics: the necessity of adapting users needs, user acceptation and integration of railways; the influence of short-term policy on transport developments over the long term; the absence of a multi-modal mindset in every transport sectors to integrate railways; and the need for tailored and on-demand mobility in railways.

Additionally, the research highlights comparability in some of the keywords mentioned in the transport roadmaps. This characteristic is expected to lead to an accelerated pace in the development of the following five topics: cross-sectoral and cross-disciplinary research (i); information management systems (ii); physical transport network (iii); safety and security (iv); and digitalization and interconnection of the rail network (v). Regarding the degree of connection between transport modes, this research show two important findings. On one side, the transport experts focusing on multi-modal approach and seamless transport networks emphasize that the railway sector must achieve more collaborations with other transport modes, especially with road transportation. On the other side, non-rail roadmaps frequently lack to mention in their respective transport vision the opportunities arising from collaboration or integration with railway services. Such a characteristic strongly hinder the process of establishing the future European mobility with rail as a backbone.

The investigation and research on key trends within the European transport roadmaps allow the output of this task to provide a robust foundation for Task 2.3 and Task 2.4. The research undertaken within Task 2.2 developed an overview of the roadmaps shortcomings published by

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the key stakeholder. These shortcomings have been defined as gaps in the European transport and railways visions. Despite while the roadmaps still belong to the state of the art, the identification of certain gaps should be seen as a valuable finding for the transport sector.

This task has shown a small glimpse of the potential that rail has to become the sustainable backbone of an energy-efficient transport chain for both passengers and freight. As the shift towards sustainable mobility requires an integrated and efficient transport system as well as secure and clean energy, this research demonstrates that a modal shift to rail will act as a major driver for de-carbonization of the transport sector. It is therefore essential to continue informing and advising policymakers and railway operators alike, to continue the trend towards and a sustainable, inclusive and future transport.

8. External communication of WP2.2

The results of the World Café activity have been shared through different channels, as shown in Table 7 and Figure 6 and 7.

Action	Channel	Audience
Press release of the event has been shared	Social media and mailing list	Ter4Rail partners and general public
Minutes of the meeting have been shared	Mailing list	Participants of World Café activity
Final report of the event has been shared	Mailing list	Participants of World Café activity
Highlights and output of the event have been shared	Ter4Rail social media and mailing list	Ter4Rail partners and general public
The results have been employed to apply to conferences and open calls for publishing papers	Mailing list, events websites and open calls	Academia and researchers

Table 7: World Café communication activities

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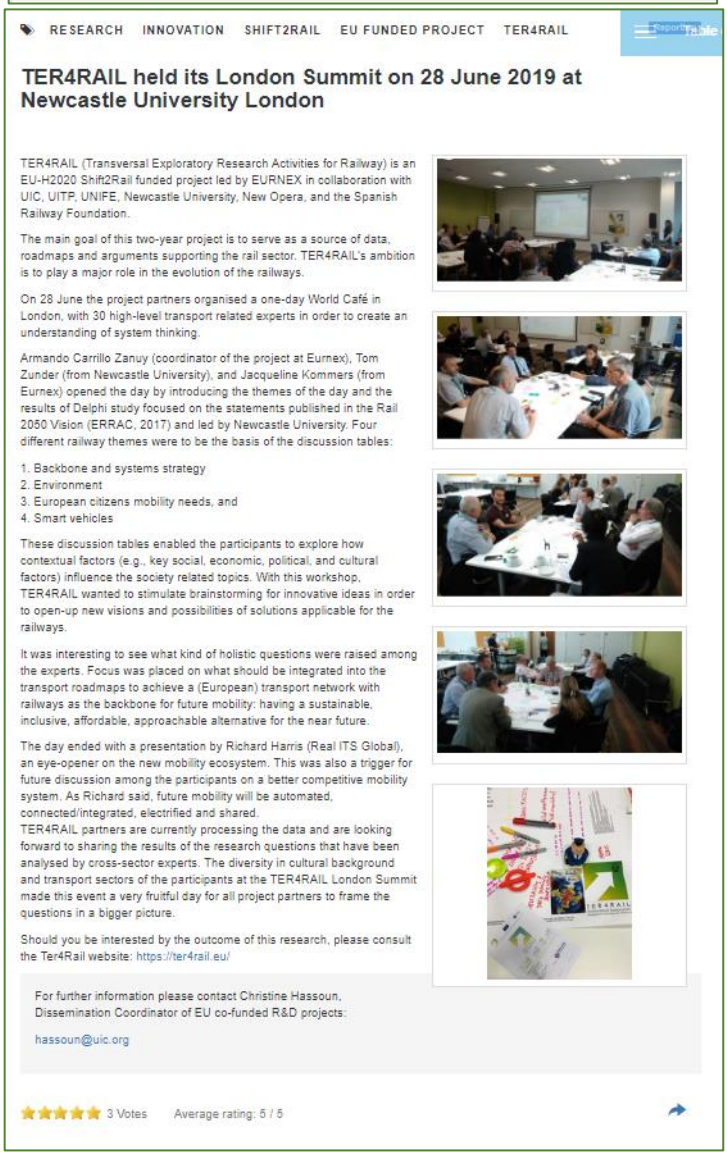

Fig. 6 and 7: Examples of communication activities

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During the execution of this research, intermediate results and the progress of this project have been presented at various events, as shown in Table 8.

Name of the activity	Theme	Content	Date and location
The 7th UIC Next Station conference	Parallel session Sustainability	Presenting the the Ter4Rail project and the scope of the research	13th November 2019, Tehran, Iran
IPMA, Iran Project Management Association	Constructing research to create a holistic view	Presenting the scope of the research, the research process of the Ter4Rail project, the research partners	15th November 2019, Tehran University, Iran
2nd meeting 2019 of the PAG ERRAC (Professional and Academic Group of the European of European Rail Research Advisory Council)	As part of the agenda Research and Innovation Priorities 2030	Presenting the research results, the detection of the gap, conclusions and research outputs	28th of November 2019, Brussel, Belgium
5th Forum exploring rail innovation: towards the next EU rail partnership, hosted by ETNA2020 and, ISERD (Israel-Europe R&I Directorate)	Promoting the European Research and Innovation Programme	Presenting the Ter4Rail research project, results and methodology	17th of December 2019, Jerusalem, Israel
Shift2Rail 2020 Call information day	Presenting the collaboration process of building a consortium for the open calls of the Shift2Rail projects	Presenting EURNEX and the project processes for the Iranian railway institutes	18th of December 2019, Jerusalem Israel
Expected in 2020			
Transport Research Arena 2020 (cancelled)	Workshop focused on balancing integrated mobility	Poster presentation, workshop	28th April, Helsinki, Finland
Transport Research Arena 2020 (cancelled)	Part of the Young Researchers competition	Research present in TRA booklet	27/28th April, Helsinki, Finland

Table 8: External communication activities

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To accelerate the results of this research, abstracts for the following mobility related conferences and events have been handed out.

Conference	Status	Date and location	Website
Tra2020	Applied /pending	27 – 30 april, Helsinki	www.traconference.eu/
Festival duurzame mobiliteit	Applied / will be mentioned on the website	1 october, Amersfoort	www.festivalduurzamemobiliteit.nl/home/
Nextstation	Applied /pending	11-13 november, Tehran	www.nextstation.org/
Smart mobility congress, Part of smart city expo world congress	Applied/ pending	19 – 21 november, Barcelona	www.smartcityexpo.com/en/topics/mobility

Table 9: Planned conferences

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10. Appendices

10.1. APPENDIX A. Participants, World Café

Participant Number	Role within the Organisation	Location of the Organisation
1	Innovation Director	France
2	Head of Department	Serbia
3	Manager	Belgium
4	Senior Specialist Transport Planner	United Kingdom
5	Head of Research and Innovation	France
6	Professor	Lithuania
7	Project Manager	Italy
8	Secretary General	Germany
9	Vice President	Italy
10	President	United Kingdom
11	Chairman	Belgium
12	Co-director	Spain
13	Public Transport Analyst	United Kingdom
14	Director	United Kingdom
15	Director	United Kingdom
16	Dissemination Manager	France
17	Economic Adviser	France
18	Project Manager	Germany
19	Researcher	Germany
20	Technical Affairs Manager	Belgium
21	Senior Research Scientist	Slovenia
22	Research Student	United Kingdom
23	Professor	United Kingdom
24	European Research Projects Advisor	Italy
25	Director	United Kingdom
26	Project Manager	Germany
27	Director	Sweden
28	Director	Sweden
29	Vice President	France
30	Head of Department	Spain
31	Senior Business Consultant Logistics	The Netherlands
32	Principal Research Associate	United Kingdom

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10.2. APPENDIX B. Interviews to transport experts

Name: Dr Niels van Oort
Institution: Co director SMART Public Transport Lab, TU Delft, The Netherlands.
Domain: Public tranport, (light rail , bus, bike, micro veihcles)

Solutions ***Please provide a short description of the solution.***	**Type of vehicle** ***To which type of vehicle is the solution referred?***	**Approach** ***What is the underlying approach on which the solution is based?***	**Issues** ***Are there any issues related to the implementation of this solution? If so, please describe them.***	**Issues addressed** ***Have (any of) these issues been addressed? How?***	**Lessons learnt** ***What did we learn from the implementation of such solution?*** ***What is the takeaway for future solutions?***
Improving mobility and reducing environmental impact by adapting bikes (sharing or private) to the public transport network and enhancing the public transport system. Bikes provide a solution to the first and last-mile trip and facilitate their integration into the chain of public transport services.	Multimodal in public transport, (light rail, bus, bike, micro vehicles, active mobility e.g. walking and biking)	Considering a wide range of parameters and characteristics for the assessment of the implementation of solutions for urban transport. Improving public transport is more than implementing a new technical innovation, it has common ground with the following 5E's framework; consisting of implementing effective mobility, efficient city, economy, environment and equity support assessing and quantifying this value.	There is a lack of services in the last and first-mile solution. This is often caused by the unfair assessment of public transport plans. That has the consequence of giving preference to certain modes of transport	Adopting the 5E framework in an early stage will help to understand the value of the public transport service and what the return of investment is for the implementation of alternative means of transport. With this solution: 'adapting bikes in public transport infrastructure' a shift to a more sustainable (urban) transport network can be fostered. Also, the public transport service can be revised in the design. For example, a traditional bus line that supplies the whole neighbourhood can be transformed into a more linear structure with fewer stops and more direct connections; this can help to upgrade the bus lines towards a Bus Rapid Transit (BRT) system.	A comprehensive and multimodal approach is the key to the success of an efficient public transport network. This approach will also promote the implementation of more sustainable means of transport According to the 5Es framework, the parameters to be included in the multimodal approach should encompass: comfort, reliability, rail bonus (perception of rail as better than, for instance, buses), accessibility, design of the public space, modal shift potentiality, impact on the urban development, increase of the property values, impact on the employment and the welfare, reduction of negative externalities and effect on the public health.

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Name: Prof. D. Christian Hoffmann
Institution: Head of Environmental Psychology, University of Applied Sciences for Media, Communication and Management, Leipzig University, Germany.
Domain: Public tranport, (light rail , bus, bike, micro veihcles)

Solutions ***Please provide a short description of the solution.***	**Type of vehicle** ***To which type of vehicle is the solution referred?***	**Approach** ***What is the underlying approach on which the solution is based?***	**Issues** ***Are there any issues related to the implementation of this solution? If so, please describe them.***	**Issues addressed** ***Have (any of) these issues been addressed? How?***	**Lessons learnt** ***What did we learn from the implementation of such solution?*** ***What is the takeaway for future solutions?***
At the moment, there is a need for a complete transport trip from A to B (door2door solution). This includes more than providing a vehicle for transport. It should also include a secure, reliable, comfortable and safe public transport. There is also a need to have a constantly working/high-reliability public transport network, including these two focus points 1. protection of the users in a physical network. (for example, adapting protection for weather extremes during summer and winter) 2. Comfort (this consist of the smell, temperature, privacy, social feeling/control).	Public transport, (light rail , bus, bike, micro vehicles) Active mobility (biking, walking)	The key to getting the right result is integrating the users in the design processes. Not only for understanding their travel behaviour but also to involve them in an early stage, so there is a higher success of adopting new mobility behaviour.	Each target group has different preferences (flexibility, safety, safety, easy access, e.g.). During the evaluation and project approach, this is something that needs to be considered. Travel behaviour is strongly depending on the daily program and the habits of the citizens. With good analyses, this can be detected and integrated. Example: one of the project names was 'last mile'. Last mile means that the last part of the public transport trip that is most of the time not supported by good infrastructure. The target group (citizens) created a totally different expectation; they linked it with funeral service. The name of the project didn't create a link with transport for the users. Having a good empathy for the end-users is needed in creating a suitable project.	The development of a good public transport infrastructure and services should be performed in a participative manner by means of a co-creation process.	Innovation is more than technical implementation. It rather consists of social acceptance and trust in the new solution. Users mindset transition is a long process.

Easy to use smartphone apps/interface for frequent or flexible users.	Public transport (light rail, bus, bike, micro vehicles) Active mobility (biking, walking)	To integrate a higher number of services in a single app (scheduling, ticketing, call center) as well as several means of transport and services (e.g. bike cargo).	Users data must be protected and contracts should be signed with multiples stakeholders and operators. The service should not be more expensive than owning a private car.	One of the big players may be the owner or responsible of this process (e.g. DB, BVG...) so that they can manage all the burdens and costs. An additional advantage would consist of avoiding the disappearance of the service if the small company/start-up owning the app goes bankruptcy. Prices should be segmented according to the target group (student, worker, retired...).	Devices or application must be supported by robust institutions/companies and accomodate to the (economic and usability) user needs.

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10.3. APPENDIX C. Table posters during World Café activity

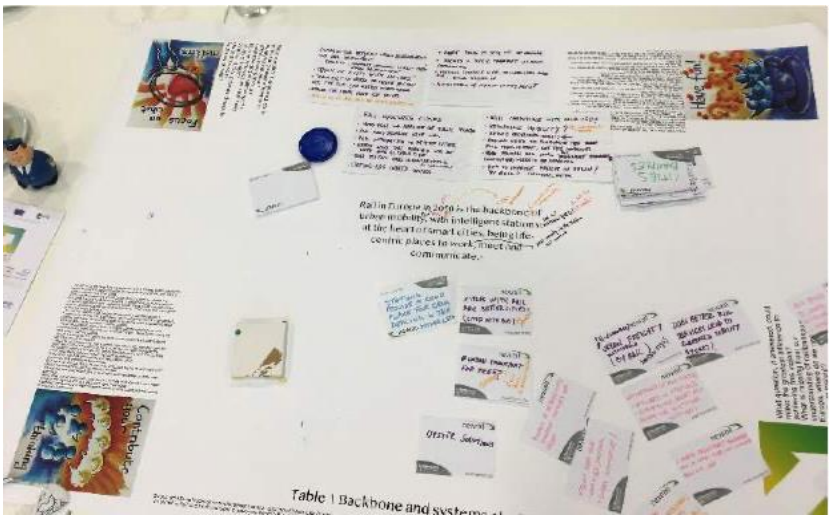

Fig. 8: Poster representing Table 1, London Summit

Fig. 9: Poster representing Table 2, London Summit

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Fig. 10: Poster representing Table 3, London Summit

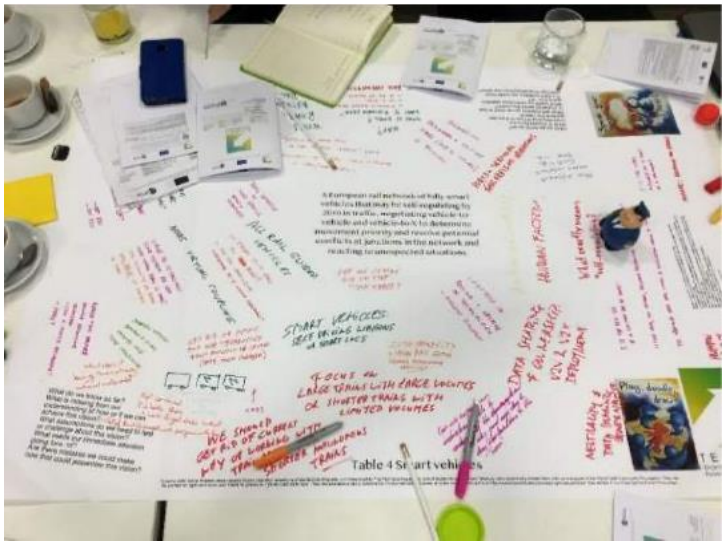

Fig. 11: Poster representing Table 4, London Summit

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10.4. APPENDIX D. MINUTES ERRAC PAG

ERRAC Permanent Advisory Group Academia

Minutes of Meeting n°4

Date: 28 November 2019 – 14:00-17:30

Place: Brussels, UIC, 53 avenue de arts

Participants

Ernesto Garcia Vadillo, University of The Basque Country, Spain
Markus Hecht, TU Berlin, Germany
Jacqueline Kommers, EURNEX
Armando Carillo, Eurnex, Germany (partly)
Marion Berbineau, IFSTTAR, France
Chris Nash, Leeds University, UK
Tom Zunder, NEWRAIL
Armand Toubol, Newopera
Juan de Dios Sanz Bobi, UPM, Spain
Martin Brennan, ERRAC Secretary
Sebastian Stichel, KTH, Sweden

1) **Welcome & Introductions**

   The Vice chairman welcomes everyone. All participants present each other.

2) **Report from last ERRAC steering Committee**

   The vice chairman summarizes the last SC. Important activities are the Vision 2030 document and a possible new phase of the S2R JU.

3) **Ongoing activities in S2R Scientific committee**

   Juan de Dios Sanz Bobi gives information about the S2R SC. Angela di Febbraro is still chairman, Juan is now vice chairman. Two new members were elected. A discussion point on

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the last meeting was that there still more involvement from Eastern European countries would be desired in S2R. The success rate of the last open call applications was 25%. Also the Hyperloop technology was discussed in the SC meeting.

4) **ERRAC PAG Mailing List**
It is decided during the meeting that the mailing list of the PAG will be turned into an open list. Today the chairman of the group sends mails with "Bcc", i.e. only the chairman knows who is on the list. This has been the policy since the group started. All members that are on the list now will be asked in an email whether they would like to remain in the group if the mailing list is changed into an open one where everyone can see all members email addresses.

5) **Input to « 2030 Research and Innovation Priorities » and « S2R-2 ».**

Martin Brennan mentions the Megaprojects that are planned as the basis for S2R-2. Work is ongoing in ERRAC to describe those. Sebastian mentions that both the ERRAC Chairman Alberto Parrondo and the S2R director Carlo Borghini are happy about input to the document from the PAG. It is decided that Sebastian will continue to gather input from the members that he can present to the ERRAC steering group.

6) **TER4RAIL activity**
Tom Zunder and Jacqueline Commers are leading a group activity regarding the Delphi study that was carried out within the project. Two "unstable" statements were discussed.

7) **AOB /Wrap-up**

The next meeting will be held on April 27 in the afternoon.

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10.5. APPENDIX E. Keyword Database

Full Name of Institute		The European Rail Research Advisory Council	ERTRAC, EPOSS - ETIP SNET	Mobility working group, ERTRAC, ERRAC, ALICE	Waterborne Technology Platform	Alliance for Logistics Innovation through Collaboration	Shift 2 Rail	Shift2Rail JU	UIC - RICG	the Directorate-General for Mobility and Transport (DG MOVE)	UIC	ACARE
Title of document		Rail the Backbone of Europe mobility, Vision 2050	European Roadmap Electrification of Road Transport	Integrated Urban Motility Roadmap	The maritime Future: An Ocean of Opportunities for Europe, Vision 2030-2050	Corridors, Hubs and Synchro modality, research and Innovation Roadmap	Multi- Annual Action Plan Part A (#2)	SHIFT2RAIL strategic master plan (#3)	The 12 Capabilities – a presenter's guide (#6)	Transport in the European Union, Current Trends and Issues (2019)	Railway Technical Strategy Europe (#10)	Strategic research and innovation agenda, Flight plan for 2050
Highlight, missions to complete		European rail transport 2050 Transformed railway 1. Railway is serving society (1.A mobility, 1.B logistics and 1. C Smart cities) Innovations to deliver the vision 2. Digitalisation/ cognitive computing/robotics/distributed immutable shared ledgers/new intelligent systems 3. Delivering the vision (A. seamless European research and innovation system, B. Strong cooperation between rail stakeholders, C. integration of experts from other scientific disciplines, D. Effective cooperation with other modes of transport = connect efficient and realisable EU transport system)	Roadmap 2030 1. Operation system dependent EVs in the urban environment 2. User-friendly affordable EV passenger car + infrastructure 3. Non - compromise electric urban bus system 4. Sustainable electrified long-distance trucks and coaches. The biggest bottle necks are: high cost, inconvenient and slow charging, limited range, perceived lack of added value, concern of limited mobility	1. Changing society trends - new urban mobility scenarios Decarbonisation, city dynamics, demographic challenges 2. Frameworks and Enablers SUMPS (Sustainable Urban Mobility Plan), big data, gov. regulation and business models, upscaling 3. Innovation urban mobility solutions and services A. Infrastructure related solutions B. Management related solutions C. Service related solutions D. Modal solutions	4 missions: 1. Transforming shipping: clean green, safe secure, cyber resilient. 2. Maintaining leadership: competitive and production, blue and circular 3. Growing in the blue: work and live at sea, food and wealth from oceans, understand to protect 4. Adapting and extending: fast and reliable, more integration, infra and infostructure	1. Integration of transport services and supply chains; 1.1. Understanding the demand for the synchro modal freight transport system 1.2. Optimize alignment between supply chains and transport services 1.3. New roles for hubs in the supply chain 2. Integration of transport services and infrastructures 2.1. An integrative freight network strategy 2.2. Transport chain design and operation for Synchro modality 2.3. Deploying ICT as integrating technology	Key points: 1. Addressing the key social trends 2. Need for radical transformation 3. Customer focused mobility Focus of the innovation program 1. Cost-efficient and reliable trains, including high capacity trains and high-speed trains 2. Advanced traffic management and control systems 3. Cost-efficient, sustainable and reliable high capacity infrastructure 4. IT Solutions for attractive railway services 5. Technologies for sustainable and attractive European rail freight	Higher goal -Single European Railway area -Attractiveness and competitiveness -Leadership on the global market Objectives 1. Improved services and customer quality 2. Reduce system cost 3. Enhanced interoperability 4. Simplified business processes Key performance indicators • KPI Level 1: monitor the progress in meeting the Technology Demonstrators related objectives and impact of the R&I developments and Technology Demonstrators of a specific topic or priority. • KPI Level 2: monitor the progress of S2R Joint Undertaking with regard to the specific targets of the S2R Joint Undertaking. • KPI Level 3: address the contribution to the accomplishment of the overall strategic objectives of the S2R Joint Undertaking (e.g. achievement of the Single European	• Automation • Artificial intelligence • Convoying • Electronic revenue capture • Open architecture data systems • 5G • Physical internet • Alternative propulsion concepts • Dynamic wireless power transfer • Smart grids • Self-healing assets • Lightweight materials • Robotics • Digital twin • Blockchain technologies • Green technologies	1. Policy Challenges: A. sub optimal market functioning, B. Infrastructure deficiencies, C. Low-emission mobility and negative externalities. 2. Identification of polity levers to address the challenges; completing market opening, intro of principle of competition for public service contract, ensuring non-discriminatory access to unfractured, reducing technical and regulatory barriers for market entry, implementing the single signalling system, introducing common passenger rights with fewer national exemptions, harmonising of technical standards across Europe, fair working conditions.	1. Railways is the backbone of an end-user focussed, integrate mobility system that provide seamless transit, irrespective of mode, each mode collaborating with other to deliver the elements at which it is the most efficient 2. Railways can provide best value in terms of service quality and cost, handling large volumes 3. End-users consistently receive a high-quality service, 4. The railways respond flexible to changing market demands and operational conditions, 5. Railways are the safest and most secure mode of land transport 6. Railways is as sustainable as reasonably practical 7. Open and attractive for innovation and talent 8. Outward-looking with global horizons	1.Meeting societal and market needs 2.Maintaining and extending industrial leadership 3.Protecting the environment and the energy supply 4.Ensuring safety and security 5.Prioritising research, testing capability and education.
Technologic solution												
Digitalization	4	1			1				1	1		
Robotics	1								1			
Information management system	4				1	1	1		1			
Cognitive computing	0											
Sustainable consumption												
Decarbonisation	3		1							1	1	
Alternative fuels	2								1			1
Energy efficient	2		1						1			
Scale of transport												
Urban Mobility	1			1								
City Dynamics	1			1								
Connectivity	3				1	1					1	
Long distance transport	1		1									
Connectivity												
Accessibility	1						1					
Interconnecting rail network	2	1						1				
Physical transport network	4	1			1	1					1	
Sharing economy solutions	1			1								
Cross sectoral / disciplinary research	4	1				1		1		1		
Infrastructure												
Electric and hydro charging stations for EV (car/train / truck/ small vehicle) in infrastructure	1		1									
Economy												
Balanced investment in infrastructure	3		1					1		1		
Cost efficiency reliable trains or infrastructure	1						1					
New business cases	1							1				
Holistic view												
Delivering the vision	0											
Long term aspects for the rail network	1										1	
New intelligent	2	1										1
EU level												
Safety and security	4				1		1				1	1
EU innovation leader	1											1
Education	0											
Policies												
Trends and policies impacting	4			1		1				1		1
User behaviour and needs	3			1			1	1				
	55	5	5	5	5	5	5	5	5	5	5	5

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10.6. APPENDIX F. Graphic visualization of the trends and themes resulting from the selected roadmaps.